Effect of Selected Sources of Mixing Water on Compressive Strength Development of Concrete in Damaturu Metropolis

Jibrin Umar, Mohommed Yau and Falmata Audu Mustapha
Department of Civil Engineering Technology
School of Engineering Technology
The Federal Polytechnic, Damaturu
Email: jibriumar@gmail.com

ABSTRACT

This study centred on the effect of selected sources of mixing water on compressive strength development of concrete in Damaturu metropolis. The suitability of a particular source of water for making concrete was checked by casting concrete cubes using water sampled from the selected sources, cured for certain period time and determining its compressive strength. This research is conducted using grade 25 concrete mixes 1:2:4 with water / cement ratio of 0.55 using water samples from four selected sources: pond water, hand dug well water, deep borehole water and shallow borehole water. The physical and chemical properties of each selected sampled sources of water were obtained and analysed before making the concrete mixes and found suitable for use in concrete mixes. A total number of 120 concrete cubes of sizes 150x150x150mm were casted and cured for the period of 7, 14, 21, 28, 56 days with each selected sampled water sources. For the determination of average compressive strength development of concrete produced six (6) concrete cubes were crushed at each curing age. The average compressive strength obtained from the concrete made from all the selected sources of mixing water samples have their 7 and 28 days compressive strength of 14.09, 13.83, 16.82 and 14.17 N/mm^2 at 7 days and 28.84, 27.23, 33.65 and 31..85 N/mm^2 at 28 days. It was observed that the compressive strength gain for all test concrete cast with all the selected sampled water sources did not increase significantly after 28 days curing. Generally with the result of this research work, it has indicated that all the selected sources of mixing water considered can be used satisfactorily in concrete production.

Keywords: Concrete; Compressive strength; Sources of water, Mixing water

1.0 Introduction

Concrete is a proportionate mixture of sand, gravel, cement and water. Water is use in concrete making for the purpose of initiating chemical reactions in cement as well as increasing the necessary utility such as flexibility and sensitivity of concrete for its hydration. (Gholizadeh & Arabshahi, 2011). Complete hydration of cement continues for a very long period time with sufficient water; "*taking about 30% completion 3 days, about 60% completion in 7 days and approximately 98% complete in 28 days*" (Chemmasters, 2016) or 85 – 90% for Ordinary Portland Cement concrete made with distilled water as specified by most standard codes of practice in the literature (Taha, Al-Harthy, & Al-Jabri, 2010). The Quality and quantity of mixing water are generally related to its performance in fresh and harden state and it is the most important determining factor that controls the concrete properties, it is considered to have both beneficial and detrimental effect on properties of concrete (Madhusudana, Reddy, & Ramana, 2011). Any water suitable for drinking is suitable enough for concrete construction; but that this assertion is not always true as water containing sugar is drinkable to some categories of people, but may not be suitable for concrete making (More & Dubey, 2014; Christopher & Peoples, 2015).

Potable water is usually used in construction industry as recommended by most of standard specifications because of its known chemical composition which is well regulated during construction processes (Al - Jabri, Al - Saidy, Taha, & Al - Kemyani, 2011). Most design codes, recommended that the compressive strength of concrete cubes made with water of unknown quality should not to be less than 90% of cubes compressive strength made with distilled water (Taha, Al-Harthy, & Al-Jabri, 2010). Water of unknown quality from alternative sources must meet certain chemical and physical requirements suitable for concrete production that could maintain its properties such as setting time, expected compressive strength and durability (Paula & Ilha, 2014; Shynie, et al.; Ikechukwu, 2015). Water for mixing and curing concrete should not contain impurities that would negate hydration reactions of cement and its compounds (Paula & Ilha, 2014). It should be free from any organic or inorganic substances that could harm the concrete in its service life (Gholizadeh & Arabshahi, 2011). When assessing the suitability of water of unknown quality for the production of concrete, both the composition of the water and the application of the concrete to be produced should be considered. The suitability and performance of any type of mixing water from a particular source for concrete can be measured from the ratio of the 28 days compressive strength to that of a similar mixes with water of known quality.

The increase in the construction activities as well as the population growth in Damaturu Metropolis caused a substantial increase in the water demand. As portable drinking water is becoming scarce, the general populace uses any alternative available water of questionable quality for their construction activities. Taking into consideration the scarcity of potable water and its demand for the construction and developmental works there is need to examine the usefulness of some selected alternative sources of mixing water for making concrete. It was specified that any water from any source with questionable and non portable quality can be used for making concrete (ASTM C1602, 2004; BS EN 1008, 2002) as water has no undisputed importance in concrete as such there is no alternative to it (Peche, Jamkar, & Sadgir, 2015).

2. 0 Materials and Methods

2.1: Cement

The cement used in this study is commercial Ordinary Portland cement (OPC) classified as CEM -1 (BS EN 197 - 1 , 2011) with a strength class of 42.5/52.5N obtained from a Cement Deport in Damaturu. This cement is the most widely used one in the construction activities in Damaturu. In using mixing water from selected sources of water under considerable qualities, the practical solution is to tests for setting time and compressive strength of concrete and comparing the results obtained between the water of proven quality. Setting of cement concrete is usually affected by the water types and its sources (Ghorab, Hilal, & Anter, 1990).

2.2. Aggregates

Coarse aggregate of nominal maximum of 12.5mm obtained from a nearby aggregates deport in Nayinawa area, which are typically the same materials used in normal concrete mixtures in Damaturu was used. The coarse aggregate met the grading requirements specified in (BS EN 932, 1999); the fine aggregate used is a clean river sand obtained Kuyel village

2.3 Mixing Water

Water samples were obtained from four Drinking water sources; deep bore hole; Shallow bore hole; hand dug well and pond water. These samples were analyzed for certain impurities that could affect concrete mixes which included: total dissolved solids total, total water hardness, sulphate content, chloride content , and nitrate. Other parameters such as pH and temperature were also measured at the point of samples taking.

2.4 Concrete preparation and test method

For this research work, concrete cubes of sizes 150x150x150mm were prepared. A nominal mix ratio of 1: 2: 4 and water/ ratio of 0.55 were adopted. For the test samples weight batching was adopted for accuracy. The cast concrete cubes were cured with the same water sampled for their production by total water submersion. The cubes were removed from water bath and allowed to dry until they are ready for testing. Six (6) concrete cubes were taken for compressive strength development for all selected sampled of sources of water for each curing ages of 7, 14, 21, 28 and 56 days. The concrete cubes were loaded to failure on an automatic compressive testing machine and the maximum failure load sustained by each cubes and compressive strength was read and recorded.

3.0 Results and Discussions

Table 3.1: Properties of Cement

Properties	Initial setting time	Final Setting Time	Slump (mm)
Deep borehole (tap water)	45	10hrs	95
Shallow borehole	50	11hrs	90
Pond water	60	14hrs	80
Hand dug Well	53	12hrs	85

Table 3.1 shows the initial and final setting times determined for various cement paste mixes with the different sources of water used for the research. The data indicate that there was a slight increase in the initial and final setting times as compared to the cement paste made with deep borehole water. The higher initial and final setting in concrete made with pond water, hand dug well water and shallow borehole water could be as a result of excessive total dissolved solid of 194 mg/l, 230m/l and 190mg/l in mixing water. These values exceeded the minimum forty-five minutes initial setting and not more than ten hours of final setting requirement as set forth in cement specifications (ASTM C1602, 2004; BS EN 196 - 3, 2016). \\the results of the slump test conducted shows that when pond water and hand dug well water were used in the concrete mixes, lower minimum slump was obtained as compared to that of the concrete mixes made with deep borehole water (tap water). This could be as a result of higher quantities of suspended solid and fine particles, which tend to increase the quantity of water for a required workable concrete, and consequently result in to lower concrete slump.

Table 3.2: Physical properties of aggregates

Properties	Coarse aggregate	Fine aggregate
Specific gravity	2.67	2.59
Unit weight	1635Kg/m^3	1540Kg/m^3
Fineness modulus	6.45	2.57
Absorption	0.8%	1.2%

The physical properties of aggregates used for the research shown in table 3.2 indicate that the Specific gravity of fine and coarse aggregate are found to be 2.59 and 2.67 respectively. These indicate that the results obtained fall within the standard specific gravity for aggregates values of 2.5 and 3.0 respectively as indicated in (BS EN 932, 1999). The densities of fine and coarse aggregate were found to be 1540kg/m ^{3} and 1635kg/m^3 which is adequate for the research and is within the range for specified in (BS 882, 1992) aggregate for concrete mixtures.

Table 3.3: Results of physiochemical analysis of water samples

Characteristics	Hand Dug Well	Pond water	Deep bore hole	Shallow Bore hole
pH	8.0	7.3	7.7	7.2
Temperature	28^{oC}	30^{oC}	28^{oC}	27^{oC}
Total Dissolve solid	194 (mg/l	230m/l	180mg/l	190mg/l
Total hardness	143mg/l	340mg/l	22mg/l	33mg/l
Turbidity	44NTU	267NTU	1.8NTU	2.1NTU
Nitrate	22.1mg/l	36.8mg/l	0.9mg/l	1.1mg/l
Chlorine	56m/l	451mg/l	30m/l	34m/l
Sulphate	55mg/l	75m/l	1.0mg/l	1.2mg/l

3.1 Water Quality Analysis

Table 3.3 presents of the chemical analysis results on the four sources of mixing water. The data indicate that all the chemical compositions of the four selected sources of mixing water were much higher than those parameters found in deep borehole which is considered as suitable for concrete making. The pH values obtained varies significantly which could be attributed to the different sources of mixing water and were within the permissible range (6 - 8) for mixing water as was described in (ASTM C1602, 2004). The maximum total dissolved solids of 230 mg/l, 194mg/l and 180mg/l for surface water, hand dug well, bore hole is acceptable since it is below the standard requirement of 2,000 mg/l as specified by (BS EN 1008, 2002) which can generally be used as mixing water for concrete. Also, the sulphate concentration of 55mg/l, 75mg/l and 1.0mg/l for Hand Dug Well, Pond water, shallow bore hole and Deep borehole (Tap water) are less than the threshold limit of 3,000mg/l as stated in British standard for mixing water for concrete. Results of turbidity test conducted on samples water are all below the turbidity limit of 2,000 mg/l, these proved to be adequate for mixing concrete.

The results of the chemical analysis conducted on the mixing water from the four sources of water are all found to be below the permissible limit set out in (BS EN 1008, 2002) for mixing water. This clearly indicates that the mixing water from the four selected sources used for this research can be satisfactorily used as mixing water for concrete admixtures.

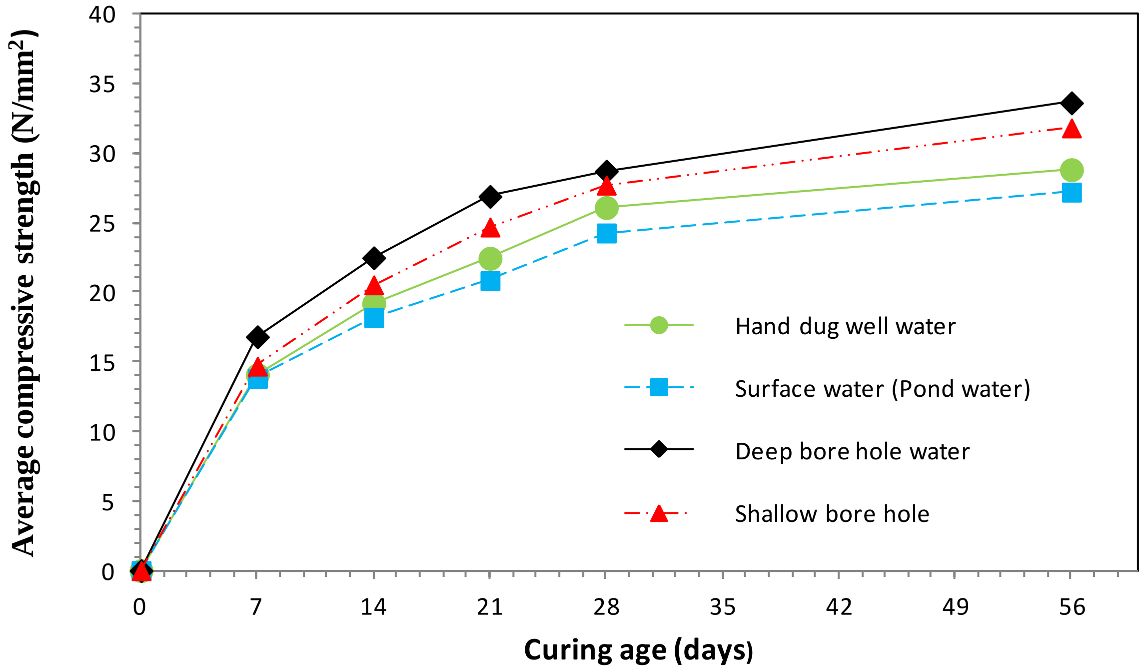

Figure 3.1: Compressive strength development for concretes cubes using various sources of mixing water

3.2 Compressive Strength Test Results

Figure 3.1 represents the compressive strength development for the test concretes using water from the four sources at various curing age. From the test results, it was observed that the compressive strength for all test concrete cast with all the sampled water sources increased with an increase in curing age at different rate. It was further observed that the compressive strength did not increase significantly after 28 day of curing for all the concrete cubes made with water from the sampled sources. From the figure above, it could be seen that compressive strength of concrete produced using deep borehole water as mixing water for concrete exhibited high compressive strength gain compared to compressive produced using water from the other sources at both 28 and 56 days curing ages. The compressive strength of concrete prepared using pond water as mixing water for concrete exhibited lowest compressive strength at both 7 and 28 days curing as specified in (BS 8110: Part II, 1997) as compared to compressive strength of concrete prepared using other sources of mixing water. This mixing water had shown relatively high total dissolved solid, total hardness and turbidity as indicated in table 3.3 which could be the reason for the lower compressive strength

4.0 Conclusion

The compressive strength obtained of 14.09, 13.83, 16.82, 14.17 N/mm^2 at 7 days and 28.84, 27.23, 33.65, 31..85 N/mm^2 at 28 days curing for all the concrete made from the selected sources of mixing water samples have the 7 and 28 days have made the 85 – 90% strength gain for ordinary Portland cement concrete as compared to grade 25 concrete. The selected sources of sampled mixing water have different levels of physical and chemical total dissolved solid and impurities and these generally were observed to have certain negative impact on the compressive strength of concrete based on the individual sources considered. The results generally indicate that the all the selected sampled sources of mixing water considered can be used satisfactorily in concrete production.

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