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Factors Affecting Water Absorption in Hardened Concrete

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***Abstract*-Concrete can absorb moisture because of its porous nature. When ambient relative humidity is high, concrete will absorb moisture from the air. When relative humidity is low, water will evaporate from the concrete in to the ambient environment. This absorption of moisture by concrete causes dampness in roof slabs and when concrete is more porous dampness will be higher. Porosity in concrete especially in roof slabs is caused by following several factors; Poor mix proportion, Poor compaction and laying, Curing regime, Poor construction practices.And dampness in roof slab which is primarily absorption of moisture by concrete is caused by following factors; Porosity of concrete, Relative Humidity, Surface area of element, Exposure period of wetting and drying.**

***Keywords*- Water Absorption, Dampness, Hardened concrete properties, curing regime, delayed curing.**

I.INTRODUCTION

Dampness in concrete slabs can be greatly related to the water absorption of concrete. Data available in BS 1881-122:2011 give test procedure for finding water absorption in hardened concrete. Environment has a significant effect on water absorption of concrete.

A detailed analysis is presented to study the relationship of water absorption with curing regime, mix proportions and water content. The temperature of curing and duration of moist curing are key factors for proper pore structure.

Effectiveness of initial curing becomes more important when mineral admixtures like fly ash are used in concrete. However effect of curing period, regime and water content alone analyzed here.

The main objective of this work is to study the effect of curing, mix proportion and workability of concrete on water absorption of hardened concrete.

II. MATERIALS

Ramco Supercrete:
Portland Pozzolona Cement was used for this experimental study. Physical and chemical analysis of cement is given in Table 1.

Crushed stone sand of Zone III gradation and crushed broken angular aggregates were used as fine and coarse aggregates respectively. Nominal maximum size of aggregate used is 20mm. Sieve analysis and material properties of fine and coarse aggregates are given in Table 2, Table 3 & Table 4.

Table 1. Chemical Properties of cement.

S.No	Chemical Composition	(%ByWeight)
1	CaO	51.52
2	SiO2	28.58
3	Al2O3	7.53
4	Fe2O3	5.40
5	Na2O	0.283
6	K2O	0.623
7	MgO	1.33
8	Cl	0.0289
9	TiO2	0.473
10	SO3	2.68
11	LOI	1.19
12	IR	19.19

Table 2. Sieve Analysis of CSS.

S.No	SieveSizeinmm	%Passing
1	4.75	100
2	2.36	89.86
3	1.18	70.58
4	0.60	54.02
5	0.30	37.65
6	0.15	23.69

Table 3. Sieve Analysis of 20mm.

S.No	SieveSizeinmm	%Passing
1	25	100
2	20	90.17
3	10	0.33
4	4.75	0.13

Table 4. Material Properties of CSS and 20mm.

Property	20mm	CSS
Fineness Modulus	7.09	2.24
Specific Gravity	2.74	2.50
Water Absorption	0.51 %	2.56 %
Type of aggregate	Single Sized	Fine Sand (Zone III)
Loose Bulk Density	1531 kg/m3	1600 kg/m3
Rodded Bulk Density	1687 kg/m3	1777 kg/m3
Void Percent	44 %	36 %

III. METHODS OF TESTING

Three different mix proportions were adopted as follows;

Mix 1:- (1:1.5:3), Mix 2:- (1:2:3) & Mix 3 :-(1:2:4).

In order to replicate site conditions, cubes were subjected to different curing regimes as follows,

- Curing 1: Specimens were submerged in water at 27 +/- 2o Cafter demolding until testing.
- Curing 2: Specimens were submerged in water at 27+/-2oC for 7days after demoulding and subsequent -tly placed in air conditions 27 +/- 2o C and RH 60+/- 5%.
- Curing 3: Specimens were submerged in water at 27+/-2oC for 14day after demoulding and subsequent -tly placed in air conditions 27 +/- 2o C and RH 60+/- 5%.
- Curing 4: Specimens were initially left to dry for 24hours after demolding and subsequently submerged in water until testing. Here curing was delayed by 48hoursi.e. curing started after 48hrs from water addition time.

Different workability conditions maintained at the time of casting cubes are as follows;

- Slump 1: 110mm to 130mm
- Slump 2: 140mm to 160mm
- Slump 3: 170mm to 180mm

Concrete cubes of 100mm x 100mm x 100mm were cast to determine the water absorption of concrete. All specimens were cast in steel molds and compacted using vibrating table.

A total of 108 numbers of 100mm cubes were cast and tested for water absorption at the age of 27days to 31days as per NBN B 15- 215: 2018.

NBN B 15-215 gives procedure for testing water absorption in hardened concrete by immersion method.

At the age of 27days specimens were placed inside hot air oven at 100o C for 72hours. Specimens were then cooled for 24hours in air tight container.

After cooling period specimens were weighed and immersed in portable water for 30minutes at 27 +/- 2o C. Weight of specimen after immersion was measured and weight of water absorbed was calculated by detecting dry weight.

IV. RESULTS AND ANALYSIS

1. Effect of Curing Period:

Specimens were subjected to different curing period and tested for water absorption at the age between 27days to 31days. Results are given in Table 5 & Figure 1.

Table 5. Effect of curing period on Water Absorption.

S.No	Mix Proportion	Curing Period	Water Absorption(%)
1	1:1.5:3	27days	2.94
2	1:1.5:3	14days	4.00
3	1:1.5:3	7days	4.33
4	1:2:3	27days	2.15
5	1:2:3	14days	3.45
6	1:2:3	7days	3.67
7	1:2:4	27days	3.15
8	1:2:4	14days	3.89
9	1:2:4	7days	4.13

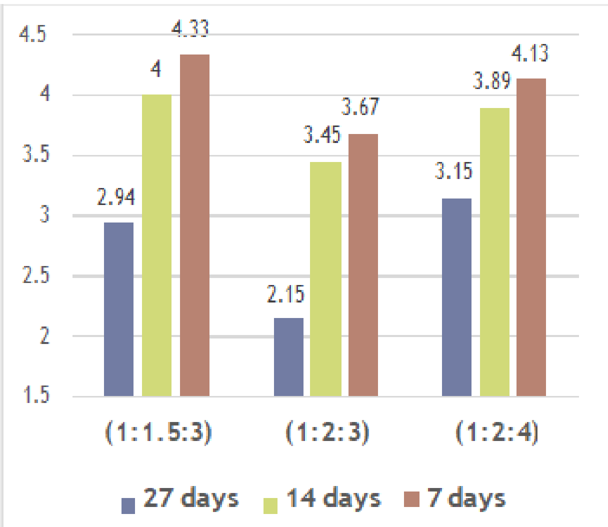

Fig 1. Effect of Curing Period on Water Absorption.

In all cases, specimens subjected to 27days curing has lowest water absorption compared to specimens subjected to 14days and 7days curing period.

Results of water absorption show that when specimens are cured for longer period porosity is reducing drastically.

2. Effect of Delayed Curing at Different Workability:
Specimens were left uncured for initial 48hours and then immersed in water until testing (up to 27days). Since early stages of curing is skipped, pore structure of concrete is greatly affected resulted in the higher porosity in concrete. Results are given in Table 6 & Figure 2.

Table 6. Effect of delayed curing on Water Absorption at 130mm Slump.

Mix	WaterAbsorption (%)		%Increase in WaterAbsorption
	Normal Curing	Delayed Curing	
1:1.5:3	2.94	4.18	42%
1:2:3	2.15	3.52	64%
1:2:4	3.15	4.14	31%

From Table 6, it is evident that delay in curing at early stages of concrete caused increase in porosity by 64% and 31% in mixes 1:2:3 and1:2:4 respectively.

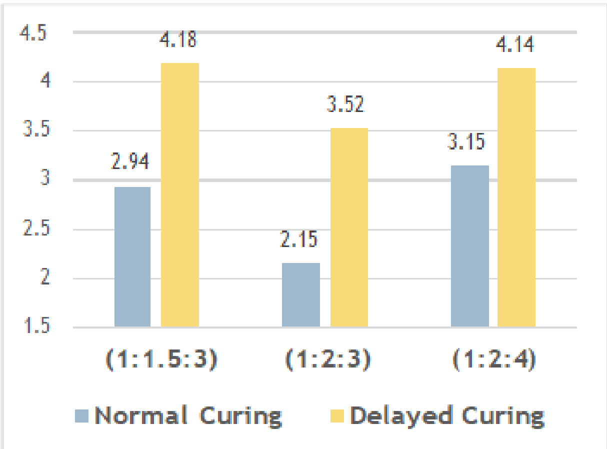

Fig 2. Effect of delayed curing on Water Absorption at 130mm Slump.

Table 7. Effect of delayed curing on Water Absorption at 160mm Slump.

Mix	WaterAbsorption(%)		%Increase in WaterAbsorption
	Normal Curing	Delayed Curing	
1:1.5:3	3.01	4.75	58%
1:2:3	2.23	4.06	82%
1:2:4	3.65	5.91	62%

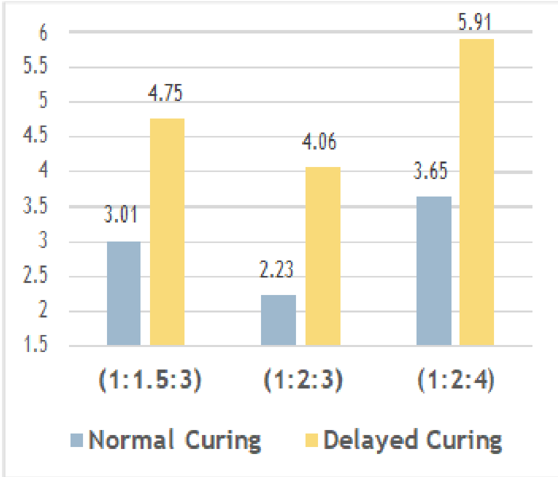

Fig 3. Effect of delayed curing on Water Absorption at 160mm Slump.

Table 8. Effect of delayed curing on Water Absorption at 190mm Slump.

Mix	WaterAbsorption (%)		%Increase in WaterAbsorption
	Normal Curing	Delayed Curing	
1:1.5:3	3.45	5.12	48%
1:2:3	2.83	5.04	78%
1:2:4	4.61	6.42	39%

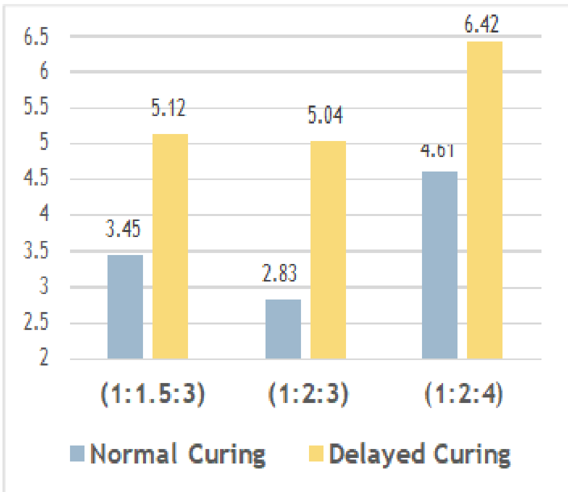

Fig 4. Effect of delayed curing on Water Absorption at 190mm Slump.

Percentage increase in water absorption is higher when slump was maintained at 160mm. And percentage increase in water absorption is lower when slump was maintained at 130mm. When specimens were casted at 190mm slump, delayed curing effect is less because of higher water content sufficient enough to continue hydration.

3. Effect of Workability:
Specimens were cast in 3 different work ability in each mix proportions. Specimens were cured for 27days submerged in water and tested for water absorption at age between 27days to 31days. Higher workability resulted in higher water absorption.

Table 9. Effect of workability on Water Absorption.

S.No	Mix Proportion	Slump	Water Absorption(%)
1	1:1.5:3	130mm	2.94
2	1:1.5:3	160mm	3.01
3	1:1.5:3	190mm	3.45
4	1:2:3	110mm	2.15
5	1:2:3	145mm	2.23
6	1:2:3	180mm	2.83
7	1:2:4	100mm	3.15
8	1:2:4	130mm	3.65
9	1:2:4	170mm	4.61

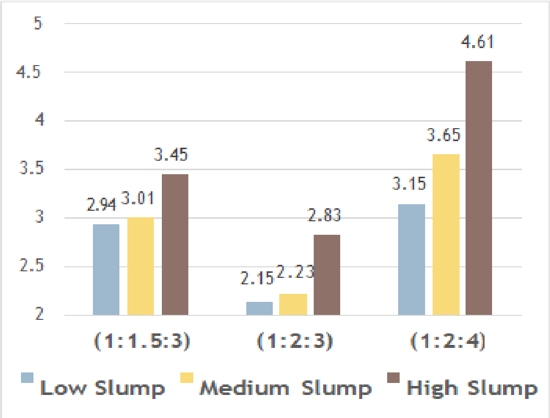

Fig 5. Effect of Workability on Water Absorption.

V. CONCLUSION

For different curing period water absorption in hardened concrete varies. Lower values being observed when concrete was cured for longer period.Early age curing is found to be more important. When early curing of concrete was skipped, water absorption in hardened concrete increased by more than 50% in many cases.Different mix proportions have different particle packing and matrix density varies accordingly. Thus water absorption and porosity also vary with mix proportion.Best particle packing which forms denser matrix has reduced porosity and water absorption.

For each source of aggregates and each gradation of aggregates, it is necessary to find particle packing. Mix proportion should be chosen based on particle packing resulting in denser matrix. Workability or water content in fresh concrete also influences the water absorption in hardened concrete.

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