

## INFLUENCE OF WATER QUALITY ON THE COMPRESSIVE STRENGTH OF CONCRETE

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### ABSTRACT

*This study investigates into the effect of water type on the compressive strength of concrete. Chemical analysis was carried out on the 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 grade 20 as well as workability test. For the grade 20, the concrete was cast and cured using tap water and river water. 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 water sources used in the casting and curing of the concrete cubes gave a satisfactory compressive strength. The average compressive strength results of the concrete at 28, 56 and 84 days cast with the potable tap water and Challawa river water are 33.0 N/mm<sup>2</sup> and 30.0 N/mm<sup>2</sup>; 34.0 N/mm<sup>2</sup> and 34.0 N/mm<sup>2</sup> ; 36.0 N/mm<sup>2</sup> and 34.0 N/mm<sup>2</sup> respectively. However, the results of the compressive strength of the concrete attained above the characteristics strength of 20.0 N/mm<sup>2</sup> required in the mix design for potable tap water and the Challawa river water at 28, 56 and 84 days. But, the target mean strength of 33.0 N/mm<sup>2</sup> which is required in the mix design is attained for both potable tap water and the Challawa river water at 56 and 84 days, unless that of the Challawa river water at 28 days which did not attained the target mean strength. Therefore, the results showed that the challawa river water can be used to produce concrete grade 20. But, however, potable tap water remains the best option to obtain a better compressive strength for concrete.*

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

### INTRODUCTION

According to Journal of Materials in Civil Engineering 2009, concrete constitutes a large part of the millions of tons of annual solid demolition waste in many countries. 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).

#### **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). According to Shetty (2001), 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**

The materials used in the research include Ordinary Portland Cement (OPC) made by Ashaka Cement Company obtained from a local seller in Kano, fine aggregate obtained from a local seller in Kano, coarse aggregate was also obtained from a local seller in Kano, and waters from different sources as follows:

portable tap waters (from Tamburawa water treatment plant, Challawa water treatment plant, Tamburawa old water works, Court road area and Dakata Quarters) and river waters (from challawa river at Madobi Village, challawa river at Tamburawa village, challawa river at plant reservoir, kano river at kura town and kano river at kumbotso town). In summary, five samples were collected for each water source; however, the source that gave the best result for tap water and the worst result for the river water after the

chemical analysis was used in the casting and curing of the concrete.

**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 Figure 1 and Figure 2 respectively, which indicates that the sand and the coarse aggregate are uniformly graded.

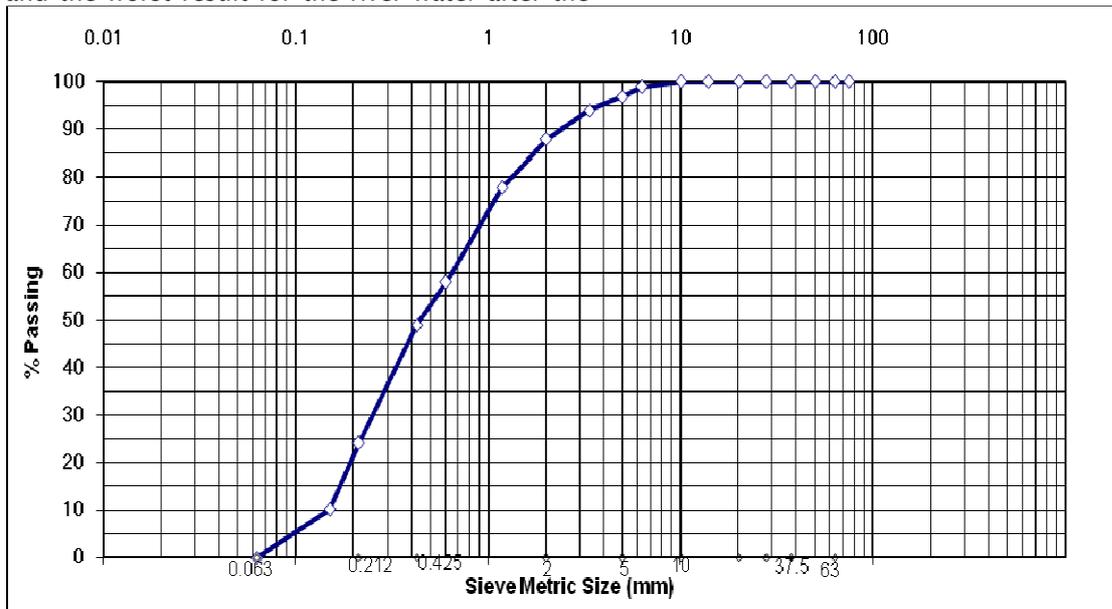


Figure 1: Sieve analysis curve of Fine aggregate Sample

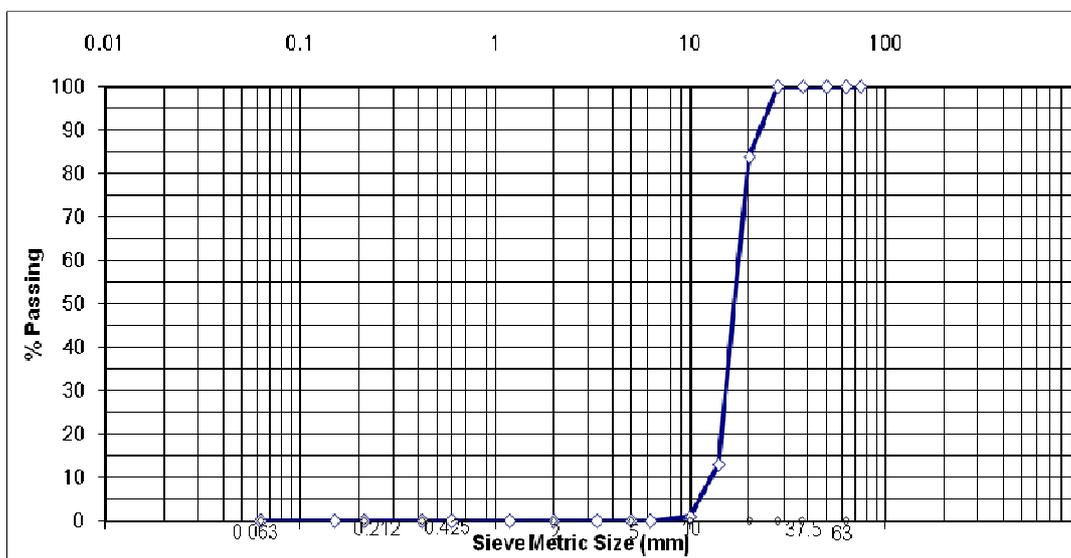


Figure 2: Sieve analysis curve of coarse aggregate Sample

**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 the design of the concrete grade 20. The slump test was also carried out on the various fresh samples of the mixed concrete.

**Water Chemical 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 best tap and worst river water is presented in Table 1.

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

Type of water	Tap water	Challawa river water
pH	7.05	7.48
Sulphate (mg/l)	3.05	97.01
Turbidity (NTU)	0.00	385.11
Total Hardness (mg/l) comprises of carbonates and bi-carbonates	16.00	70.15
Total Dissolved Solids (mg/l)	475.48	560.35
Chlorides (mg/l)	3.07	20.46

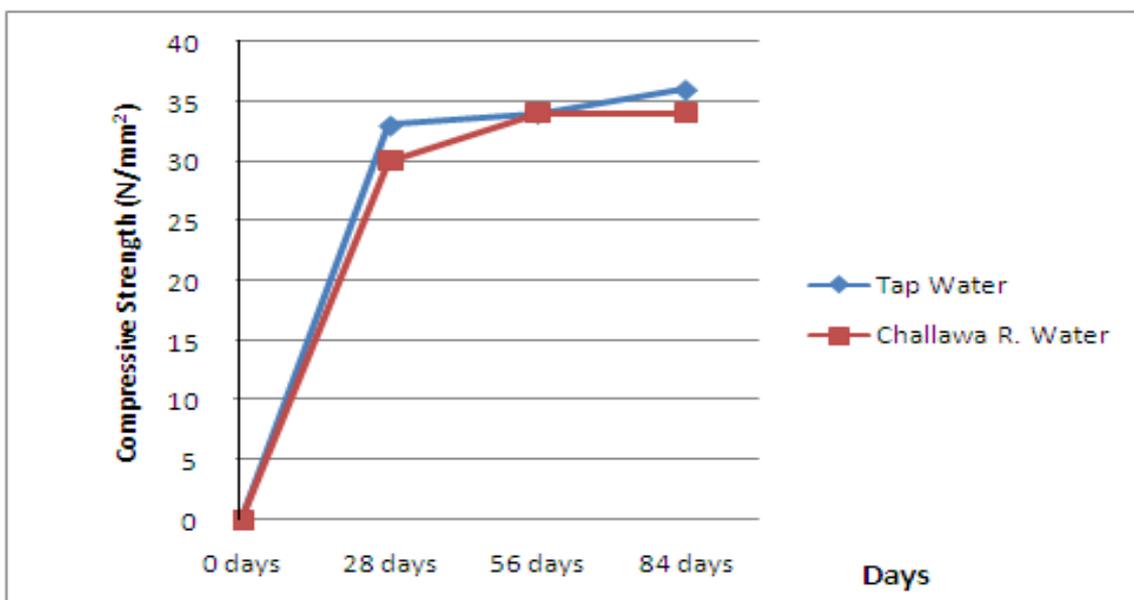
**Compressive Strength Test**

At the age of 28, 56, and 84 days of curing, the compressive strength test of the concrete grade 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 result is presented in Table 2 and Figure 3 below.

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

Casting/ Curing water	Tap water	Challawa river water	Tap water	Challawa river water	Tap water	Challawa river water
Grade of Concrete (N/mm <sup>2</sup> )	20	20	20	20	20	20
Compressive strength of cubes (N/mm <sup>2</sup> )	33.33 32.89 33.33	28.89 31.11 29.78	35.11 33.33 33.78	33.33 35.11 33.33	36.00 38.67 33.33	36.00 33.33 33.33
Average Compressive strength (N/mm <sup>2</sup> )	33.00	30.00	34.00	34.00	36.00	34.00
Age in (Days)	28	28	56	56	84	84
Remarks	Control Specimen	Test Specimen	Control Specimen	Test Specimen	Control Specimen	Test Specimen



**Figure 3: Compressive Strength Test Results using tap and Challawa river water**

## 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 result in Table 2, the 28, 56 and 84 day mean compressive strength of concrete grade 20 cast with tap water and the challawa river water are 33.0 N/mm<sup>2</sup> and 30.0 N/mm<sup>2</sup>; 34.0 N/mm<sup>2</sup> and 34.0 N/mm<sup>2</sup>; 36.0 N/mm<sup>2</sup> and 34.0 N/mm<sup>2</sup> respectively. The results have shown that, concrete specimens cast with tap water gave an average compressive strength value of 33.0 N/mm<sup>2</sup>, 34.0 N/mm<sup>2</sup> and 36.0 N/mm<sup>2</sup> which are above the target mean strength obtained from the mix design. And these values are higher than that cast with challawa river water by 3.0 N/mm<sup>2</sup> (9.09%) at 28 days and by 2.0 N/mm<sup>2</sup> (5.56%) at 84 days. The results also showed that the average compressive strength values obtained for concrete specimens cast with challawa river water are higher than the characteristics strength of 20.0 N/mm<sup>2</sup> by 10.0 N/mm<sup>2</sup> (33.33%) and 14.0 N/mm<sup>2</sup> (41.18%) respectively. The results again showed that, concrete specimens cast with tap water for 56 days gave an average compressive strength value of 34.0 N/mm<sup>2</sup> which is the same as that of the challawa river water which are all higher than the characteristics and target mean strength obtained from the mix design so also that at 84 days. The results as shown in figure 3 above showed that, concrete compressive strengths increases with an increase in the curing days. This has shown that a concrete compressive strength is proportional to the curing days. Therefore, all the compressive strength values obtained by using the two water sources in

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mixing and curing of the concrete specimens are satisfactory. This show that the impurities present in the challawa river water did not have a serious effect on the compressive strength as such the concrete specimens attained the characteristics strength required.

## CONCLUSIONS

The following conclusions can be drawn from the study.

- 1) The challawa river water considered within the study area produced concrete with satisfactory compressive strength.
- 2) The challawa river water used did not adversely affect the compressive strength of concrete, and compressive strength development increases with an increase in the duration of curing.
- 3) Also from the results obtained it is observed that, for the concrete grade considered, the values of the compressive strengths obtained are above the characteristics strength required in the mix design at 28, 56 and 84 days of curing with the use of tap water and Challawa river water. Also, the target mean strength required in the mix design is attained at 56 and 84 days curing period with the use of Challawa river water.

## RECOMMENDATIONS

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

It is recommended that the challawa river water considered in the study can be used to produce concrete grade 20. However, potable tap water remains the best option to obtain a better compressive strength for concrete.