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IMPROVING THE COMPRESSIVE STRENGTH OF CONCRETE BY CURING IN WATER/LIME SOLUTION

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ABSTRACT

There are various methods of curing concrete after casting. The most common method is curing by immersing in a water curing tank. This research involved the curing of concrete cubes in water/lime solution of water/lime as in the following proportions: 100%0%, 80%20%, 60%40% and 40%60%. 108 concrete cubes, with equal numbers of 36 each were cast at water/cement ratio of 0.4. 0.5and 0.6 for the 4Nos water/lime curing medium. The mix ratio used for the experiment was 1:2:4. The concrete cubes were crushed after 7, 14, and 28 days respectively to determine their compressive strength. The 100% water and 0% lime solution was used as the control curing medium for all the water/cement ratios. There is a general increase in the compressive strength of the concrete cubes at 0.4, 0.5 and 0.6 at 7, 14 and 28 days curing periods as the quantity of lime in the curing solution was increasing. The optimum compressive strength was obtained at 40%60% water/lime curing solution for all water/cement ratios and for all curing ages. The percentage increase at 7, 14 and 28 days was 52%, 20% and 22% at 0.4 water/cement ratio, which had the highest compressive strength. At 0.5 water/cement ratio, the percentage increase in compressive strength was 35%, 7% and 20% at 7, 14 and 28 days respectively, while at 0.6 water/cement ratio the percentage increase in compressive strength was 60%, 19% and 29%.

Keywords: compressive strength, concrete, curing, lime/water solution.

1. INTRODUCTION

Concrete is the single most extensively used man-made material in the world. It has been used for construction of buildings, bridges, dams, systems, etc One of the most important properties of concrete its compressive strength. It is a major indicator of its quality.

Curing is one process that facilitates the maximization of its potential strength. Lime has from previous observation and experiments improved the compressive strength of concrete over the years [1]. Curing ensures that concrete experiences continued hydration, leading to its continued strength gain [2]. Curing is also a process by which moisture loss is prevented at a particular temperature to enhance the hydration process of cement. The curing process not only increases the strength of the concrete and durability but also decreases the porosity of the concrete.

To ensure that there is satisfactory development of strength during hydration process, it is necessary to prevent moisture loss [3].

Aside accelerating the strength gain of concrete, curing also improves its durability, water-tightness, abrasion resistance and volumetric stability. The main categories of methods for curing concrete are: (a) those that maintain availability of water (b) those that minimize the loss of mixing water from concrete by sealing its exposed surface. The use of membrane-forming compounds, impervious paper or plastic sheets and leaving forms in place are methods used for preventing loss of water from concrete. It is advisable to use the methods of preventing loss of water for concrete with water-cementitious materials ratio of less than 0.4. This is because the concrete does not have sufficient water for hydration [4-6].

Raheem *et al* [7] investigated the effects of curing methods on density and compressive strength of concrete. The concrete used had a mix proportion of 1:2:4 (cement, sand, granite) and was cured for 3, 7 14 and 21 and 28 days. They discovered that the concrete cured using moist sand gave the highest 28 day compressive strength.

The effect of the global warming is that the world has continued to get warmer. One of the effects of global warming is that dry areas are becoming drier and wet areas are becoming wetter. It follows therefore that previous concrete curing methods may become less effective in aiding maximum attainable strength development of concrete. [1].

An increase in temperature increases the rate of exothermic hydration reaction and also the development of strength with time. [6]

When quick lime (chemically known as Calcium Oxide Cao) is mixed with water, calcium hydroxide (slaked lime) is formed. This reaction is highly exothermic and a large amount of heat is released in the process [8]. It follows therefore that curing concrete in lime/water solution will result in heating of the concrete resulting in high strength development.

The higher the initial curing temperature increases the rate of hydration process and early age strength. [9].

Akinwunmi and Gbadamosi [1] investigated the effect of curing conditions and curing period on his compressive strength development of plain concrete. They observed that those immersed in lime had the highest compressive strength compared to those covered with wet rug and air drying. This study investigated the potential improvement of compressive strength of concrete by curing in a water tank with various proportions of water/lime solution.

2. MATERIALS AND METHODS

2.1 MATERIALS

2.1.1 Cement

Ordinary Portland Cement (OPC) Grade (42.5) produced by DANGOTE CEMENT Plc. at Obajana plant in Nigeria was obtained from Mile 3, Building Materials section in Port Harcourt, Rivers State, Nigeria. The cement conformed to [10].

2.1.2 Powdery lime

The powdery lime used was purchased from chemical suppliers at Mile 3 Market in Port Harcourt.

2.1.3 Fine aggregate

Fine aggregate used was naturally occurring River sharp sand obtained from Imo River at Oyigbo, a suburb of Port Harcourt., Rivers State. It was dried and confirmed to be free from impurities. It conformed to [11]. The maximum size was 4.75mm.

2.1.4 Coarse aggregate

Coarse aggregate used is crushed angular and rough textured granite obtained from Ishiagu io Ebonyi State, South Eastern Nigeria. Maximum size was 20mm. It conformed to [12].

2.1.5 Water

Potable water was used was obtained from the Civil Engineering Laboratory of the Rivers State University, Nkpolu, Port Harcourt It conformed to [13].

2.2 METHOD

A total of 108 cubes were cast using a steel mould of 150mm X 150mm X 150mm. 36 cubes each were cast using water/cement ratio of 0.4, 0.5 and 0.6 respectively. The mix proportion for all the cubes was 1:2:4. 4 curing tanks, A, B, C and D respectively were filled with 100%0%, 80%20% 60%40%. and 40%/60%, water/lime content as the curing medium.

3 cubes each of the 0.4, 0.5 and 0.6 water/cement ratio were brought out from curing tanks A, B, C and D and crushed after 7, 14 and 28 days and the average compressive strengths were recorded. The compressive strength test was carried out in accordance with [14].

Table-1 shows the /lime/water contents of tanks A, B, C and D.

3. RESULTS AND DISCUSSIONS

Table-1 shows the water/lime content of the 4 Nos. curing tanks. The basis of the mixing is 50kg of water for all percentages of lime.

Table-1. Water/Lime content for the test (Basis is 50kg of water for all percentage of lime).

TANK	Water	% Powder lime	Lime proportion (kg)
A	100	0	0
B	80	20	10
C	60	40	20
D	40	60	30

Tables 2, 3 and 4 are the results of the compressive strength tests for 7, 14 and 28days for water/cement ratios of 0.4, 0.5 and 0.6 respectively.

Table-2. The compressive strength for 7 days, 14 days and 28 days for w/c of 0.4.

	Compressive strength (N/mm^2)			
Water/Lime ratio for curing (%)	**Days**	**7**	**14**	**28**
100/0		21	35	45
80/20		27	38	48
60/40		30	39	52
40/60		32	42	52

Table-3. The compressive strength for 7 days, 14 days and 28 days for w/c of 0.5.

	Compressive strength (N/mm^2)			
Water/Lime ratio for curing (%)	**Days**	**7**	**14**	**28**
100/0		10	18	24
80/20		12	19.5	26
60/40		14	21	28
40/60		16	21.5	31

Table-4. The compressive strength for 7 days, 14 days and 28 days for w/c of 0.6.

	Compressive strength (N/mm^2)			
Water/Lime ratio for curing (%)	**Days**	**7**	**14**	**28**
100/0		10	18	24
80/20		12	19.5	26
60/40		14	21	28
40/60		16	21.5	31

While Figures 1, 2 and 3 are the combined lots of compressive strength against the age of curing (days) for the various lime/water content in the curing tanks.

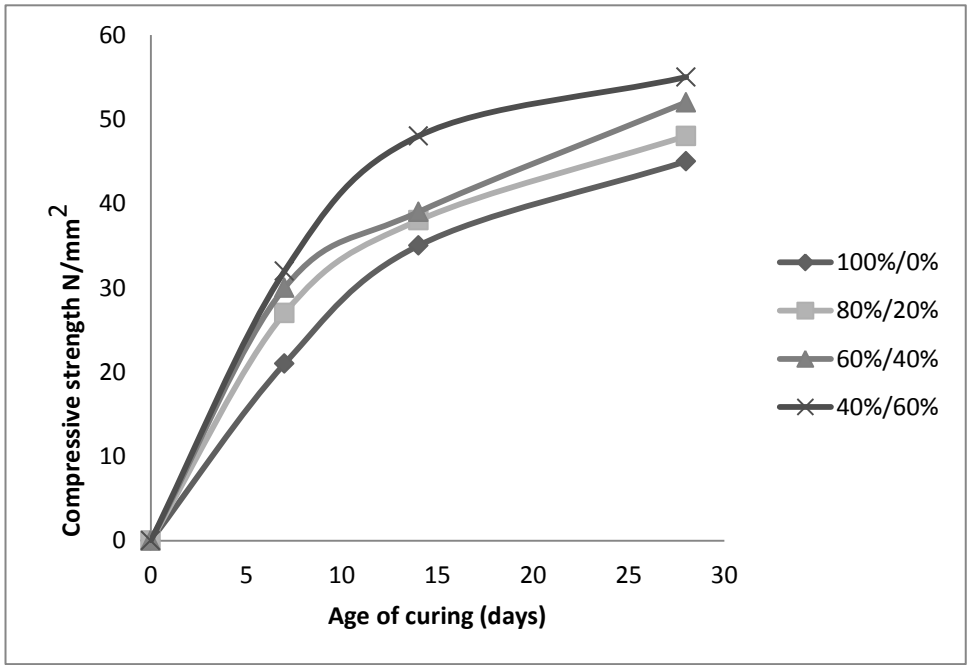

Figure-1. Compresive strength versus age of curing for 0.4 water/cement ratio.

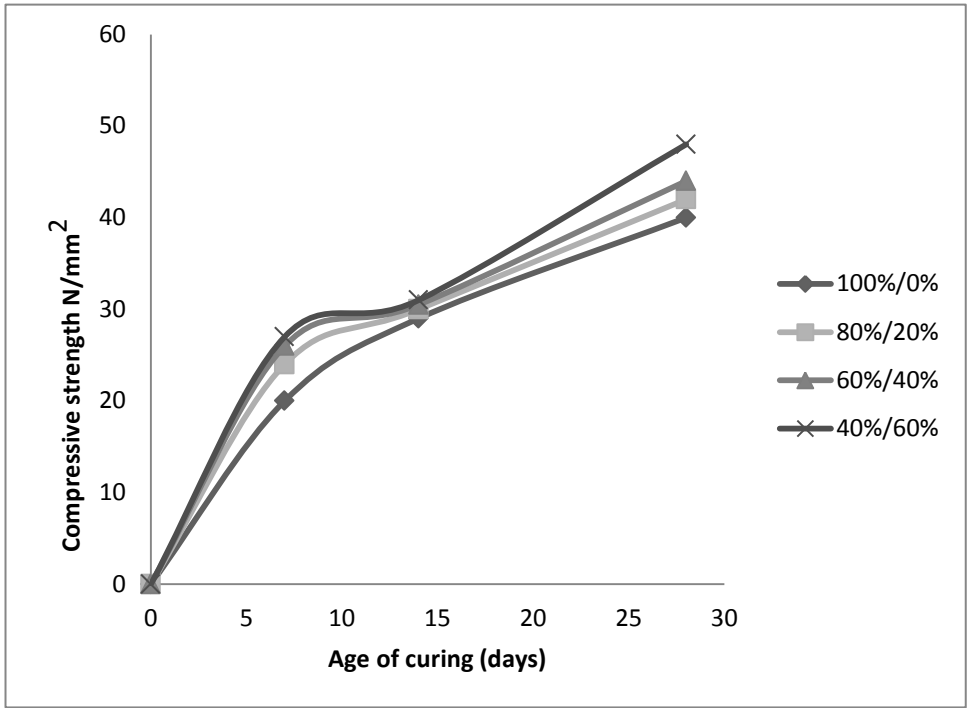

Figure-2. Compresive strength versus age of curing for 0.5 water/cement ratio.

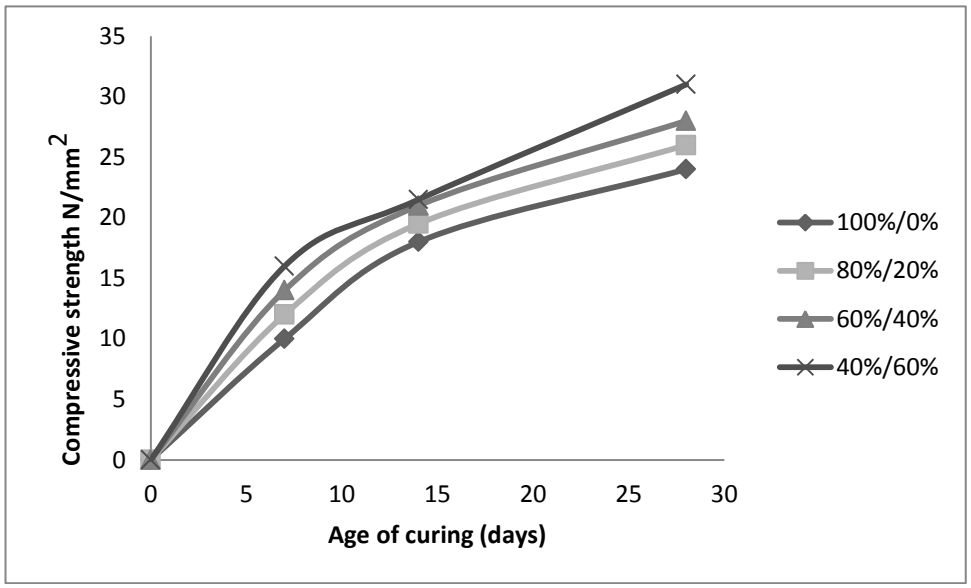

Figure-3. Compresive strength versus age of curing for 0.6 water/cement ratio.

3.1 Compressive strength test results for water cement ratios of 0.4, 0.5 and 0.6

The compressive strength for all water/cement ratios increased as the lime content in the lime/water solution increased at 7, 14 and 28 days. Table-5 shows the percentage increase in the compressive strength of concrete for the various lime/water curing solution. The 40%/60% water/lime curing solution exhibited the highest compressive strength for all the various water/cement ratios was highest. Shashi Chawla [8] had concluded in a previous study that when quick lime (chemically known as Calcium Oxide Cao) is mixed with water, calcium hydroxide (slaked lime) is formed. This reaction is highly exothermic and a large amount of heat is released in the process.It follows therefore that curing concrete in lime/water solution will result in heating of the concrete resulting in high strength development. The higher the initial curing temperature, the higher the initial strength development. The heat generated by the exothermic reaction increased as the quantity of lime in the curing solution increased with the optimum heat being generated at 040%/60% water/lime curing solution.

4. CONCLUSIONS

The following conclusions were drawn from the experiment.

a) There is a general increase in the compressive strength of the concrete cubes at 0.4, 0.5 and 0.6 at 7, 14 and 28 days curing periods as the quantity of lime in the curing solution was increasing.

b) The optimum compressive strength was obtained at 40%60% water' lime curing solution for all water/cement ratios and for all curing ages.

c) For water/cement ratio of 0.4, a maximum of 22% compressive strength increase obtained after 28 days at 40%60 water/lime curing solution.

d)) For water/cement ratio of 0.5, a maximum of 20% compressive strength increase obtained after 28 days at 40%/60% water/lime curing solution.

e) For water/cement ratio of 0.6, a maximum of 29% compressive strength increase obtained after 28 days at 40%60% water/lime curing solution.

f) There was very high strength development at 7 days curing period with compressive strength increase of 52.4%, 53% and 60.0% for 0.4, 0.5 and 0.6 water/cement ratio respectively.

g) The early high compressive strength gain at 7 days is due to the fact that t5hat the heat generated from the exothermic reaction between lime and water is higher at the early stage of curing.

h) The general increase in compressive strength for all water/cement ratios and for all curing ages is as a result of the exothermic reaction mentioned above.

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