

INVESTIGATION INTO THE INFLUENCE OF WATER TYPE ON COMPRESSIVE STRENGTH OF CONCRETE

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ABSTRACT

This study investigates into the effect of water type on the compressive strength of concrete. Water analysis was carried out on the two water sources to identify some parameters in the waters. Sieve analysis on fine and coarse aggregates samples was carried out to identify the zone and size respectively. Mix design of concrete was also carried out for concrete grades 20 and 30. Workability test was also carried out for each grade of concrete. For each grade, the concrete was cast and cured using the two water sources. After curing the concrete cubes for 28, 56, and 84 days, the compressive strength of the concrete cubes were tested. From the results obtained, it is found that all the two water sources used in the casting and curing of the concrete cubes gave a satisfactory compressive strength. The average compressive strength results of concrete grade 20 at 28, 56 and 84 days cast with the potable tap water and Ladanai pond water are 33.0 N/mm² and 31.0 N/mm²; 34.0 N/mm² and 34.0 N/mm²; 36.0 N/mm² and 32.0 N/mm² respectively. Also for concrete grade 30, the average compressive strength results at 28, 56 and 84 days cast with potable tap water and Ladanai pond water are 32.0 N/mm² and 29.0 N/mm²; 34.0 N/mm² and 32.0 N/mm²; 34.0 N/mm², and 33.0 N/mm² respectively. However, the results of the compressive strength of concrete grades 20 and 30 attained the characteristics strength required in the mix design. Therefore, the results showed that any of the two water sources can be used to produce concrete grades 20 and 30. But, however, potable tap water remains the best option to obtain a better compressive strength for concrete.

KEYWORDS: Concrete, Concrete grade, Water Sources and Compressive Strength.

INTRODUCTION

Concrete for many years, has been one of the major materials used in the construction of buildings and civil engineering structures. Concrete is a civil engineering material resulting from the mixture of cement, coarse and fine aggregates, and water. Sometimes admixtures may be added to modify one or more properties in the fresh and/or hardened states of the concrete. The materials when properly batched and thoroughly mixed sets through the process of hydration and hardens into a concrete mass which is capable of resisting compressive forces, (Mtallib, 2000). The cement is the binding material in concrete, which reacts with water to form hard cementitious substance, and is the fundamental material because it provides the chemical bonding (binding matrix) that allows concrete to be used structurally, (Mtallib, 2000). The aggregates gives rigidity and dimensional stability to concrete and its cheapness relative to cement assures its use for reason of economy. For a concrete to be suitable for a particular purpose, it is necessary to carefully select the constituent materials and to combine and use them in a way that the concrete will develop the strength and other properties required, (Suleiman, 1995). The requirements in the fresh concrete are the consistency of the mix and sufficient workability; also the mix should be cohesive enough for the method of placing adopted without the concrete been segregated, (Folaranmi, 1995). The usual primary requirement of a good concrete in its hardened state is a satisfactory compressive strength. A

satisfactory compressive strength is a major factor because other properties of concrete such as durability, deformation, tensile strength, shrinkage, permeability, weathering etc are directly related to the compressive strength, (Neville, 1981).

Compressive strength of cubes are usually used in the construction industry for the purpose of specification and quality control for the strength of the concrete to be used for a particular work. Because as the compressive strength of concrete increases, other properties of concrete such as durability, shrinkage, tensile strength etc, usually improves, (Neville, 1981). Many factors affect the compressive strength of concrete such as the constituents materials, method of preparation (batching, mixing, placing and compaction), and curing, (Suleiman, 1995). Water as part of the constituent materials is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to forms a medium for a strength development, the quantity and quality of water should be looked into very carefully. The suitability of water for mixing concrete is that, the water should be potable, (Shetty, 2001). It is also presented in Shetty (2001) that, some standard specifications for making of good concrete requires that if the water is not obtained from source that has proved satisfactory; the strength of concrete or mortar made with questionable water should be compared with similar concrete or mortar made with potable water.

Shetty (2001) also added that, the specifications also accept water for making concrete if the pH value of water lies between 6 and 8 and the water is free from organic matter. Instead of depending only upon pH value and other compositions, the best course to find out whether a particular source of water is suitable for concrete making is to assess the compressive strength of concrete made with the water. It is reported in Shetty (2001) that, if the compressive strength is up to 90 percent, the source of water may be accepted. This criterion may be safely adopted in places like coastal area or marshy area or in other places where the available water is brackish (slightly salty) in nature and of doubtful quality. However, it is logical to know what harm the impurities in water do to the concrete and what degree of impurity is permissible for mixing concrete and curing concrete. Algae in mixing water may cause a marked reduction in compressive strength of concrete due to their deleterious effect on cement which in turns reduce the bond or by causing large amount of air entrainment in concrete, (Shetty, 2001).

Significance: That the different water sources when use in mixing of concrete will affect the compressive strength of concrete are obviously possible, but the extent to which the water sources will affect the compressive strength of concrete is not very clear. There appear to be some written literatures providing this, but not to some extent of explanation. This particular paper will greatly prove to be of high significance in providing this clarity and providing the missing link in the relationship between type of water used and the compressive strength of concrete.

BACKGROUND

It is a common practice on sites to see contractors using different types of waters apart from potable water in order to achieve a particular mix or grade of concrete. These different types of waters used may not be suitable in the mix of concrete that is required for a specified job to be carried out. Therefore, the required concrete strength may not be achieved. As such the quality and the durability of the concrete and of the structure to be constructed could be in doubt. Therefore, the need to investigate the effect(s) of water on the compressive strength of concrete is essential in order to ascertain for certainty the quality and durability of the concrete and also of the structures that may be constructed using different types of water in the concrete mix. It is against this background that the study was planned and carried out.

Water as one of the main constituent materials is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. The general requirement for the suitability of

water for mixing concrete is that, if the water is fit for drinking it is fit for making concrete. Impurities may be either dissolved in the water or present in the form of suspension. Some of these impurities such as sugar, tannic acid, vegetable matter, oil, and sulphates, may interfere with the hydration of the cement, thus delaying setting and reducing the strength of the concrete, (Shetty, 2001; ASTM C156, 1998). Algae in mixing water may cause a marked reduction in compressive strength of concrete as a result of its deleterious effect on cement, which in turns reduce the bond strength, or by causing large amount of air entrainment which creates voids in the concrete, (Shetty, 2001). The concentrations of carbonates and bi-carbonates of sodium and potassium affect the setting time of cement as well as the strength of the concrete. While sodium carbonate may cause quick setting, the bi-carbonates may either accelerate or retard the setting depending on the quantity present. And higher concentrations of these salts mentioned above will materially reduce the concrete strength, (Abrams and Duff, 1997). If some of these salts of carbonates and bi-carbonates of sodium and potassium exceed 1,000 parts per million (ppm) (1000 mg/l) test for compressive strength at 28 days or more should be carried out, (Neville and Brooks, 2003). Brackish (slightly salty) water contains chlorides and sulphates. When chloride does not exceed 10,000 ppm (10,000 mg/l) and sulphate does not exceed 3,000 ppm (3000 mg/l) the water is harmless, but water with even higher salt content has been used satisfactorily. Salts of manganese, Tin, Zinc, Copper, and Lead cause a marked reduction in strength of concrete. Sodium iodate, Sodium phosphate, and Sodium borate reduce the initial strength of concrete to an extra-ordinary high degree, (Abrams and Duff, 1997). Another salt that is detrimental to concrete is Sodium sulphide and even a sulphide content of 100 ppm (100 mg/l) needs to be tested. Silts and suspended particles are undesirable as they interfere with setting, hardening and bond characteristics. A turbidity limit of 2,000 ppm (2000 mg/l) has been suggested, (Shetty, 2001). According to Miringa (2003), water that contains impurities may affect the compressive strength of concrete when mixed and cured. But, potable water can be used for making and curing of concrete. Excessive amount of silt, oil, acids, alkalis, salt of alkali, organic matter or sewage in water have an injurious effect upon concrete, (Miringa, 2003). Impurities in mixing water may cause; Abnormal setting time, decreased strength, volume changes, efflorescence and corrosion of reinforcement bars in the case of reinforced concrete, (Shetty, 2001). Miringa (2003), also added that, some of the impurities in mixing water that causes the injurious effect in the final concrete are; Dissolved chemicals, silt and suspended solids, algae etc.

MATERIALS AND METHODS

Materials

The materials used in the research include cement (OPC), fine aggregate from a local seller , coarse aggregate from a local seller, and water from different sources as follows: portable tap waters (from Tamburawa water treatment plant, Challawa treatment plant, Tamburawa old water works, Court road area and Dakata Quarters) and Pond waters (from Ladanai Village at Eastern Bypass Hoto, Gwadogwado pond at Badawa Quarters, Karkasara pond near masallacin Murtala, Sabuwar kofa pond B.U.K road and jakara pond within kano city). In summary, five samples were collected for each water source; however, the sources that gave worst result after analysis were used in the casting and curing of the concrete.

Methods

Particle Size Distribution of Fine and Coarse Aggregates

The particle size distribution for fine and coarse aggregates was done in accordance with BS 812: Section 103.1: 1985. The results are presented in Figures 1 and 2 respectively, which indicates that the sand and the coarse aggregate are uniformly graded.

Concrete Mix Design

The concrete mix design was done in accordance with BS 5328: Part 2: 1991, as presented in (Teychem et al., 1975), popularly know as Department Of Environment (DOE) mix design method. This was adopted for both concrete of grades 20 and 30. The slump test was also carried out on the various fresh samples of the mixed concrete grades.

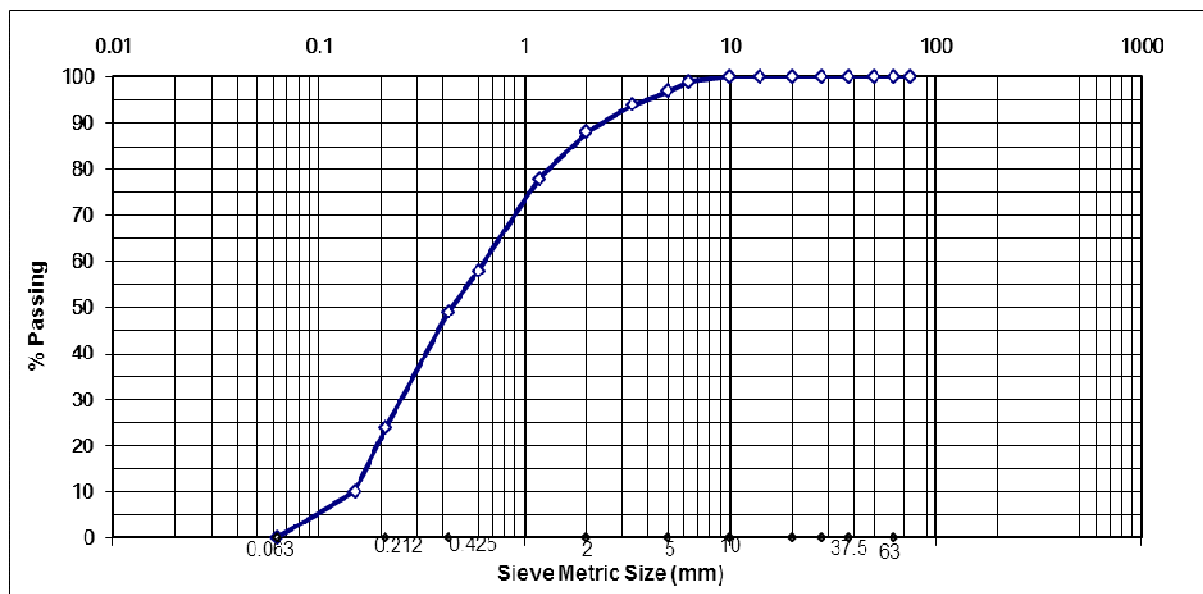


Figure 1: Sieve analysis curve of Fine aggregate Sample

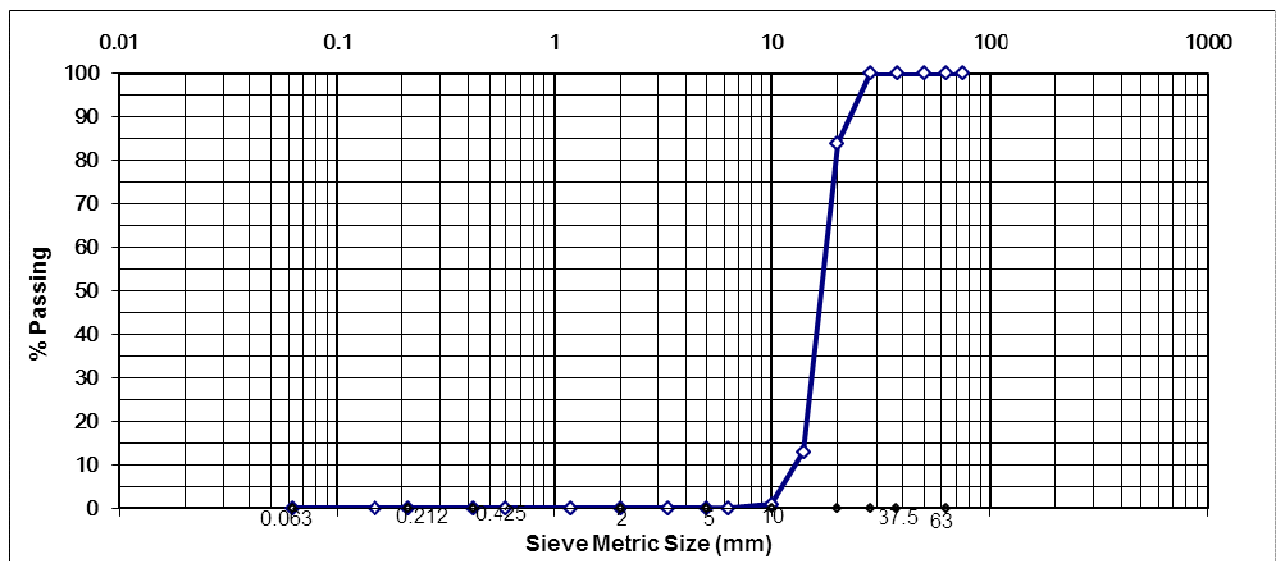


Figure 2: Sieve analysis curve of coarse aggregate Sample

Water analysis

Water test was carried out on the two sources of waters used. In the test the waters were analyzed to determine the following characteristics: pH value, total hardness, sulphate content, turbidity level, total dissolved solids (TDS), and chloride content. The result of the water test representing the worst tap and pond water is presented in Table 1.

Compressive Strength Test

At the age of 28, 56, and 84 days of curing, the compressive strength test of grades 20 and 30 was carried out. The test was done in the Civil Engineering Laboratory of Bayero University, Kano. And it was done in accordance with BS 1881: Part 116: 1983. The results are presented in Tables 2 and 3 respectively.

Table 1: Water Test Results for the worst tap and pond water

Type of water	Tap water	Pond water
pH	7.05	8.95
Sulphate (mg/l)	3.05	0.0
Turbidity (NTU)	0.0	89.07
Total Hardness (mg/l) comprises of carbonates and bi-carbonates	16.0	2,001
Total Dissolved Solids (mg/l)	475.48	205.5
Chlorides (mg/l)	3.07	34.51

Table 2: Compressive Strength Test Results for Grade 20 Concrete.

Casting/ Curing water	Grade of Concrete (N/mm ²)	Compressive strength of cubes (N/mm ²).	Average compressive strength (N/mm ²)	Age (Days)
Tap water	20	33.33 32.89 33.33	33.00	28
Pond water	20	29.78 30.67 32.00	31.00	28
Tap water	20	35.11 33.33 33.78	34.00	56
Pond water	20	31.11 35.11 34.67	34.00	56
Tap water	20	36.00 38.67 33.33	36.00	84
Pond water	20	32.00 31.11 34.22	32.00	84

Table 3: Compressive Strength Test Results for Grade 30 Concrete.

Casting/ Curing water	Grade of Concrete (N/mm ²)	Compressive strength of cubes (N/mm ²).	Average compressive strength (N/mm ²)	Age (Days)
Tap water	30	33.33 32.00 30.67	32.00	28
Pond water	30	29.33 28.89 29.33	29.00	28
Tap water	30	32.89 34.67 33.33	34.00	56
Pond water	30	32.89 30.67 31.11	32.00	56
Tap water	30	34.22 35.56 32.00	34.00	84
Pond water	30	32.89 32.00 33.33	33.00	84

DICUSSION OF RESULTS

Concrete Grade 20 at 28, 56 and 84 days

The mean compressive strengths were obtained from the average crushing load for three cubes of concrete cast. As it can be seen from the results in Table 2, the 28, 56 and 84 day mean compressive strength of concrete grade 20 cast with tap water and the pond water are 33.0 N/mm² and 31.0 N/mm²; 34.0 N/mm² and 34.0 N/mm²; 36.0 N/mm² and 32.0 N/mm² respectively. The results have shown that, concrete specimens cast with tap water gave an average compressive strength value of 33.0 N/mm² which is the target mean strength obtained from the mix design. And this value is higher than that cast with pond water by 2.0 N/mm² (6.06%). The results also showed that the average compressive strength values obtained for concrete specimen cast with tap water and pond water are higher than the characteristics strength of 20.0 N/mm² by 13.0 N/mm² (39.39%) and 11.0 N/mm² (35.48%) respectively. The results showed that, concrete specimens cast with tap water for 56 days gave an average compressive strength value of 34.0 N/mm² which is the same as that of the pond water which are all higher than the target mean strength obtained from the mix design. Therefore, the results also showed that the average compressive strength values obtained for concrete specimens cast with tap water and pond water are higher than the characteristics strength of 20.0 N/mm² by 14.0 N/mm² (41.18%). The results for 84 days also showed that the average compressive strength values obtained for concrete specimens cast with tap water and pond water are also higher than the characteristics strength of 20.0 N/mm² by 16.0 N/mm² (44.44%) and 12.0 N/mm² (37.5%) respectively. Therefore, all the compressive

strength values obtained by using the two water sources in mixing and curing of the concrete specimens are satisfactory. This show that the impurities in the tap water and pond water did not have a serious effect on the compressive strength as such the concrete specimens attained the characteristics strength required.

Concrete Grade 30 at 28, 56 and 84 days

As it can be seen from the results in Tables 3 the 28, 56 and 84 day mean compressive strength of concrete grade 30 cast with tap water and the pond water are 32.0 N/mm² and 29.0 N/mm²; 34.0 N/mm² and 32.0 N/mm²; 34.0 N/mm² and 33.0 N/mm² respectively. The results have shown that, concrete specimens cast with tap water gave an average compressive strength value of 32.0 N/mm² which is less than the target mean strength of 43.0 N/mm² obtained from the mix design. And the value is greater than that cast with the pond water by 3.0 N/mm² (10.34%). The results also showed that the average compressive strength values obtained for concrete specimens cast with tap water and pond water are higher than the characteristics strength of 30.0 N/mm² by 2.0 N/mm² (6.25%) and value obtained for pond water is less than the characteristic strength by 1.0 N/mm² (3.45%). The results showed that, concrete cubes cast with tap water for 56 days gave an average compressive strength value of 34.0 N/mm² which is higher than the characteristics strength of 30.0 N/mm² by 4.0 N/mm² (11.76%) in the mix design. The results for 84 days also showed that the average compressive strength values obtained for concrete cubes cast with tap water and pond water are also higher than the characteristics strength of 30.0 N/mm² by 4.0 N/mm² (11.76%) and 3.0 N/mm² (9.09%) respectively.

Therefore, all the compressive strength values obtained by using the two water sources in mixing and curing of the concrete cubes are satisfactory. This shows that the impurities in the tap water and pond water did not have a serious effect on the compressive strength as such the concrete specimens attained the characteristics strength required.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following conclusions can be drawn from the study.

- 1) The tap and pond water considered within the study area produced concrete with satisfactory compressive strength.
- 2) The two water sources used did not adversely affect the compressive strength of concrete, though compressive strength

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development increases with an increase in the duration of curing.

- 3) Also from the results obtained it is observed that, for grade 20 concrete the target mean strength required in the mix design is attained, while for grade 30 concrete the characteristics strength required in the mix design is attained for the two sources of water used.

Recommendations

From the findings of this study the following recommendation can be made.

- Any of the two water sources can be used to produce concrete grades 20 and 30. However, potable tap water remains the best option to obtain a better compressive strength for concrete.

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