Water retentivity of internal cured concrete using polyethylene glycol

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Abstract: Concrete with poor water retentivity can easily bleed, laminate, and segregate, thus result in bonding improperly and influencing the normal hardening, at the same time decreasing the strength of concrete. The influencing factors of water retentivity are: type and quantity of cementitious material, property of aggregate, water quantity, admixtures, etc.

Experimental investigation is performed to investigate the retentivity or water absorption of low strength concrete with different percentages of self-curing agent. Polyethylene glycol (PEG) of lower molecular weight PEG-600 and polyethylene glycol of higher molecular weight PEG-6000 is used as self-curing agent.

Water retentivity test of concrete specimens is conducted. After remoulding of concrete specimen, the initial weight and after curing of some (3, 7, 14, or 28) days again the final weight of concrete are determined. Weight loss or water absorption is obtained and the observations are compared with each other's.

Key words: Air curing condition, higher molecular weight PEG-6000, Internal curing, lower molecular weight PEG-600, polyethylene glycol (PEG), self-curing agent, water absorption, water loss, water retentivity, wet/conventional curing.

2 GENERAL:

The experimental program is designed to investigate the water retentivity of internal curing of OY mix (1:1.4:2.6:0.45) of concrete with polyethylene glycol (PEG) of PEG-600 and PEG-6000 and ordinary Portland cement (OPC) of 53 grade is used. The program consisted of casting and testing of 72 cubes of size 150mm×150mm×150mm. All cubes were casted involves different dosages (0%, 0.1%, 1% and 3%) of self-curing agents (PEG-600 and PEG-6000), under different curing condition (indoor, conventional). Compressive strength test is conducted after 7, 14 and 28 days of curing. The experimental program is presented in table 1. Table 1 Mix OY (1:1.4:2.6:0.45) concrete cubes to be casted and tested

Days			7 Days cured	14 Days cured	28 Days cured	Total
Materials		Nomenclature				
Normal concrete	Moisture Cured	OYW	3	3	3	9
	Air Cured	OYD	3	3	3	9
600 MW*	0.1% PEG	OYL 0.1	3	3	3	9
	1% PEG	OYL 1	3	3	3	9
	3% PEG	OYL 3	3	3	3	9
6000 MW*	0.1% PEG	OYH 0.1	3	3	3	9
	1% PEG	OYH 1	3	3	3	9
	3% PEG	OYH 3	3	3	3	9
Grand Total						72

*MW- Molecular Weight.

NOMENCLATURE FOR SPECIMEN

Y or Mix Y- (1:1.4:2.6:0.45)
P-Ordinary Portland cement (OPC).
L-PEG 600 (Lower Molecular Weight).
H-PEG 6000 (Higher Molecular Weight).
D-Dry or air curing condition.
W-Wet/Conventional Curing.
S.C.A-Self-Curing Agent or I.C.A.-Internal Curing Agent.
For example sample with name OYL-1 represent Mix Y (1:1.4:2.6:0.45) with PEG 600 and dosage of 1% by weight of cement subjected to indoor curing.

3 MATERIAL USED:

The properties of used materials are as under: Table 2 physical properties of cement, coarse and fine aggregates.

S/No	Specification	PEG 600	PEG 6000
1	Mol. Wt.	550-650	5100 – 7000
2	Appearance	Clear or colorless liquid	White flake
3	Color, boha	10 max	10 max
4	Moisture	0.5% max	0.1 % max
5	Hydroxyl value	172-204 (mg KOH/g)	17- 22 (mgKOH/g)
6	Ph.	5-7	5-7
7	Specific gravity	1. 12 _ 1.13	1.08 – 1. 09
8	Dioxane	1ppm max	1ppm max

POLYETHYLENE GLYCOL (PEG)

In this investigation Polyethylene glycol is used as internal curing agent. Polyethylene glycol is a condensation polymers of ethylene oxide and water. The low molecular weight compounds up to 700 are colorless, odorless viscous liquids with higher freezing point from 10C0 (diethylene glycol), while polymerized compounds with higher molecular weight than 1,000 are wax like solids with melting point up to 67C0 for n 180. The abbreviation (PEG) is termed in combination with a numeric suffix which indicates the average molecular weights. One common feature of PEG appears to be water-soluble. The specification of PEG 6000 and PEG 600 are shown in table 7. They are used to make emulsifying agents and detergents, and as plasticizers, humectants, and water-soluble textile lubricants.

Polyethylene glycol is non-toxic, odourless, neutral, lubricating, non-volatile and no irritating and is used in a variety of pharmaceuticals and in medications as a solvent, dispensing agent, ointment and suppository bases, vehicle, and tablet excipient. Polyethylene glycol is produced by the interaction of ethylene oxide with water, ethylene glycol or

ethylene oligomers.

Table 3. Specification of PEG 600 &PEG 6000.

S/ No	Specification	PEG 600	PEG 6000
1	Mol. Wt.	550-650	5100 – 7000
2	Appearance	Clear or colorless liquid	White flake
3	Color, boha	10 max	10 max
4	Moisture	0.5% max	0.1 % max
5	Hydroxyl value	172-204 (mg KOH/g)	17- 22 (mgKOH/g)
6	Ph.	5-7	5-7
7	Specific gravity	1. 12 _ 1.13	1.08 – 1. 09
8	Dioxane	1ppm max	1ppm max

4 MIX DESIGN OF MIX-Y:

In this study, mix design of mix-Y is done by method of IS CODE (Indian Standard recommended Method IS 10262-82) in order to obtain strength around 30MPa

Number of trails were conducted to obtain the desired strength and to maintain good workability and finally acquired a mix proportion (1: 1.4:2.6:0.45) (C: FA: CA: W/C). For mix-OY of 30Mpa. To obtain good workability and desired strength the optimum water cement ratio used is 0.45 with no super-plasticizer is used in the mixes.

5 QUANTITY OF MATERIALS REQUIRED FOR OY MIX OF CONCRET:

Table 4 Material required for OY mix of concrete.

S/ NO	Nomenclature of Mix	No. Of Cubes	Cement (Kg)	FA (Kg)	CA (Kg)	Water (Kg).65	PEG (600) (gm)	PEG (6000) (gm)
1	OYW	9	17	24	44	7.65	0	0
2	OYD	9	17	24	44	7.65	0	0
3	OYL-0.1	9	17	24	44	7.65	17	0
4	OYL-1.0	9	17	24	44	7.65	170	0
5	OYL- 3.0	9	17	24	44	7.65	510	0
6	OYH-0.1	9	17	24	44	7.65	0	17
7	OYH- 1.0	9	17	24	44	7.65	0	170
8	OYH- 3.0	9	17	24	44	7.65	0	510
Total		72	136	192	352	61.2	697	697

6 CASTING PROGRAM:

Casting program consists of preparation of moulds as per IS 10086: 1982, preparation of materials, weighing and mixing of materials and casting of cubes, compacting and curing of concrete is done according to IS 516: 1959. The cubes which are intended for self-curing are kept in indoor/shade at room temperature.

7 WATER RETENTIVITY TEST:

Water retentivity is the ability of keeping water, or the inseparability of the composites of mortar or concrete.

Mortar or concrete with poor water retentivity can easily bleed, laminate, and segregate, thus result in bonding improperly and influencing the normal hardening, at the same time decreasing the strength of mortar. The influencing factors of water retentivity are: type and quantity of cementitious material, property of aggregate, water quantity, admixtures, etc. Procedure for water retentivity test of concrete specimen are that, after remoulding of concrete specimen, the specimen must be weighed and recorded this weight is called initial weight and after curing of some (3, 7, 14, or 28) days again the specimen should be weighed this weight is called final weight. Weight loss or water absorption will be determined by the following formula:

Weight loss of individual specimen = final weight - initial weight and also:

Water absorbed by individual specimen = final weight - initial weight

In above formulae the difference between the water loss and water absorption is that, in weight loss the result will have minus sign and in water absorption the result will be positive.

Concrete with low and higher molecular weight polyethylene glycol (PEG) subjected to indoor curing was studied by weighing the samples at 7, 14 and 28 days with digital weighing machine of accuracy 5gm. The results were recorded and the weight loss for individual specimen is shown in the following tables. The work was carried out in temperature of 38C0 and at relative humidity of atmosphere between 20% and 30% with reference to local weather report. The following are the observation and results on water retentivity of concrete.

8 WATER RETENTIVITY TEST RESULTS FOR MIX OYL:

Water retentivity test results for lower grade concrete with low molecular weight PEG (OYL) of each sample is shown in the following tables:

Table 5 Results for water retentivity test for OYW mix of concrete.

Testing day	7days				14 days				28 days			
Specimen	OYW (1)	OYW (2)	OYD (3)	Avg	OYW (4)	OYW (5)	OYW (6)	Avg	OYW (7)	OYW (8)	OYW (9)	Avg
Initial weight (kg)	8.28	8.2	8.31	8.263	8.25	8.1	7.94	8.097	8.07	8.16	8.2	8.143
Last weight (kg)	8.38	8.29	8.4	8.356	8.33	8.15	8.01	8.164	8.17	8.18	8.27	8.206
Water loss (kg)	0.1	0.09	0.09	0.093	0.08	0.05	0.07	0.067	0.1	0.02	0.07	0.063

Table 6 Results for water retentivity test for OYD mix of concrete

Testing day	7days				14 days				28 days			
Specimen	OYD (1)	OYD (2)	OYD (3)	Avg.	OYD (4)	OYD (5)	OYD (6)	Avg.	OYD (7)	OYD (8)	OYD (9)	Avg.
Initial weight (kg)	8.23	8.17	8.20	8.20	8.24	8.19	8.36	8.26	8.15	8.21	8.46	8.27
Last weight (kg)	8.11	8.05	8.11	8.09	8.14	8.10	8.25	8.16	7.94	8.04	8.27	8.08
Water loss (kg)	-0.12	-0.12	-0.09	-0.11	-0.10	-0.09	-0.11	-0.10	-0.21	-0.17	-0.19	-0.19

Table 7 Results for water retentivity test for OYL0.1 mix of concrete

Testing days	7 days				14 days				28 days			
Specimen	OYL 0.1(1)	OYL 0.1(2)	OYL 0.1(3)	Avg	OYL 0.1(4)	OYL 0.1(5)	OYL 0.1(6)	Avg	OYL 0.1(7)	OYL 0.1(8)	OYL 0.1(9)	Avg
Initial weight (kg)	8.16	8.31	8.45	8.30	8.35	8.23	7.99	8.19	8.28	8.34	8.36	8.24
Last weight (kg)	8.02	8.21	8.32	8.18	8.12	8.15	7.88	8.05	8.12	8.21	8.22	8.27
Water loss (kg)	-0.14	-0.10	-0.13	-0.12	-0.23	-0.08	-0.11	-0.14	-0.16	-0.13	-0.14	-0.14

Table 8 Results for water retentivity test for OYL1.0 mix of concrete

Testing days	7 days				14 days				28 days			
Specimen	OYL 1.0(1)	OYL 1.0(2)	OYL 1.0(3)	Avg.	OYL 1.0(4)	OYL 1.0(5)	OYL 1.0(6)	Avg.	OYL 1.0(7)	OYL 1.0(8)	OYL 1.0(9)	Avg.
Initial weight (kg)	8.03	8.21	8.31	8.18	8.07	8.22	8.65	8.31	8.21	8.49	8.09	8.26
Last weight (kg)	7.98	8.15	8.24	8.12	7.95	8.12	8.53	8.20	8.03	8.35	7.95	8.11
Water loss (kg)	-0.05	-0.06	-0.07	-0.06	-0.12	-0.10	-0.12	-0.11	-0.18	-0.14	-0.14	-0.15

Table 9 Results for water retentivity test for OYL3.0 mix of concrete

Testing days	7 days				14 days				28 days			
Specimen	OYL 3.0(1)	OYL 3.0(2)	OYL 3.0(3)	Avg.	OYL 3.0(4)	OYL 3.0(5)	OYL 3.0(6)	Avg.	OYL 3.0(7)	OYL 3.0(8)	OYL 3.0(9)	Avg.
Initial weight (kg)	8.28	8.25	8.38	8.30	8.07	8.18	8.19	8.14	8.18	8.45	8.38	8.33
Last weight (kg)	8.13	8.11	8.22	8.15	7.97	8.10	8.06	8.04	7.85	8.14	8.06	8.01
Water loss (kg)	-0.15	-0.14	-0.16	-0.15	-0.10	-0.08	-0.13	-0.10	-0.33	-0.31	-0.32	-0.32

Table 10 water retentivity test results for Lower grade concrete with low molecular Weight PEG (mix OYL)

S/ No	Mix Design		Water loss@ 7days (kg)				Water loss@ 14days (kg)				Water loss@28days (kg)			
	Type of Curing	Nomenclature	1	2	3	Avg.	4	5	6	Avg.	7	8	9	Avg.
1	Air Cured	OYD	0.12	0.12	0.09	0.11	0.1	0.09	0.11	0.1	0.21	0.17	0.19	0.19
2	0.1% PEG- 6oo	OYL 0.1	0.14	0.1	0.13	0.12	0.23	0.08	0.11	0.14	0.16	0.13	0.14	0.145
3	1.0% PEG-600	OYL 1.0	0.05	0.06	0.07	0.06	0.12	0.10	0.12	0.11	0.18	0.14	0.14	0.153
4	3.0%PEG-600	OYL 3.0	0.15	0.14	0.16	0.15	0.10	0.08	0.13	0.10	0.33	0.31	0.32	0.32

OBSERVATIONS:

From Table 10 for lower grade concrete with low molecular weight PEG- 600 it is observing that:

1) 0.1% dosage shows lower weight loss when compared to dosages (0%, 1% and 3%).
2) 3% dosage of self-curing agent is losing more weight when compared to other dosages.
3) It is clear that 0% dosage is losing more weight compared to dosage (0.1%, 1% and 3%)

9 WATER RETENTIVITY TEST RESULTS FOR MIX OYH

Water retentivity test results for lower grade concrete with high molecular weight PEG-600 (OYL) of each sample is shown in the following tables:

Table 11 Results for water retentivity test for OYH 0.1 mix of concrete.

Testing days	7 days				14 days				28 days			
Specimen	OYH 0.1(1)	OYH 0.1(2)	OYH 0.1(3)	Avg.	OYH 0.1(4)	OYH 0.1(5)	OYH 0.1(6)	Avg.	OYH 0.1(7)	OYH 0.1(8)	OYH 0.1(9)	Avg.
Initial weight (kg)	8.43	8.30	8.37	8.37	8.29	8.40	8.08	8.257	8.09	8.33	8.31	8.24
Last weight (kg)	8.29	8.18	8.24	8.24	8.13	8.26	7.94	8.11	7.84	8.17	8.15	8.05
Water loss (kg)	-0.14	-0.12	-0.13	-0.13	-0.16	-0.14	-0.14	-0.147	-0.25	-0.16	-0.16	-0.19

Table 12 Results for water retentivity test for OYH 1.0 mix of concrete.

Testing days	7 days				14 days				28 days			
Specimen	OYH 1.0(1)	OYH 1.0(2)	OYH 1.0(3)	Avg.	OYH 1.0(4)	OYH 1.0(5)	OYH 1.0(6)	Avg.	OYH 1.0(7)	OYH 1.0(8)	OYH 1.0(9)	Avg.
Initial weight (kg)	8.29	8.09	8.28	8.22	8.47	8.51	8.29	8.42	8.50	8.27	8.20	8.32
Last weight (kg)	8.15	7.98	8.14	8.09	8.22	8.30	8.10	8.20	8.31	8.07	8.00	8.12
Water loss (kg)	-0.14	-0.11	-0.14	-0.13	-0.25	-0.21	-0.19	-0.22	-0.19	-0.20	-0.20	-0.20

Table 13 results for water retentivity test for OYH3.0 mix of concrete.

Testing days	7 days				14 days				28 days			
Specimen	OYH 3.0(1)	OYH 3.0(2)	OYH 3.0(3)	Avg.	OYH 3.0(4)	OYH 3.0(5)	OYH 3.0(6)	Avg.	OYH 3.0(7)	OYH 3.0(8)	OYH 3.0(9)	Avg.
Initial weight (kg)	8.30	8.08	8.09	8.15	8.22	8.16	8.02	8.13	8.21	8.21	8.05	8.15
Last weight (kg)	8.17	7.95	7.95	8.02	8.07	8.03	7.88	7.99	7.77	7.52	7.58	7.62
Water loss (kg)	-0.13	-0.13	-0.14	-0.13	-0.15	-0.13	-0.14	-0.14	-0.44	-0.69	-0.47	-0.52

Table 14 Water retentivity test results for lower grade concrete with high molecular PEG-600 (mix OYH)

S. No	Mix Design	Water loss @7days (kg)				Water loss @14days (kg)				Water loss @28 days(kg)			
		1	2	3	Avg.	4	5	6	Avg.	7	8	9	Avg.
1	OYD	0.12	0.12	0.09	0.11	0.1	0.09	0.11	0.1	0.21	0.17	0.19	0.19
2	OYH 0.1	0.14	0.12	0.13	0.13	0.16	0.14	0.14	0.147	0.25	0.16	0.16	0.19
3	OYH 1.0	0.14	0.11	0.14	0.13	0.25	0.21	0.09	0.23	0.19	0.2	0.2	0.20
4	OYH 3.0	0.13	0.13	0.14	0.13	0.15	0.13	0.14	0.14	0.44	0.69	0.47	0.533

OBSERVATION:

From table 14 for lower grade concrete with high molecular weight PEG- 6000 it is observed that:

1) It is clear that 0% dosage of self-curing agent is losing less weight when compared to other dosage (0.1%, 1% and 3%) of S.C.A.
2) 3.0% dosage of S.C.A. shows higher weight loss when compared to other dosage.
3) 0.1 % dosage of S.C.A. shows lower weight loss when compared to other dosage.

10 COMPARISON OF WATER RETENTIVITY TEST RESULT OF OYL, OYH AND OYW

A comparison is done for water lose test results of low concrete between indoor curing of different dosage of internal curing agent of higher and lower molecular weight PEG and wet curing of normal concrete and it is shown in Table 15.

Table 15 Comparison of water retentivity test results for Lower grade concrete between OYL, OYH and OYW.

S No:	Mix Design	Water lose@7days(kg)				Water lose@14days(kg)				Water lose@28days(kg)			
		1	2	3	Avg.	4	5	6	Avg.	7	8	9	Avg.
1	OYW	0.1	0.09	0.09	0.093	0.08	0.05	0.07	0.067	0.1	0.02	0.07	0.063
2	OYD	-0.12	-0.12	-0.09	-0.11	-0.1	-0.09	-0.11	-0.1	-0.21	-0.17	-0.19	-0.19
3	OYL 0.1	-0.13	-0.1	-0.13	-0.12	-0.23	-0.08	-0.11	-0.14	-0.16	-0.13	-0.14	-0.145
4	OYL 1.0	-0.05	-0.06	-0.07	-0.06	-0.12	-0.10	-0.12	-0.11	-0.18	-0.14	-0.14	-0.153
5	OYL 3.0	-0.15	-0.14	-0.16	-0.15	-0.10	-0.08	-0.13	-0.10	-0.33	-0.31	-0.32	-0.32
6	OYH 0.1	-0.14	-0.12	-0.13	-0.13-	-0.16	-0.14	-0.14	-0.147	-0.25	-0.16	-0.16	-0.19
7	OYH 1.0	-0.14	-0.11	-0.14	-0.13	-0.25	-0.21	-0.09	-0.23	-0.19	-0.2	-0.2	-0.20
8	OYH 0.3	-0.13	-0.13	-0.14	-0.13	-0.15	-0.13	-0.14	-0.14	0.44	0.69	0.47	-0.533

11 CONCLUSION:

From Table 15 for low grade concrete of indoor curing with different dosage of internal curing agent of higher and lower molecular weight PEG and wet curing of normal concrete it is observed that:

1) In both lower and higher molecular weight PEG lower dosage (0.1%) losing less weight.
2) In both lower and higher molecular weight PEG higher dosage (3%) losing more weight.
3) In both lower and higher molecular weight PEG 0% dosage losing less weight compare to 3% dosage
4) It is clear that 0% dosage of wet curing absorbing water and there is no losing of weight.
5) The lower molecular weight PEG losing less weight compare to higher molecular weight PEG.

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