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Comparative Analysis on the effect of different Methods of Curing on Compressive Strength of Concrete, in Ovia North East, Okada

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Abstract: *The most effective method of curing concrete depends on the accessibility of curing materials and the compressive strength required. Prevention of the loss of water from the concrete is of importance not only because the loss of water negatively affects its strength, but also because it leads to plastic shrinkage, reduced resistance to abrasion and increased permeability. This study evaluates the effect of four different curing methods on the compressive strength of concrete and to verify the method that is/are unsuitable which may impair the quality of the concrete. The laboratory program consisted of casting 150 mm by 150 mm concrete cubes using one single mix design ratio of 1:2:4 (cement: sand: granite) at water-cement ratio of 0.6 targeting a moderate strength of 20MPa. The curing regimes employed were: curing by immersion; wrapping with polythene sheet; burying in saw dust and keeping in open air. Compression tests at the age of 7, 14, 21 and 28 days for the four curing conditions were carried out. Curing by immersion had the highest compressive strength, while curing by exposing the cubes to open air produced the least compressive strength. From all the methods of curing regarded, except open air curing produced concrete cubes that met the minimum compressive strength. In situations where curing by immersion is not possible, wrapping the concrete member with polythene presents acceptable values of compressive strength.*

Key words: *Curing Methods, Concrete Hydration, Compressive Strength of Concrete, Concrete Failure*

INTRODUCTION

According to (Rodgers, 2018), concrete is the most widely used man-made material in existence, and it is second only to water as the most-consumed resource on the planet. Oloyede, 2010 stated that concrete has also been widely used for the construction of building structural

elements in the Nigerian urban areas. In the research work of Ede, et al., 2015, he stated that building materials used in Nigeria is comparatively humdrum as shown by the huge number of residential buildings in Nigeria made from weighty materials such as concrete blocks.
Concrete is a composite construction material composed of cement, fine and coarse aggregates mixed with water, which hardens with time. It's been said to be an exceptionally sturdy and robust building material with a compressive strength that varies from 20 N/mm^2 to 60 N/mm^2 depending of the concrete grade. The most significant attribute of concrete is its compressive strength. The 28 day's compressive strength of concrete cylinders or cube samples has widely been accepted as the minimum specified concrete strength in most design codes (FPrimec, 2020). According to Adewole et al., 2015, the compressive strength of concrete used during the design and construction of a building's structural elements is determined by the strength and durability requirements. The durability, strength, and other properties of concrete depends upon the properties of its constituents, the mix proportion , the method of compaction and other controls which are considered during placing, compaction and curing of concrete (Gambhir, 2005).

Curing as defined by (Naderi et al., 2009), means water at the surface of the concrete is retained to allow the concrete to hydrate to a point where it has a strong, durable structure. If curing is insufficient, the water evaporates and hydration stops, resulting in a concrete mass with low compressive strength and cracking may occur. Durability of the concrete may also be abridged due to inadequate hydration of the cementitious material; hence the continuous pore structure formed on the near surface may allow the ingress of deleterious agents. According to Naderi et al., 2009, he stated that the loss of water from the concrete mass should be prevented as this could possibll lead to the following: reduced resistance to abrasion, plastic shrinkage and increased permeability. Jackson and Dhir, 1996 stated that for a given concrete sample, physical make-up of the hydration products, the amount and rate of hydration, are solely dependent on the time moisture-temperature history. The most effective technique of curing concrete depends on the conditions on site, the availability of curing materials, the type of job, final appearance of the structure and the economics, and can be any one method or a combination of methods (Jackson and Akomah, 2018).

Some of the previous investigators (Jackson and Dhir, 1996; Gadzama and Malachi, 2011; Goel et al., 2013) in their studies on the effect of different curing methods on the density and compressive strength of concrete, found that ponding as the curing method yielded the highest compressive strength and was followed by jute bag while the method with the lowest results was the wet sand method. In Naderi at al., 2009, his study on the comparison of different curing effects on the concrete strength found that curing system greatly influences the concrete strength. The highest gain in compressive strength was recorded for cubes covered with wet Hessian and polythene sheet, the lowest gain in compressive strength was recorded for the specimens cure using steam curing. It is against this backdrop that this research seeks to evaluate the effect of four different curing methods on the compressive strength of concrete and to verify the method which could impair the quality of the concrete in terms of compressive strength.

MATERIALS AND METHODS

The following are the constituent materials used to cast the concrete cubes for this study: Fine aggregate (river sand); coarse aggregate (crushed gravel) 19mm sizes; portland cement (Dangote cement) and portable water.

A. Preparation of Test Specimens

The dry constituents namely the aggregates (sand and gravel) and Portland cement were mixed thoroughly; water was added gradually to achieve a grey uniform coloured mix. The mix ratio used was1:2:4 with water/cement ratio of 0.60 and the batch by weight method was used. The casting, curing and the concrete cube crushing were done in accordance with the guidelines specified by (BS 1881, Part 108, 1983), (BS, 1881, Part 3, 1992) and (BS 8110, Part 1, 1985) respectively. A cube mould size of (150mm×150mm×150mm) was used.

B. Curing Methods Used

The concrete specimens were cured using four different methods and their compressive strengths were ascertained at ages 7, 14, 21 and 28 days using the universal testing machine. The curing techniques that were applied are:

- **Open Air Curing (OAC):** This served as the control. It involved no form of active curing by just exposing the specimens to air in the Laboratory
- **Curing by Immersion (CBI):** This involved the immersion of the concrete cube specimens in water
- **Polythene Sheets Curing (PSC):** The specimens were covered with polythene membrane to prevent moisture escaping from the concrete specimens.
- **Curing by Sawdust (CBS):** This involved burying the entire concrete cube specimens in sawdust, and keeping it moist by spraying water on it intermittently.

RESULTS AND DISCUSSION

From Table 1, specimen cured fully immersed in water performed better in terms of compressive strength than all other methods. The strength decrease between those cured fully immersed in water and the polythene sheet cured specimen at 7days, 14days, 21days and 28days were 2.1KN/mm^2, 1.4KN/mm^2, 1.9KN/mm^2, 1.5 KN/mm^2, respectively. The highest strength differences occurred at 7days. Strength difference at 7days was higher than 14days, 21days and 28days. The percentage strength difference between the two methods at 7days was almost two times what was achieved at 28days. The strength difference between the curing by immersion and saw dust method were recorded as 2.9KN/mm^2, 1.0KN/mm^2, 1.7KN/mm^2 and 4.5KN/mm2 for 7days, 14days, 21days and 28days respectively. The two methods recorded 15.26% strength difference at 7days. Though the percentage strength difference fell at 14days, the rise from 14days to 28days was sudden. The difference at 28days was very high compared to other ages. There was a recorded difference of 17.78%. The performance of the curing by immersion method was even better against curing by open air method than other methods. The strength difference at 14days was the lowest recorded. Meanwhile, the increase from 14days to 21days was gradual but there was a huge increase of 6.3 KN/mm^2 from 21 to 28days.

Table 1. Compressive Strength for the different Ages carried out different Curing Method

Curing Methods	**Compressive strengths for the different ages in KN/mm²**			
Curing Methods	**Compressive strengths for the different ages in KN/mm²**			
	7 days	14 days	21 days	28 days
Curing by Immersion	19	20.7	22	25.3
Polythene sheet curing	16.9	19.3	20.1	23.8
Difference in compressive strength (KN/mm2)	2.1	1.4	1.9	1.5
Percentage deviation	11.0526	6.76329	8.63636	5.92885
Curing by Immersion	19	20.7	22	25.3
Curing by saw dust	16.1	19.7	20.3	20.8
Difference in compressive strength (KN/mm2)	2.9	1	1.7	4.5
Percentage deviation	15.2632	4.83092	7.72727	17.7866
Curing by Immersion	19	20.7	22	25.3
Curing by open air	16.2	19.6	20.5	19.2
Difference in compressive strength (KN/mm2)	2.8	1.1	1.5	6.1
Percentage deviation	14.7368	5.31401	6.81818	24.1107
Polythene sheet curing	16.9	19.3	20.1	23.8
Curing by saw dust	16.1	19.7	20.3	20.8
Difference in compressive strength (KN/mm2)	0.8	-0.4	-0.2	3
Percentage deviation	4.733728	-2.07254	-0.99502	12.60504
Polythene sheet curing	16.9	19.3	20.1	23.8
Curing by open air	16.2	19.6	20.5	17.5
Difference in compressive strength (KN/mm2)	0.7	-0.3	-0.4	6.3
Percentage deviation	4.142012	-1.5544	-1.99005	26.47059
Curing by saw dust	16.1	19.7	20.3	20.8
Curing by open air	16.2	19.6	20.5	17.5
Difference in compressive strength (KN/mm2)	-0.1	0.1	-0.2	3.3
Percentage deviation	-0.62112	0.507614	-0.98522	15.86538

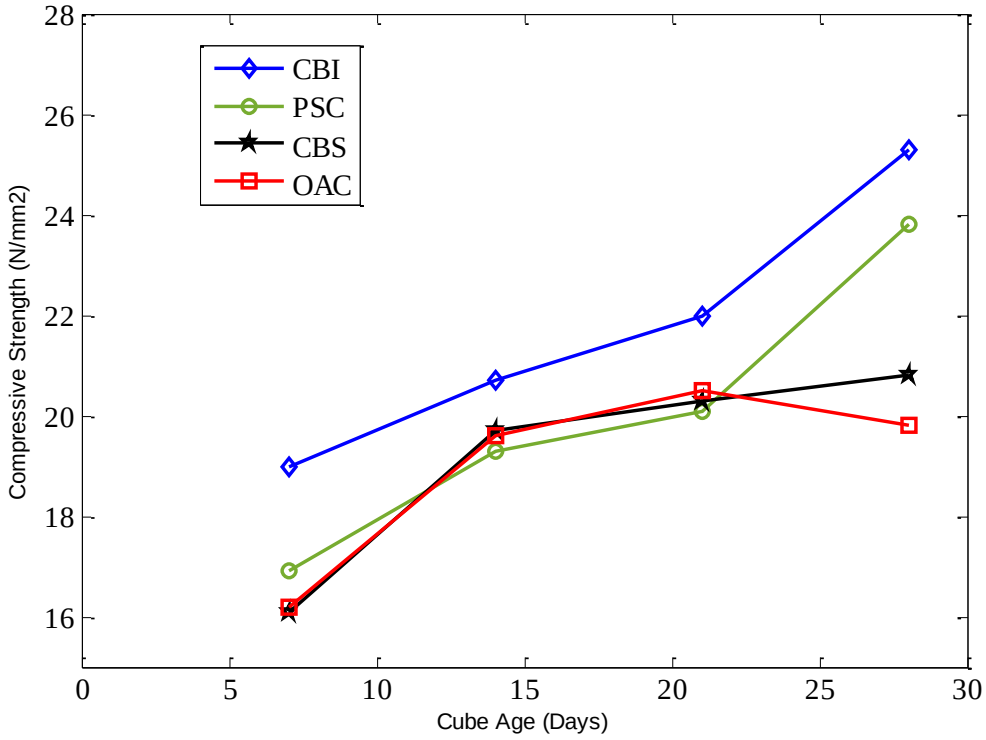

Fig. 1 Variation of Compressive Strength at different Days with Curing Methods

The result in Fig. 1 above shows four different curing methods and how they affect the compressive strength of concrete in 7, 14, 21 and 28days respectively. It shows that curing by immersion has the highest compressive strength, while curing by exposing the cubes to open air produced the least compressive strength. In curing by immersion, the compressive strengths were recorded as 19.0, 20.7, 22.0, and 25.3KN/mm^2 at ages 7, 14, 21, and 28 days respectively. Curing by wrapping the concrete cubes with polythene produced the second highest compressive strength producing compressive strength of 16.9, 19.3, 20.1 and 23.8 at 7, 14, 21, and 28 respectively. Curing by burying the concrete cube in saw dust and sprinkling it with water produced the third highest value of 16.1, 19.7, 20.3 and 20.8 at 7, 14, 21, and 28 respectively. Open air curing produced the lowest compressive strength at 7, 14, 21, and 28 days having values of 16.2, 19.6, 20.5 and 19.2 respectively with a remarkable decrease between 21 and 28 days this can be ascribed to lack of any form of moisture in the atmosphere to aid its strength gaining.

CONCLUSION

In this research work, the four different methods of curing impacted differently on the compressive strength of concrete. Immersion method of curing produced concrete cubes with the highest compressive strength while open air curing produced the lowest. From all the methods of curing studied, except curing by open air, produced concrete cubes that met the minimum compressive strength. In situations where curing by immersion is not possible, wrapping the concrete member with polythene presents acceptable values of compressive strength. Compared with curing by immersion, leaving the cubes in open air in the dry laboratory conditions after 28days of casting, tends to produce lower compressive strength which is below the acceptable limit.

CONFLICT OF INTEREST

There is no conflict of interested associated with this research work

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