Compressive strength of internal cured concrete using polyethylene glycol

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Abstract: The compressive strength of concrete is one of the most important and useful properties of concrete. In the most structural applications concrete is employed primarily to resist compressive stresses. Compressive strength is also used as a qualitative measure for other properties of hardened concrete. The compressive strength of concrete is influenced by water cement ratio, aggregate cement ratio, properties of aggregates and curing, mixing and testing conditions.

In this article experimental investigation is performed to find the compressive strength 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 internal curing agent.

Cube specimens 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 compressive strength of all specimens are find out and the observations are compared with each other's.

Key words: compressive strength, higher molecular weight PEG-6000, internal curing, lower molecular weight PEG-600, polyethylene glycol (PEG), self-curing agent.

1. General

The experimental program is designed to investigate the strength 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	Materials	Normal concrete		(600 MW*)			(6000 MW*)		
		Moisture Cured	Air Cured	0.1% PEG	1% PEG	3% PEG	0.1% PEG	1% PEG	3% PEG
	Nomenclature	OYW	OYD	OYL0.1	OYL1	OYL3	OYH0.1	OYH1	OYH3
7 Days cured		3	3	3	3	3	3	3	3
14 Days cured		3	3	3	3	3	3	3	3
28 Days cured		3	3	3	3	3	3	3	3
Total		9	9	9	9	9	9	9	9
Grand Total		72							

*MW- Molecular Weight.

2. 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.

Physical properties of coarse and fine aggregate.			Physical properties of cement	
Materials	Fine aggregate	Coarse aggregate	Cement	
Fineness modulus	2.86	6.64	Specific gravity	3.14
Bulk density	1.37 gm/cc	1.404 gm/cc	Initials setting time	75min
Specific gravity	2.48	2.69	Final setting time	215min

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 arewax like solids. 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 [Ahmad Hashimi S.S.,2011].

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 MethodIS 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 concrete

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. Compressive strength

The cube specimens will be test on compression testing machine. Compressive strength was found out as per IS 516-1959. The compressive strength test was conducted after 7, 14 and 28 days of curing. Standard cast iron moulds of dimensions 150x 150x 150mm were used to cast the specimen. The bearing surface of machine must be wiped off clean and looses other sand or other material removed from the surface of the specimen. The specimen was placed in machine in such a manner the load to be applied to opposite sides of the cubes as casted that is, not top and bottom. The axis of the specimen was carefully aligned at the center of loading frame. The load applied will increase 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 cube specimen must be recorded. The average compressive strengths of all the cubes to be taken. The capacity of the compressive strength testing method used was 3000KN. The compressive strength testing machine as shown to below.

8. Compressive strength test result for mix OYL

Compressive strength test results for low grade concrete with low molecular weight PEG -600(OYL) of all samples are shown in the Table 5:

Table 5Compressive strength test results for mix OYL

S. No	Mix Design	Crushing load @7days(kg)					Crushing load @14days(kg)					Crushing load @28days(kg)				
		1	2	3	Avg.	Comp MPa	4	5	6	Avg.	Comp MPa	7	8	9	Avg.	Comp MPa
1	OYW	510	730	450	480	21.3	610	670	660	665	29.5	690	700	750	725	33.2

2	OYD	470	740	560	515	23	490	580	660	577	25.6	450	690	720	700	31.1
3	OYL0.1	490	580	480	532	23.6	370	620	610	615	27.3	450	710	760	735	32.7
4	OYL 1.0	340	390	520	417	18.5	580	620	430	600	26.7	460	680	700	690	30.7
5	OYL 3.0	420	390	560	457	20.3	600	600	690	645	28.7	455	640	550	695	30.9

OBSERVATION:

As per the Table 5the following observations on compressive strength test results low grade concrete with lower molecular weight PEG 600 are made:

1) The compressive strength of 0.1% of S.C.A is more when compare to other dosages.
2) The strength of the specimen without S.C.A also showed better compressive strength when compared to 1% and 3% of S.C.A.
3) The specimen with 0%0.1%,3% dosage showed better performance when compared to specimen with 1%.

9. COMPRESSIVE STRENGTH RESULT FOR MIX OYH

Compressive strength test results for low grade concrete with higher molecular weight PEG-600(OYH) of all samples is shown in the Table 6:

Table 6 Compressive strength test result for mix OYH

S/ No	Mix Design	Crushing load @7days(kg)					Crushing load @14days(kg)					Crushing load @28days(kg)				
		1	2	3	Avg.	Comp (MPa)	4	5	6	Avg.	Comp (MPa)	7	8	9	Avg.	Comp (MPa)
1	OYW	510	730	450	480	21.3	610	670	660	665	29.5	690	700	750	725	32.2
2	OYD	470	740	560	515	23	490	580	660	577	25.6	450	690	720	700	32.1
3	OYL 0.1	450	330	390	390	17.3	690	630	390	660	29.3	735	700	620	685	30.7
4	OYL 1.0	260	360	450	405	18	590	640	460	615	27.3	280	715	645	680	30.2
5	OYL 3.0	390	200	430	410	18.2	630	480	710	610	27.1	620	650	700	675	30

Observation:

As per the Table 6 the following observations on compressive strength test results low grade concrete with higher molecular weight PEG 600 are made:

1) The compressive strength specimen without S.C.A is more when compare to other dosages.
2) The compressive strength of specimen with 0.1% PEG showed more strength then other dosages (1%and 3%)

10. COMPARISON OF COMPRESSIVE STRENGTH OF LOW GRADE CONCRETE (OY MIX)

Comparison of compressive strength of low grade concrete (OY mix) for indoor curing of all different percentages of lower and higher molecular weight PEG and wet curing is shown in Table 7.

Table 7 Comparison of compressive strength test results of OY mix in different curing

S/No:	Mix Design	Crushing load @7days(kg)					Crushing load @14days(kg)					Crushing load @28days(kg)				
		1	2	3	Avg.	Comp MPa	4	5	6	Avg.	Comp MPa	7	8	9	Avg.	Comp MPa
1	OYW	510	730	450	480	21.3	610	670	660	665	29.5	690	700	750	725	32.2
2	OYD	470	740	560	515	23	490	580	660	577	25.6	450	690	720	700	31.1
3	OYL 0.1	490	580	480	532	23.6	370	620	610	615	27.3	450	710	760	735	32.7
4	OYL 1.0	340	390	520	417	18.5	580	620	430	600	26.7	460	680	700	690	30.7
5	OYL 3.0	420	390	560	457	20.3	600	600	690	645	28.7	455	740	550	695	30.9
6	OYH 0.1	450	330	390	390	17.3	690	630	390	660	29.3	735	700	620	685	30.7
7	OYH 1.0	260	360	450	405	18	590	640	460	615	27.3	280	715	645	680	30.2
8	OYH 0.3	390	200	430	410	18.2	630	480	710	610	27.1	620	650	700	675	30

11. CONCLUSION:

As per the Table 7 the following observations for comparison compressive strength test results of low grade concrete with higher and lower molecular weight PEG & conventional curing are made:

1) 0.1% lower molecular weight PEG shown better strength when compare to all other.
2) Compressive strength in wet curing showed better results that in indoor with OYL0.1.
3) 0.%S.C.A shown better strength in both indoor % conventional Curing.
4) 3% higher molecular weight PEG shown strength lesser strength when compare to all other

12. REFERENCES

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