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AN INVESTIGATION INTO THE EFFECT OF DIFFERENT CURING METHODS ON CONCRETE GRADE

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ABSTRACT
An investigation into the effect of different curing method son concrete grades 20, 25, and 30 were investigated in this study. Different curing methods are usually adopted to evaluate the compressive strength of a concrete. It is a well-known fact that concrete product after casting achieved their design strength through proper curing. Curing requirement can differ from one concrete grade to another. This work is aimed at identify the most appropriate curing method of concrete grade. The compressive strength of three (3) different curing methods (sprinkling, immersion, and covering method on each grade has been investigated with the aim of finding the suitable curing method for each grade of concrete. From the experimental observation, it is found that the ponding method has the highest strength compared to the covering and sprinkling method. Therefore; the ponding method proved to be the suitable method for the entire concrete grade counseled in the research. Also Scanning Electron Microscopy SEM analysis result revealed that concrete grade 20N/mm^2 achieved the highest hydration when cured using immersion method than covering and sprinkling. Therefore the study recommended that curing concrete grade 20, 25, & 30N/mm^2 by ponding (immersion) method is the best.

Keywords: Curing, Concrete Grade, Compressive Strength, Concrete

INTRODUCTION

Concrete is being widely adopted as construction material since because of its availability, versatility and durability (Jatoi et al, 2019). It is a man-made construction material composed of cement, fine aggregates, coarse aggregates and water (Raza et al, 2020).According to Ammarnath & Ranchandrudu (2012)concrete is described as artificial materials made up of cement, sand, coarse aggregate and water mixed in a definite proportion. The cement in concrete acts as a binder that sets and hardens other components of concrete together while the aggregates are employed for adequate bonding (Raza et al, 2020). This process of setting and hardening of cement is a chemical process called as hydration which is caused and accelerated by water used for curing of concrete (Raza et al, 2019).The improper curing of concrete can result in loss of half of its strength and proper curing of concrete ensures 90% attainment of concrete strength (Memon et al, 2018). For proper curing, adequate moisture and temperature should be provided to concrete (James et al, 2011).Hence, the curing of concrete is of extreme importance as it ensures the attainment of design strength and decreases the occurrence of surface cracks (Raza et al, 2020).

Curing not only reduces the shrinkage and permeability loss, but it also protects it from strength and durability losses, essentially on early days of strength gain (James et al, 2011). The prime purpose of concrete curing in early age is to provide concrete enough amount of water for strength gains (Memon et al, 2018). Based on conditions and availability, various methods for concrete curing are employed such as curing with gunny bags, curing with potable water, air curing, polythene curing, steam curing, ponding, sprinkling, wet covering etc (Raheem et al, 2013).

The curing of concrete with potable water involves sprinkling and/or ponding methods. In sprinkling method, the concrete is sprayed by water and in ponding method; concrete specimens are kept immersed in water for certain curing regimes (James et al. 2011). The gunny bags curing and or polythene sheet curing fall under the category of curing with wet covering. The concrete samples are kept under gunny bags, polythene sheets or wet burlaps for providing moisture to concrete matrix for hydration process (Zeyad 2019) Similarly, in air curing, the concrete units are placed in stacks at room temperature to allow free flow of ambient air for curing (Boakyet al. 2014).

CONCRETE GRADES

Concrete mix design is the process of selecting the proportions of cement, water, fine and coarse aggregates and, if they are to be used, additions and admixtures to produce an economical concrete mix with the required fresh and hardened properties. It is often, perhaps justifiable, referred to as 'mix proportioning' rather than 'mix design'. The cement and other binder constituents are usually the most expensive components and 'economical' usually means keeping its/their content as low as possible, without, of course compromising the resulting properties. (ACI 211.1-91, 2009).

Ibrahim et al. (2013) examined the effect of curing methods on mechanical properties of concrete with normal Portland cement and silica fume cement. The authors studied four types of curing compounds including water-based, acrylic-based, and bitumen-based and coal tar epoxy. The effect of curing method on concrete was evaluated through compressive strength, water absorption, and chloride permeability tests. The authors noted the durability and strength of concrete cured using chemical compounds was the same or better than that of concrete cured using the traditional method of covering concrete with wet burlap. Curing method had a limited effect on concrete compressive strength but had a more pronounced effect on durability. The best concrete performance was noted for samples cured using bitumen-based curing compound.

Yash et al. (2014) explored the effect of the curing method on concrete samples made with four w/b ratios 0.45, 0.5, 0.55, and 0.6. Total of four curing techniques were used in the study, air curing where the samples are left exposed in room temperature, water bath curing, saturated wet covering where samples are covered with wet burlap cotton mats till the testing date and curing compounds where a total of 7 chemical compounds are used. The authors concluded that using membrane curing through chemical compounds produced concrete properties that are 80% to 90% of concrete samples cured using conventional water methods.

MATERIALS AND METHODS

The sand, coarse aggregate and cement used for the research work was purchase within Sokoto State at Arkila behind Umaru Ali Shinkafi polytechnic. The aggregate used was 20mm.portland linestone cement "Sokoto cemen" and sharp sand was used for the concrete production. The concrete sample were batched, mixed and cast using square size mould of 15x15x15cm in the laboratory of department of building technology, Umaru Ali Shinkafi Polytechnic Sokoto, Sokoto State. Absolute Volume method of batching was used to produce concrete of nominal mix of 1:2:4 using w/c ration of 0.60. Total no. of 81 cubes were casted and then cured using different curing methods. Twenty seven (27) cubes were produced for each grade of the concrete used for the work that is, G20, G25, and G30. Concrete samples were tested at 7,14 and 28 days respectively at each curing period, three (3) cubes were used and also at 28 days the SEM test was carryout in the department of civil engineering Ahmadu Bello university Zaria. In order to determine the effect of different curing method of concrete grades, certain tests were conducted and the results were presented in this chapter. The following tests were performed on the aggregate to determine its aggregates properties like the moisture content, water absorption, bulk density and specific gravity. Others tests including; compressive strength test, water absorption test, and Scanning Electron Microscopy SEM test were also presented.

RESULTS AND DISCUSSION

Table 1; Properties of Aggregate in Concrete

Properties	Fine aggregate	Coarse Aggregate
Specific Gravity	2.61(kg/m^3)	2.560(kg/m^3)
Bulk density	1673.087(kg/m^3)	1558.52(kg/m^3)
Moisture content	0.0002%	0.0001%
Water absorption	20.08%	1.4%

Source: Experiment work (2022)

Looking at these results of various tests performed on the samples, itis clearly shows that there is nomuch differences between the standard it shows that the specific gravity of the aggregate are within the average standard as stated according to shetty (2005) that the average specific gravity of aggregate vary from 2.6 to 2.8. According to Safiuddin, et al,(2007) the specific gravity of the aggregate gives valuable information on its quality and properties. The higher the specific gravity of an aggregate, the harder and stronger it will be.

Table 2; Compressive strength of concrete cubes for 20N/mm^2

Curing Condition	7 days	14 days	28 days
Sprinkling Method	15.51	19.64	22.26
Immersion (ponding)	19.05	23.39	28.34
Covering Method	17.85	21.72	25.58

Source: Experimental work (2022)

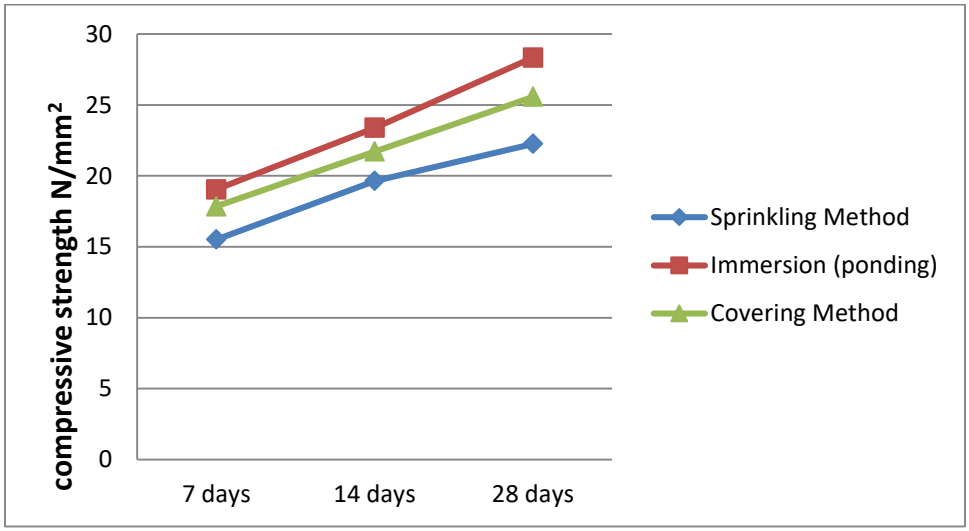


Figure 1. Compressive strength of concrete cubes at 20N/mm^2

From Figure 1, it can be observed that the immersion and covering method of curing for 20N/mm^2 at 28 days achieved the compressive strength. This shows that the strength of concrete increase as well as curing period increase.

Table 3; Compressive strength of concrete cubes for 25N/mm^2

Curing Condition	7 days	14 days	28 days
Sprinkling Method	18.03	21.85	27.32
Immersion (ponding)	26.60	30.15	36.16
Covering Method	21.88	26.90	33.29

Source: Experimental work (2022)

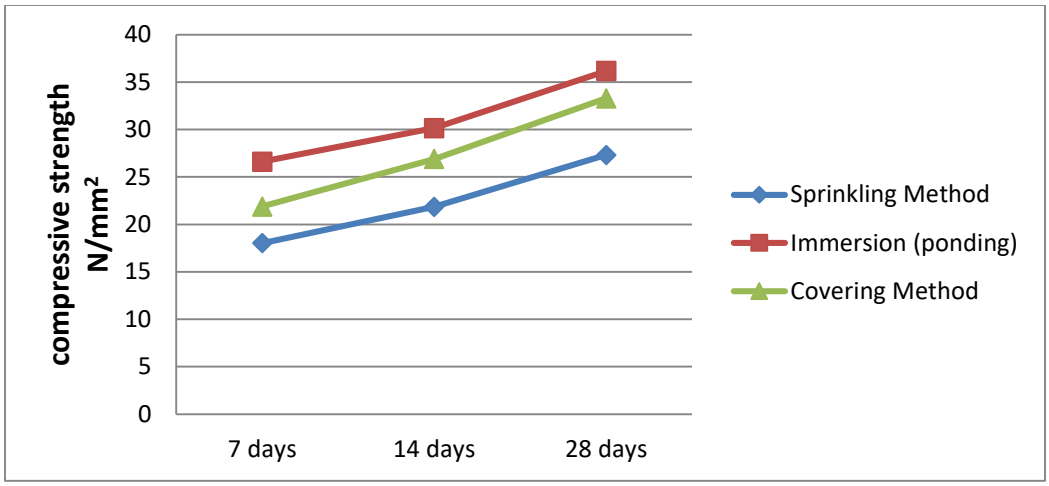


Figure 2.Compressive strength of concrete cubes at 25N/mm^2

The Figure 2 shows that among the three different curing methods used in this work the immersion method has the higher compressive strength of 25N/mm^2 at 28 days.

Table 4; water absorption test of concrete cubes

Curing condition	**Concrete Grade**		
	20N/mm^2	25N/mm^2	30N/mm^2
Sprinkling	22.69%	2.05%	2.50%
Immersion	10.71%	14.84%	6.95%
Covering	15.29%	18.37%	2.11%

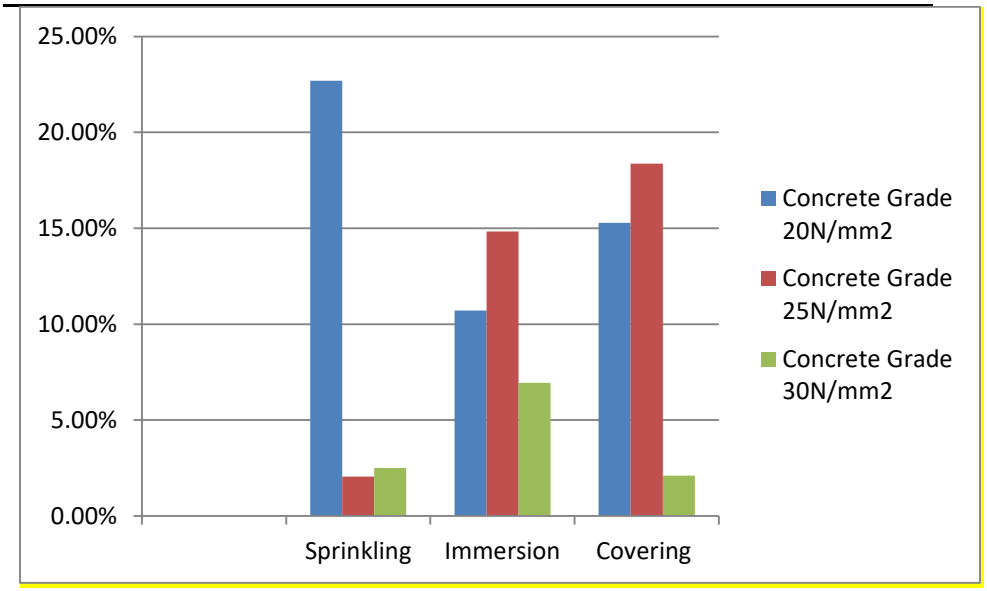
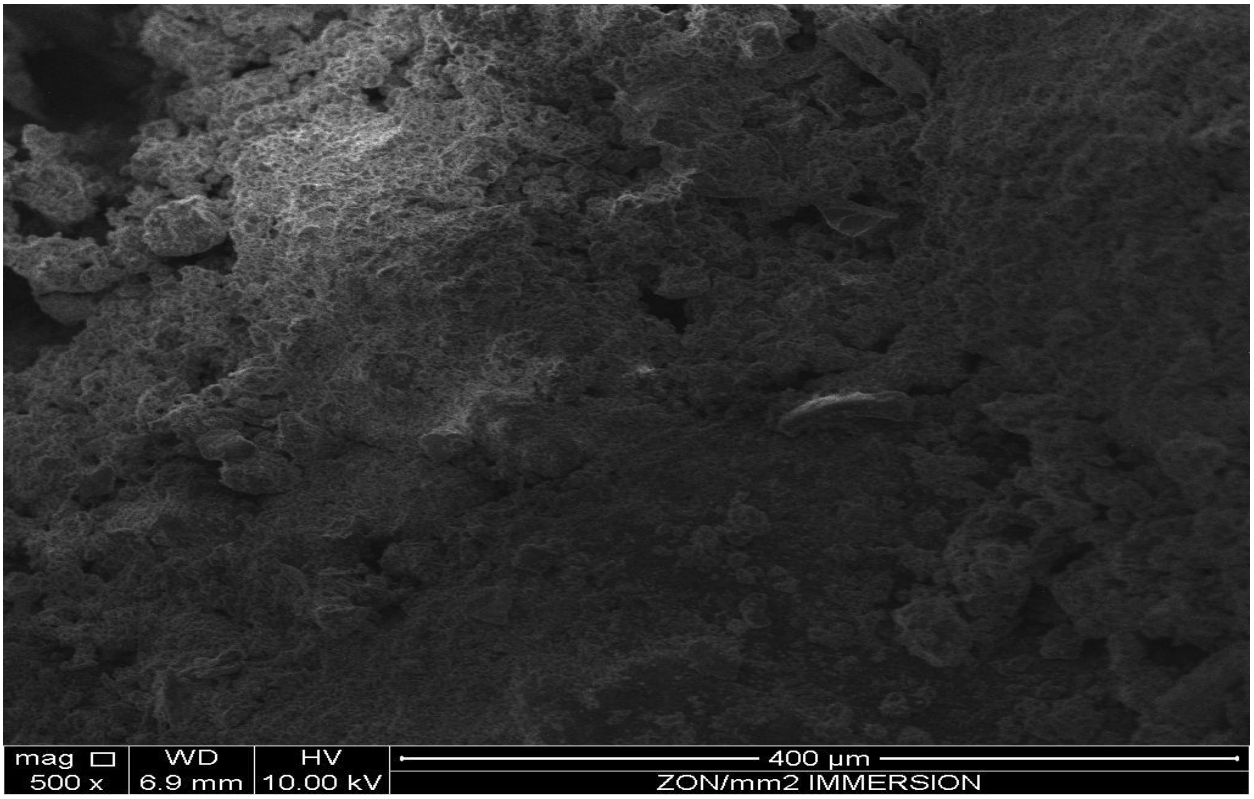


Figure 3. Water absorption test of concrete cubes

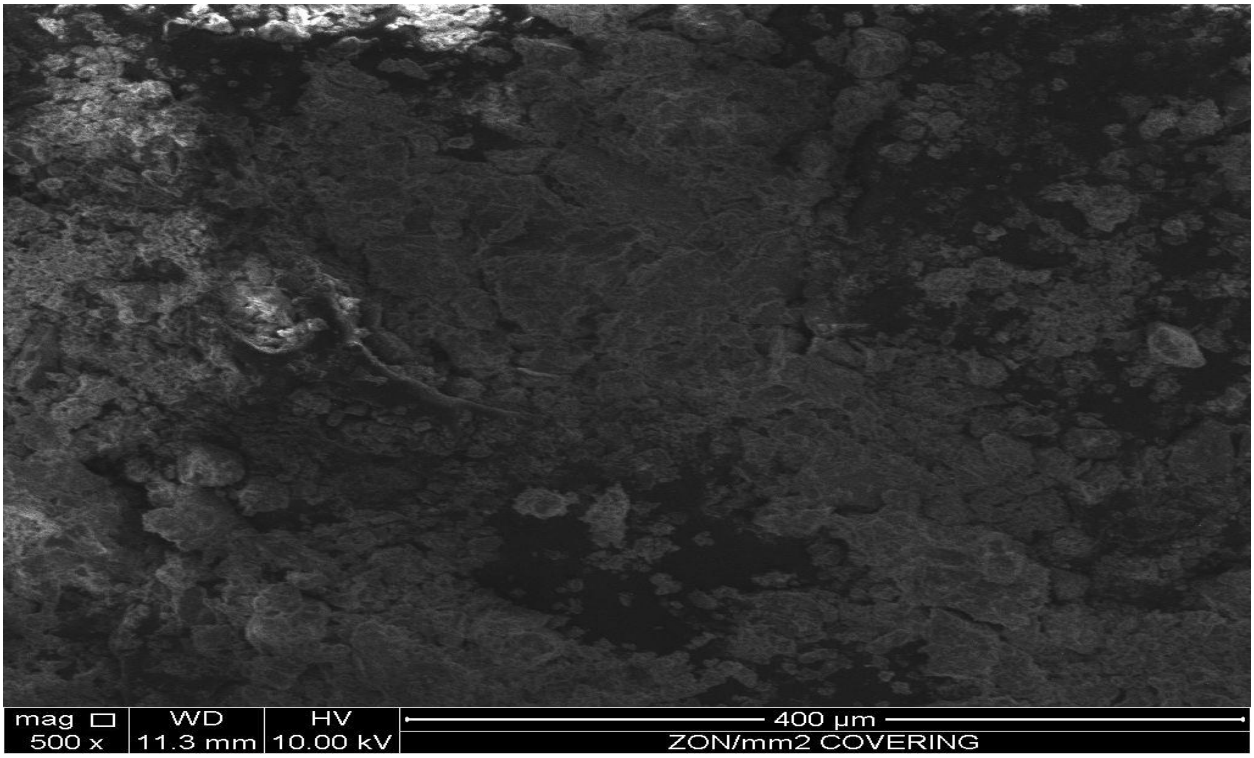
Figure 3 shows that the sprinkling method of grade 20N/mm^2 absorbed more water than sprinkling method of grade 25 and 30N/mm^2, at immersion grade 25N/mm^2 absorbed more water than at grade 20 and 30N/mm^2, while at covering method grade 25N/mm^2 also absorbed water than grade 20 and 30N/mm^2.This shows that concrete grade 25N/mm^2 lead to absorb more water than concrete grade 20 and 30N/mm^2.

SCANNING ELECTRON MICROSCOPY (SEM)

According to the result of the scanning electron microscopy test, at 20N/mm^2 concrete grade, the immersion method with 500 magnification is well compacted and well cured compared to others method such as covering and prinkling method. Therefore, immersion method exhibited the higher strength compared to other methods been applied. As shown in the microscopy 1



Micrograph1(immersion method of 500 mag.)



Micrograph2

SUMMARY OF THE RESEARCH FINDINGS

1 It discovered that the aggregates have the specific gravity of 2.61kg/m^3 and 2.56kg/m^3 with a bulk density of 1673kg/m^3 and 1559kg/m^3 respectively, the; specific gravity of aggregate is within the limit as compared with the normal weight aggregate which is varies from 2.6 to 2.8

2 Water absorption capacity of 20.08% and 1.4% indicate high porosity of the aggregate and these have effect on the specific gravity of the materials, while the moisture content of aggregate has 0.0002% and 0.0001% respectively.

3 The compressive strength of the concrete samples were observed to increase with age. The compressive strength of concrete was found to depend on the method of curing the concrete. The compressive strength of concrete at 28 days shows that both at 20N/mm^2, 25N/mm^2, and 30N/mm^2 concrete grade, the water (immersion) curing method has the higher strength compared to other methods adapted to this research.

4 But according to the result of SEM analysis test, at 20N/mm^{2}concrete grade, the immersion method with 500 magnification is well compacted and well cured compared to others method such as covering and sprinkling method.

CONCLUSION

The present study investigates the effect of different curing methods on concrete grade. i.e. ponding, sprinkling and covering methods and curing days 7, 14, and 28 days on compressive strength of concrete cubes.

a. Of all the curing methods applied, the immersion (ponding) method happened to be the best curing method.
b. The results depicted that sprinkling provides lowest of compressive strengths observed in this study.
c. Curing of concrete is mostly governed by period.
d. The result of the SEM analysis shows that at grade 20N/mm^2, immersion method is the best.

RECOMMENDATIONS

a. If the water (immersion) method is not feasible then covering method should be adopted.
b. Further research can be carried out by applying another method not be used in this research

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Appendix

Plate I (Sprinkling Method)

Plate II (Covering Method)