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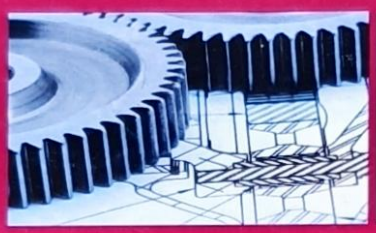





Effect of Algae Infested Water on the Compressive Strength of Concrete

James, Olayemi
Department of Civil Engineering, Federal University of Technology Minna
olayemi.james@yahoo.com

Abstract
The aim of this research work is to investigate the effect of algae infested water on the compressive strength of concrete. In order to ascertain its effect the physical properties of the aggregate were determined while P^H Value tests for the clean and algae infested water were also carried out. The result shows that the P^H value for portable water was 6.90 while that for algae infested water was 8.26 indicating that the algae infested water is alkaline in nature and this has negative effect on the compressive strength of the concrete. This conclusion is based on the fact that the average compressive strength of the concrete cast with algae infested water showed a reduction in both the 7 and 28 days compressive strength when compared with the results of cubes cast with portable water and cured for same period of time. The cause of this strength reduction was as a result of the presence of oxides of sodium and potassium in the algae infested water. These oxides have been found to react with some aggregates producing alkali-aggregate reaction that causes disintegration of concrete and have also been found to affect the rate of gain of strength of cement negatively. The lower strength obtained from algae infested cubes can also be trace to the formation of air entrainment in the concrete because of the presence of algae.

Keywords: Algae, Alkali-aggregate reaction, Concrete, Compressive Strength, Curing

Introduction

Concrete is composed mainly of three materials namely cement, water and aggregates. An additional material known as admixture is sometimes added to modify certain of its properties (Jackson and Ravindra, 1996). Concrete solidifies and hardened after mixing and placement due to chemical process known as hydration. The water reacts with cement which binds the other components together, eventually creating a store-like material.

Cement, the most reactive components of concrete is a chemical substance that needs water as a solvent that enable it performs its engineering functions. The quality and quantity of water affects the strength of the resulting concrete. Gambhir (1986), while laying emphasis on the importance of the quality of water posited that the strength and durability of concrete is reduced due to the presence of impurities in the mixing water. For this reason, suitability of water for mixing and curing purposes should be considered. Generally water satisfactory for mixing is also suitable for curing (Neville and Brooks, 1987).

In many specifications, the quantity of water is covered by a clause saying that water should be fit for drinking. This is because there is no appreciable difference between the behavior of distilled water and ordinary drinking water in concrete mix. BS 3148:1980 suggests a tolerance of 10 percent to allow for chance variation in strength. The criterion of portability of water is that absolute drinking water may be unsuitable as mixing water when the water has a high concentration of sodium or potassium and there is a danger of alkali aggregate reaction

(chemical reaction between the active silica constituents of the aggregate and the alkali in the cement known as alkali-silica reaction which may endanger the concrete. BS 3148:1980 gives the requirements for test of water for its suitability for use in concrete mixing.

Algae infested water is the water that contains the presence of algae. This organism, if present in water makes the water impure. One of the glaring physical properties of such water is the greenish colouration which is as a result of the presence of the algae. The greenish colouration contradicts the colourless colouration of pure (clean) water.

This study is mainly concerned with the effect of algae infested water on the compressive strength of concrete. Therefore, algae infested water was used to produce half of the concrete cubes used in this test while the remaining half of the cubes produced with portable water served as control. For curing purposes, the algae cubes were cured using algae infested water while the cubes for control experiment were cured using clean and portable water as specified in BS 3148:1980.

Materials and Methods

Materials

Cement: Ordinary Portland cement was used for the experiment. The Ordinary Portland Cement was package by Dangote group of companies. The Cement conformed to BS12 (1996) as confirmed by Yahaya (2008) in Aguwa and Amadi (2010).

Aggregate: Locally available natural sand with 5.0mm maximum size was used as fine aggregate. Crushed granite stone with 20 mm maximum size was used as coarse aggregate. This is done in order to maintain conformity with BS 882, (1983) recommendation. The physical properties of the aggregate used are as given in table 1.

Table 1: Physical properties of Fine and Coarse aggregates.

Physical test	Fine aggregate	Coarse aggregate
Spec. gravity	2.70	2.94
Bulk density (kg/m^3)	1602.84	1623.61
Fineness modulus	3.62	4.96
Porosity (%)	6.12	17.37

Water: The water used for mixing is from two sources. The first one is potable (clean) water from Civil Engineering Lab supply by F.U.T Minna while the second one is algae infested water water obtained from a nearby pond very close to the Gidan kwano campus of F.U.T Minna. Tests were carried out on both the Potable water and algae infested water to determine the PH values and the levels of the minor compound (mainly oxides of Sodium and Potassium) present in the water from the two sources. The results obtained are as shown in table 2.

Table 2: Properties of the mixing waters.

Type of water	P^H value	Oxide of Sodium	Oxide of Potassium
Potable water	6.90	1.15 ppm	1.17 ppm
Algae water	8.26	5.02 ppm	6.10 ppm

In this study, a mix ratio of 1:2:4 (cement: sand: coarse aggregate) by mass was adopted. The

grade of concrete designed was 35 mpa at 28 days of curing. A total of 48 (150 X150X150mm) cubes were cast. 24 cubes were cast with potable water as mixing water while the remaining 24 cubes were cast using algae infested water. The water- cement ratio used was 0.50. The compressive strength of the cubes was determined by crushing test at age 7 and 28 days of curing respectively.

Method

Laboratory Tests

Various laboratory tests were carried out on the sand and coarse aggregate for the purpose of characterization and classification of the aggregates. The tests include particle size distribution, specific gravity, bulk density, aggregate impact value, void ratio and moisture content of the aggregates. These were done in accordance with BS 812, part 2:1975. Compacting factor and slump tests of the fresh concrete were carried out in accordance with BS 1881, part 102, (1983) while the compressive test was carried out in accordance with BS 1881 part 116, (1983).

Mix design

Mix design can be defied as the selection of the ingredients for concrete and determining their relative proportions which would produce, as economically as possible, a concrete that satisfies the job requirements. According to Gambhir, (1986), the proportioning of the ingredients of concrete is an important phase of concrete technology as it ensures quality and economy. A 20mm size of coarse aggregate and a water-cement ratio of 0.50 were adopted yielding a slump value of 36mm-42mm. The quantities of the ingredients used for the concrete were determined by Absolute volume method. A mix ratio of 1:2:4 was used. Manual method of production was adopted and a total of 48 cubes of 150mm size were used in compressive strength test determination. BS 1881 part 108, (1983) serves as a guide in the proportioning, mixing and casting of the cubes.

Mixing of the concrete

There are two methods of mixing concrete. These are machine and manual methods of mixing. The batch mix of 1:2:4 by volume of the ingredients as determined from the mix design adopted were mixed by hand in an iron tray. First to be mixed thoroughly were sand and cement, after which they were spread in the tray. Immediately after this, the coarse aggregate was spread on top of sand and cement mixture. Water was then added and mixing continued until uniformity was achieved in colour and consistency. A total of 48 cubes of 150mm size were cast and cured for 7 and 28 days respectively.

Compressive strength test

The compressive strength test was carried out in accordance with BS 1881 Part 116, (1983) with the aid of an electrically operated Seidner compression machine at the end of 7 and 28 days of curing respectively. Before crushing, the concrete cubes were air-dried and weighed and the values obtained were duly recorded. Throughout the process of crushing, care was taken to ensure that the cubes were properly placed and aligned with the axis of the thrust of

the compression machine to achieve uniform loading on the cubes.

Results and Discussion

Table 2 shows the properties of sand and coarse aggregate used in the production of the concretes. The fineness modulus of the sand and coarse aggregate is 3.62 and 4.96 respectively, while their specific gravities are 2.70 and 2.94. The value of the fineness modulus obtained for sand shows that the sand is very coarse in nature while the specific gravity test on the aggregates shows that the aggregates are normal aggregates, i.e. aggregate with specific gravity ranging between 2.60 and 3.00. The uncompacted and compacted density for the sand was 1602.84kg/m3 and 1702.26kg/m3 while that of the coarse aggregate was 1623.61 kg/m3 and 1680.02 kg/m3 respectively.

The porosity of the fine and coarse aggregate used for the concrete are 6.12% and 17.37% respectively. These values are lower than the porosity of some common rocks which ranges from 0-50% as stated by Neville and Brooks (1987). The strength of the concrete is low and the durability is greatly reduced when the porosity of the aggregates is very high (Aguwa and Amadi, 2010).

Table 2: Results of compressive strength for both control test and algae infested cubes after 7 days of curing.

Control cubes (N/mm^2)	Mean result for control cubes (N/mm^2)	Algae infested cubes (N/mm^2)	Mean result for algae infested cubes (N/mm^2)
19.37		18.73	
19.06		18.67	
19.55		18.93	
18.66		17.46	
19.67		18.31	
18.66	19.24	18.04	18.25
19.20		17.46	
19.51		18.57	
19.55		18.76	
19.24		17.73	
19.91		18.22	
18.48		18.13	

Table 3: Result of compressive strength for both control cubes and algae infested cubes after 28 days of curing

Control cubes (N/mm^2)	Mean result for control cubes (N/mm^2)	Algae infested cubes (N/mm^2)	Mean result for algae infested cubes (N/mm^2)
29.28		27.91	
29.97		28.13	
30.31		28.84	
29.15		27.64	
30.31		27.20	
29.73	29.49	27.51	27.81
29.91		27.86	
28.70		27.33	
29.20		27.86	
29.33		28.40	
29.77		27.46	
28.24		27.68	

The result of compressive strength have been presented in tables 2 and 3 and the graphical representation of average compressive strength versus curing ages for both the control and algae infested cubes shown in figure 1. The concrete cubes (both control and algae infested) showed an increase in the values of compressive strength with age (i.e. from 19.24N/mm2 at age 7 days to 29.49N/mm2 at age 28 days for control experiment and from 18.25N/mm2 at age 7 days to 27.81N/mm2 at age 28 days for algae infested cubes. This confirms the positive effect of longer period of curing on the compressive strength of concrete. The measured average

compressive strength after 7 days of curing for both the control and algae infested cubes are 65.24% and 65.62% of 28 days compressive strength of control and algae infested cubes respectively. These values are a little lower than that of 70 to 85% of 28 days as stated by Gambhir (1986).

Also revealed from tables 2 and 3 is the reduction in the compressive strengths of algae infested concrete cubes when compared with the sets of cubes used for the control experiments at the various ages of curing. At age 7 days of curing, the average compressive strength was 94.85% of that of the control. This signifies a reduction of about 5.15% at the same age. Also, for 28 days of curing, the average compressive strength of algae infested cube is 94.30% of the control cubes. This represents a reduction of about 5.70% at the same age of curing. The difference observed in the compressive strength of the algae infested concrete in respect to the control at the various ages of the concrete cubes can be attributed to the negative effect of the algae infested water. The presence of algae in the mixing water would have combined with cement leading to the reduction of the bond between aggregates and cement paste. The water containing algae has the effect of entraining large quantities of air in concrete (Gambhir, 1986). The PH value of mixing water for control cubes was 6.90 while that of algae infested was 8.26. This shows that the algae infested water is alkaline in nature with the presence of high concentration of oxides of sodium (Na2O) and Potassium (K2O). From the water analysis carried out, it shows that the concentrations of sodium and potassium for the algae infested water are 5.02mg/kg and 6.10mg/kg while that of portable (clean) water are 1.15mg/kg and 1.17mg/kg for sodium and potassium respectively. The presence of higher concentration of oxides of sodium and potassium in algae infested water would have increase the quantities of the minor compounds contributed by cement to the concrete conglomerate. As a result of this an alkali-aggregate reaction which causes disintegration of the concrete would have occurred which will negatively affect the rate of the gain of strength of cement according to Neville and Brooks, (1987).

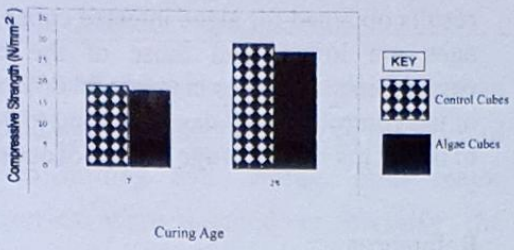

Figure 1: Mean Compressive Strength Vs Curing Age for concrete produced with clean and algae infested water.

Conclusion

The effect of algae infested water on the compressive strength of concrete has been studied and the following conclusion can be safely made based on the results obtained in the research.

a. Algae infested water is alkaline in nature. The result of the PH analysis of the water carried out shows that the PH value of the algae infested water used in the experiment is 8.26 while that of portable water is 6.90.

b. The algae infested water increases the quantities of the minor compounds contributed by cement to the concrete conglomerate. Two of the minor compounds that are of interet are oxides of sodium (Na2O) and potassium (K2O). These are known as alkalis (although other alkalis also exist in cement). They have been found to react with some aggregates, producing alkali-aggregate reaction that causes disintegration of concrete and have also been observed to affect the rate of the gain of strength of cement.

c. Algae infested water is a compressive strength inhibitor. The average compressive results obtained for algae infested cubes for all ages are lower than those of the control experiments. It ranges between 94.85% of that of the control at age 7 days of curing to 94.30% of that of the control at age 28 days of curing.

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