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Effect of Curing Methods on the Compressive Strength of Concrete

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Abstract

Different methods are usually adopted to cure concrete. Concrete strength partly depends on the method and duration of curing. The structural use of concrete depends largely on its strength, especially compressive strength. This study uses three curing methods to determine their effects on the compressive strength and density of concrete. These methods are immersion of concrete cubes in curing tank (Ponding), covering of cubes with wet rug (Continuous wetting) and the use of polythene sheet (Water-barrier). Laboratory experimental procedures were adopted. A total of sixty (60) cubes were cast with 1:2:4 mix ratios. The cubes were cured in the laboratory at room temperature. The results showed that the average compressive strength values for 28-day curing vary with curing methods. The cubes cured by immersion have an average compressive strength of 29.7 N/mm^2 while the ones cured by wet rug and polythene sheet have average compressive strength of 26.8 and 24.7 N/mm^2 respectively. The traditional curing by immersion appeared to be the best method to achieve desired concrete strength.

Key Words: Curing Method, Compressive Strength, Hydration, Mix Ratio

1. INTRODUCTION

Concrete is good in resisting compressive load. It is the most widely used material in construction. It is a heterogonous material obtained by mixing cement, aggregates, water and sometimes admixtures in the required proportion (Mehta and Monteiro, 1993). The use of concrete in civil engineering structures such as building, pavement, bridge, etc. cannot be overemphasized. Concrete curing enhances gain in strength of concrete. It is the process of keeping concrete element in contact with water for a period of time. The necessity of curing arises from the fact that hydration of cement can take place only in water filled capillaries. Hydration leads to strength development in concrete. This is why loss of water from fresh concrete must be prevented and ingress of water into the concrete must be allowed for complete and proper strength developments (Neville, 1996). Neville (1996) also defines Curing as procedures used for promoting the hydration of cement, and consists of a control of temperature and of the moisture movement from and into the concrete. Apart from hardening, curing also minimizes shrinkage and cracking of concrete (lambertcorporation, 1999). Gambir (1986), defines curing as process of creation of an environment during a relatively short period immediately after placing and compaction of concrete, favorable to setting and hardening of concrete.

A proper curing maintains a suitable warm and moist environment for the developments of hydration products, and thus reduces the porosity in the hydrated cement paste and increases the density of microstructure in concrete. The hydration products extends from the surfaces of cement grains, and the volume of pores decreases due to proper curing under appropriate temperature and moisture. Proper curing greatly reduces drying shrinkage of concrete and makes it resistant to physical or chemical attacks in aggressive environments. Therefore, a suitable curing method is essential in order to produce strong and durable concrete (Klieger, 1956). The rate of hydration is fast at the beginning but continues over a very long time at a decreasing rate. The quantity of the product of hydration and consequently the amount of gel formed depends upon the extent of hydration. The curing allows the hydration to be continued, giving rise to gain in concrete strength. In fact, once curing stops the concrete dries out and the strength gain stops (Murdok, 1995).

Broadly, concrete curing processes can be classified into the following categories:

I. Methods that maintain the presence of mixing water in the concrete during the early hardening period or The Water adding technique. These include ponding or immersion, spraying or fogging, and saturated wet coverings. These methods afford some cooling through evaporation, which is beneficial in hot weather (http://www.ce.memphis.edu).

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II. Methods that reduce the loss of mixing water from the surface of the concrete, the method is also known as “water retaining technique”. This can be done by covering the concrete with impervious paper or polythene sheets, or by applying membrane-forming curing compounds (http://www.ce.memphis.edu).

III. Methods that accelerate strength gain by supplying heat and additional moisture to the concrete. This is usually accomplished with live steam, heating coils, or electrically heated forms or pads (Klieger, 1956).

IV. Dry-Air curing: dry-air curing is a curing method wherein the concrete cubes are left in open air to be cured at room temperature. Experimental results indicate that Dry-air curing is not an efficient method to achieve good hardened properties of concrete (Ho, 1989).

V. Steam curing and hot water curing is sometimes adopted. In steam curing the temperature of steam should be restricted to a maximum of 75°C as in the absence of proper humidity (about 90%), concrete may dry too soon. In hot water curing,, temperature may be raised to any limit. At this raised temperature, the development of strength is about 70% of 28-day strength after 4 to 5 hours. In both cases, the temperature should be fully controlled to avoid non-uniformity. The concrete should be prevented from rapid drying and cooling which would form cracks (Dias, et al, 1990).

The method or combination of methods chosen depends on factors such as availability of curing materials, size, shape, and age of concrete, production facilities (in place or in a plant), esthetic appearance, and economics. As a result, curing often involves a series of procedures used at a particular time as concrete ages. The timing and use of each curing method depends on the degree of hardening of the concrete needed to prevent a particular procedure from damaging the concrete surface (ACI 308, 1997). Price (1951) showed that the 28-day compressive strength of concrete cube specimens, continuously moisture cured, had compressive strength 20% higher than those of uncured cubes.

It is a known fact that many other factors affect the development of strength of concrete and consequently its durability other than curing or curing technique applied. These factors include quality and quantity of cement used in the mix, grading of aggregates, maximum nominal size, shape and surface texture of

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aggregate, others include water/cement ratios, degree of compaction , and the presence or otherwise of clayey particles and organic matter in the mix ((Price, 1951). Bushlaibi (2012) studied the effect of curing methods on the compressive strength of silica fume high strength concrete. Five curing conditions were used, water curing (for 28 days), no curing, sprinkle curing (sprinkling two times in a day for seven days), plastic curing (sprinkling two times in a day with plastic cover sheet for seven days) and burlap curing (sprinkling two times in a day with burlap cover for seven days), and concluded as follows:

i. The compressive strength of the silica fume high strength concrete, as in normal strength concrete, is directly related to curing duration.

ii. The adverse effect on the development of concrete compressive strength increases with increasing temperature and test duration.

iii. At curing ages of 28 days and beyond, the strength reduction reaches up to 12% of the control strength in some curing conditions.

iv. Silica fume high strength concrete is adversely affected by hot dry environment in a manner similar to the way normal strength concrete is adversely affected by excessive moisture evaporation and badly dispersed hydration products, resulting from high curing temperatures.

2. MATERIALS AND METHODS

2.1 Materials

The main materials used in this study are crushed granite and River sand aggregates, Ordinary Portland cement (OPC) and portable water. The materials were assessed at Makurdi, Benue State, Nigeria.

2.2 Methods

2.2.1 Sieve Analysis

The sieve analysis of the crushed granite and the River sand were carried out as prescribed in the British Standard (BS) 812: section 103.1: 1985.

2.2.2 **The Concrete**

The concrete mix ratios of 1:2:4 at 0.51 water-cement ratio was used for all the concrete test cubes. The fresh concrete was produced by manually mixing sand, cement and the crushed granite with the specified quantity of water. It was cast into 150mm cube in three layers. 60 concrete cubes were cast in all.

2.2.3. **Curing**

The concrete cubes were demoulded after 24 hours of casting. 20 of the cube specimens were immersed in water in a curing tank for 28 days. Another set of 20 cubes were arranged in one layer on concrete floor and then covered with wet rug. The rug was sprayed with water morning and evening for 28 days. The remaining 20 cubes were arranged on two layers on polythene sheet and the sheet wrapped round the cubes such that no part of cube surface was left exposed. The cubes were left in this condition for 28 days.

2.2.4 **Density**

On the 28th day, all the cubes were removed from curing to be tested for compressive strength. Each cube was surface-dried and weighed (M).

$$\text{Density} = \frac{M}{V} \qquad 1$$

V is volume of cube

2.2.5 **Compressive Strength Test**

On the 28th day, all the cubes were removed from curing to be tested for compressive strength. The test was carried out as prescribed in BS 1881: part 116: 1983.

$$\text{Compressive strength} = \frac{Crushing\ Load}{Ares}\ (\text{N/mm}^2)$$

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3. RESULTS AND DISCUSSION

3.1 Aggregate Grading

The results of sieve analysis of the River sand and the crushed granite aggregates are shown in Figures 1 and 2 respectively. The sand is uniformly graded while the crushed granite aggregate is well graded. The maximum size of the crushed granite is 20 mm.

3.2 Density and Compressive Strength of the Cubes

The density and compressive strength results for ponding, continuous wetting and polythene sheet methods are shown in tables 1, 2 and 3 respectively. The mean compressive strength of the cubes cured by ponding method is 29.7 N/mm^2 while the values from wetting and polythene methods are 26.8 and 24.7 N/mm^2 respectively. The mean compressive strength achieved from ponding method is 9.8 and 16.8 percent higher than the strengths gained from wetting and polythene methods respectively. This implies that the traditional method of curing by immersion of concrete in water is superior to the other two methods. However, due to large size of some concrete elements, the use of the other two methods of curing could still be good alternative.

Density is directly related to strength of concrete. The average density of the concrete cubes cured by ponding is greater than the other methods of rug wetting and polythene cover.

Table 1: Density and Compressive Strength of the Cubes at 28-Day by Complete Immersion (Ponding) Curing Method.

Sample No.	Mass (kg)	Density (Kg/m^3)	Failure Load (KN)	Compressive Strength (N/mm^2)
1	9.488	2811	740	32.9
2	8.127	2412	760	33.8
3	8.060	2390	600	26.7
4	8.814	2612	660	29.3
5	8.220	2443	784	34.8
6	9.187	2721	600	26.7
7	8.152	2422	580	25.8
8	8.541	2532	600	26.7
9	8.069	2390	680	30.2
10	8.463	2512	680	30.2
11	8.100	2403	720	32.0
12	8.428	2490	740	32.9
13	8.720	2582	680	30.2
14	8.825	2613	640	28.4
15	8.180	2431	740	32.9
16	8.650	2563	600	26.7
17	8.490	2521	620	27.6
18	9.100	2690	608	27.0
19	8.472	2513	700	31.1
20	8.310	2462	640	28.4

Table 2: Compressive Strength of the Cubes at 28-Day by Rug Wetting Curing Method

Sample No.	Mass (kg)	Density (Kg/m^3)	Failure Load	Compressive Strength

			(KN)	(N/mm^2)
1	8.240	2440	500	22.2
2	8.574	2543	520	23.1
3	8.047	2381	520	23.1
4	8.369	2482	700	31.1
5	8.766	2603	540	24.0
6	7.892	2431	720	32.0
7	8.465	2511	700	31.1
8	8.466	2512	680	30.2
9	8.500	2520	580	25.8
10	8.420	2490	600	26.7
11	8.476	2512	520	23.1
12	8.319	2461	708	31.5
13	8.720	2580	516	22.9
14	8.610	2550	680	30.2
15	7.985	2372	548	24.4
16	8.150	2410	520	23.1
17	8.750	2591	700	31.1
18	8.222	2441	660	29.3
19	8.410	2490	560	24.9
20	8.075	2393	600	26.7

Table 3: Compressive Strength of the Cubes at 28-Day by Polythene Curing Method

Sample No.	Mass (kg)	Density (Kg/m^3)	Failure Load	Compressive Strength (N/mm^2)

			(KN)	
1	7.964	2362	560	24.9
2	9.234	2742	500	22.2
3	8.284	2450	520	23.1
4	8.369	2482	700	31.1
5	8.766	2600	540	24.0
6	7.892	2342	480	21.3
7	8.728	2582	500	22.2
8	8.227	2442	664	29.5
9	8.103	2400	580	25.8
10	8.257	2453	508	25.6
11	8.334	2470	580	25.8
12	8.428	2490	480	22.6
13	8.947	2652	588	26.1
14	9.127	2700	648	28.8
15	8.220	2440	516	22.9
16	8.350	2472	488	21.7
17	7.910	2340	520	23.1
18	7.997	2373	660	29.3
19	8.620	2550	480	21.3
20	8.416	2491	508	22.6

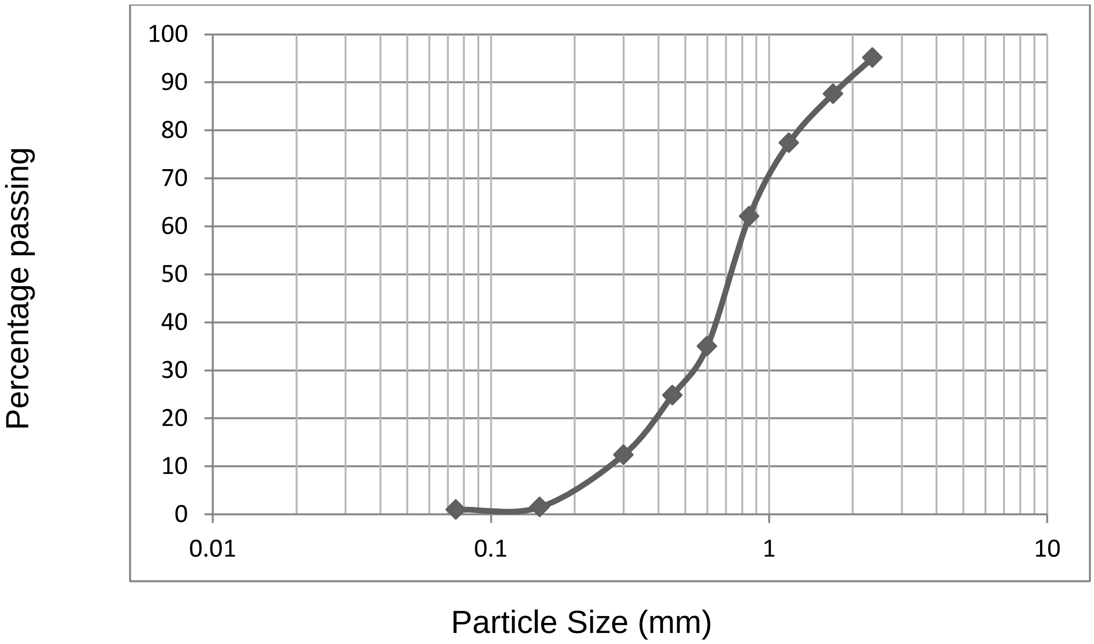

Figure 1: Grading curve of the River sand

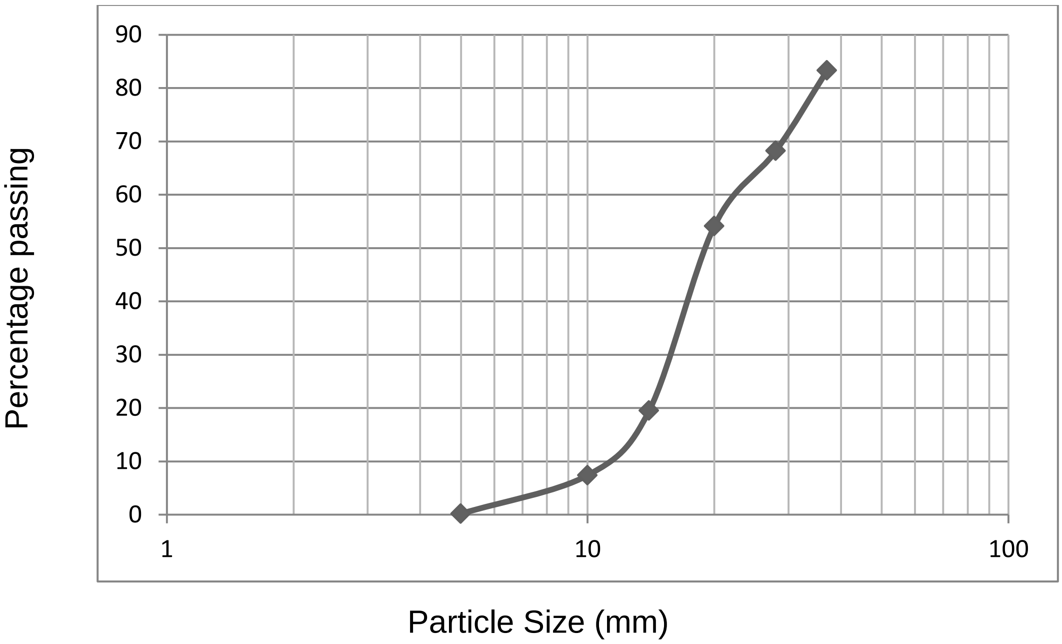

Figure 2: The Grading Curve of the Crushed Granite

4. CONCLUSION

Curing of concrete is important in achieving its desired strength. Many methods are employed in curing; the study examined three of these methods. The structural use of concrete depends on its strength. It is therefore, necessary to pay proper attention to the process of hardening of concrete.

This research uses three curing methods to determine their effects on the compressive strength and density of concrete. These methods are immersion of concrete cubes in curing tank (Ponding), covering of cubes with wet rug (Continuous wetting) and the use of polythene sheet (Water-barrier). Laboratory experimental procedures were used. A total of sixty (60) cubes were cast with 1:2:4 mix ratios at 0.51 water-cement ratio.

The results showed that the average compressive strength values for 28-day vary with curing methods. The mean compressive strength realized from ponding method is 9.8 and 16.8 percent higher than the strengths gained from wetting and polythene methods respectively. This implies that the traditional curing by immersion appeared to be the best method to achieve desired concrete strength. It should be noted that the other two methods have better advantage of accommodating larger-size concrete elements.

REFERENCES

American Concrete Institute (ACI) 308-1997, Standard Practice for Curing Concrete

British Standard (BS) 1881: part 118: 1983; Method for determination of compressive strength of cubes

BS 812: part 103.1: 1985; Sieve analysis

Bushlaibi (2012); Curing Effect on Concrete Properties, htt:/www.concretecuring.light.edu; assessed in September 22, 2015 at 19 hours GMT.

Dias, W. P., Khoury, G. A. and Sullivan, P. J. (1990); Mechanical Properties of Hardened Cement Paste Exposed to Temperature Up to 700 C. ACI Material Journal, 87(2); 160-166

Gambir M. L. (1986); Concrete Technology, Third Edition. Tata Mcgraw-Hill Publishing Company Limited

Ho, D, W. (1989); Influence of humidity and Curing Time on the Quality of Concrete. Cement and Concrete Research, 19(3), 457-464

Klieger, P.H. (1958); Effect of Mixing and Curing on Concrete Strength. ACI Journal, Proceeding, 4(12); 1063-1081.

Kosmatka (2003); Design and Control of Concrete Mixtures. Portland Cement Association, Skokie, Iuinois

LambertCorporation (1999); Civil Engineering Materials, Fifth Edition. Palgrave Houndmills Ltd, Hampshire New York

Mehta and Monteiro (1993); Concrete Structure, Properties and Materials; Prentice-Hall, Englewood Cliffs

Murdock, L.S. (1995); Concrete Materials and Practice; Roland Ph. Ltd,

Neville A.M. (1996); Properties of concrete, Fifth Edition, Wesley Longman Ltd, London

Price, W. (1951); Factors Influencing Concrete Strength, American Concrete Institute Journal, Vol. 47, 417-422

htt:/www.ce.memphis.edu; Curing Methods in Concrete. It was assessed in April 5, 2016 at 08 hours GMT.