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Determining the Effect of Water Quality On The Strength Of Concrete Using Water Samples from Ureje River, Ado-Ekiti, Ekiti State, Nigeria.

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Abstract
Concrete develops strength when water reacts exothermically with water in a process termed hydration of cement. The quality of reactants, no doubt, would have a great influence on the quality of the final concrete product. Ureje is a river that flows across several settlements within the Ado – Ekiti environment. It is considered by many small and medium sized contractors as a ready source of water for mixing concrete. It is observed there are no heavy industries discharging their effluent into river Ureje.. This paper examines the quality of water obtained from the Urejeriver and its likely influence on strength development of concrete over a period of 28days. Water samples obtained at two different points separated by a distance of about 3kilometers were analyzed for their chemical content. Concrete cubes of 150mm sides were cast using the two water samples. The results did not show significant differences in the chemical composition, pH values and the dissolved solid content. The destructive strength testing method using the crushing machine was carried out at 7 days, 14 days, 21 days and 28 days. The compressive strength of 16.9 N/mm^2 developed at 28 days may be considered inadequate for high loading conditions which often require a strength of 21N/mm^2 within the same period. Compared with the cubes cast with water samples from the drilled borehole within the same study area, a slightly lower rate of strength development was observed. It was thus recommended that the best source of water for high quality work in the research area is the drilled borehole but for those building works where the concrete is not required to develop more than 16N/mm^2 in 28 days, Ureje river water is adequate.
***Key words:* concrete, Urejeriver, quality, strength.**

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I. Introduction

Strength is developed in concrete as a result of the reaction between cement and concrete. The rate at which a chemical reaction proceeds will among other factors be influenced by the purity of the reactants. (Neville,1995)

The process of strength development is therefore defined by the rate of reaction between water and cement. These two reactants must be in sufficient quantities and of the right quality for complete and speedy reaction.

Fagbohun& Mohammed, (2017) citing The Nigerian Institute of Building reports on collapsed buildings observed that some buildings collapsedunder construction due to premature loading of concrete members that were yet to developthe adequate strength required to bear the load imposed on them.In some instances, the number of days during which the concrete is expected to have developed adequate strength, usually 28 days, would have lapsed before the load is imposed yet the structure failed which could be a pointer to a slower rate of strength development than envisaged.

In Nigeria, it is not unusual to find contractors sourcing for water, using motorized tankers, from rivers, ponds and similar natural sources. Ado Ekiti, the study area is gradually moving away from the sleepy fairly big rural town to full urbanization. There has been in recent times a new trend in building developments. Higher number of storeys are now being favoured as opposed to bungalows and single storey buildings of the previous times. There is thus a need to pay more attention to structural members which are exclusively constructed with reinforced concrete.

Some of the small and medium sized contractors as identified in Fagbohun and Mohammed (2013)find in Urejeriver a cheap, readily available source of water for construction of residential and in recent times, commercial buildings.

Oftentimes, rivers such as the ones investigated herein contain impurities caused by partially dissolved refuse of different descriptions dumped in them at various points through their journeys. The chemical composition of these wastes, dissolved or in suspension, could have significant impact on the nature of the water and an influence on the rate of strength development of the concrete mix.

In construction works, the 28-days strength is normally taken as the standard for further imposition of loads to take place. By that date the concrete is believed to have developed at least 60% of the strength it will ever do. BSI (2000)

The main purpose of this paper was to study the rate of strength development of concrete produced over a period of 28 days using water sourced from Urejeriver.

The role of water in Concrete Production

Concrete has proven through the ages to be a reliable material for virtually all types of construction works in all parts of the globe. It is made from a well-proportioned mixture of cement and aggregates with water. The rock-solid mass formed on drying has such a high compressive strength that it can resist loads imposed. Additionally, in its green state, it is plastic and can thus be formed into various shapes required to improve the aesthetic quality of the structure. Other qualities which make concrete such an attractive construction material is its ability to resist fire attack and survive under fairly intense heat.Arunakanthi*et al*(2012). Also, tensile strength can be introduced to complement its natural compressive strength by the introduction of steel bars in the tension zone. (Mosley,Bungey& Hulse,2007)

The aggregates constitute the bulk of the volume but the strength is determined by the reaction of cement with water. The water cement ratio is thus an important factor of consideration. BSI (2000) requires that the water considered as fit for drinking is the only type that should be used for the mixing which could be done manually or better still, by the use of a concrete mixer.Whatever method is used, the ratio should not be less than 38% by weight to ensure adequate flow and workability. Excessive use of water during the initial mixing or re-tempering of the concrete after initial setting has taken place has been reported to lessen the strength of concrete. (Lee, 1971), Neville (1996) and Gupta & Gupta (2012).

The emphasis on fitness for drinking is considered from two premises: one is the tendency for certain chemical contents to interfere with the procedure of setting. In chemical reactions certain chemicals outside the original reactants may be introduced to hasten or slow down the rate of chemical reaction as desired. They are called catalysts and inhibitors respectively. Similarly, chemicals may be introduced to hasten the rate of setting of cement and thus strength development. Such substances are called accelerators. An example is calcium chloride. $CaCl_2$. On the other hand, there are substances, usually of organic origin, which if present in the water for mixing could slow down the rate at which the cement hardens. Generally called retarders, an example is finely divided coal. Al-Manseer*et al* (1988), Neville (1996). While the final strength developed may not vary much after a long period post production, the speed with which strength is developed may be important to the job at hand. For example, in mass concrete work, a slower rate of hardening will evolve less heat and is therefore preferred whereas in extreme cold weather, water for mixing would has to be warmed and rapid hardening cement used. Seeley(1995). Since water evaporates under ambient temperature and could thus lose some moisture, it is important to ensure that there be devised some measure to ensure that water is retained in the cast concrete until the hydration process is completed. There are a number of methods of doing this as described in Seeley, (1995), Neville (1996) and Falade (1991) and supported by other authors cited herein.

The Urejeriver

Ado – Ekiti is the capital City of EkitiState in South West Region of Nigeria. Ureje is the major river which flows rather gently, except after a heavy rainfall, through the city.Bridges are constructed across it in two different places: along Ikere road and along Poly/Ikare road in the City.Water tankers and operatives on small sites can sometimes be seen drawing water for their works from the river. Urejeriver is not known to effluents discharged into it from any manufacturing or extractive industry within the geographical area of this research. However, refuse mostly from household and commercial premises are observed to be dumped into the river especially via run-offs during the rainy season. Adults, particularly male adults are often observed taking their bath after their daily work at different areas through which the river flows. Similarly, clothes are washed and artisan/agricultural tools cleaned therein. The manner in which these have modified the initial character of the river is reflected in the values of pH, amount of suspended solids per million and the presence of ions and organic substances in its water samples. Casual observation does not present a brackish appearance for the better part of the year. However, it presents the light brown colour for some hours after a heavy rainfall due to the fact that run offs flow into it from different areas increasing temporarily, the water volume and solid matters in suspension.

II. Methodology

Two criteria were considered in evaluating the suitability of water used for mixing concrete. One was whether the impurities in the waste water from questionable sources would affect the compressive strength of concrete and the other is the degree of impurity which can be tolerated.Both (BSI 2000) and The American Standard ASTM C 94 recommends that at the age of 28days mortar/concrete strengths for cubes made with distilled water is sufficient to commence loading.

This study analysed the quality of water from Urejeriver in Ado-Ekiti during the month of August. Rainfall had been on for about 3 to 4months and taken a break in the month of August as is normal annually in the study area. The analysis was to determine the level of total dissolved solid (TDS) of impurity present and the pH value of each sample of water collected before using them to cast concrete.

Going by findings of Neville (1996), the pH range between 6.0 and 8.0 have no significant effect on the compressive strength of concrete. And according to BS 3148: Methods of test for water for making concrete, the permissible limit of total dissolved solids (TDS) is 200ppm (part per million). The analysis was to investigate whether or not water samples tested have their TDS within the acceptable limit. The laboratory tests were also to indicate the levels of metallic ions dissolved in the water samples.

The Ureje water sample was labelled "UR". 150mmx150mmx15mm cubes were cast in steel moulds using the 1:2:4 mix ratio. The cement used was Ordinary Portland Cement (OPC) meeting the requirements of BS EN 197-1 (2001). The coarse aggregate was granite, i.e crushed rockto nominal maximum size of 12.5mm The coarse aggregate met the grading requirements of BS EN 932 (1999); its water absorption was 0.6% and its specific gravity 2.65 obtained from a quarry in nearby Akure, Ondo State while the fine aggregate was clean river sand with water absorption of 0.8% and a specific gravity of 2.70. Water sourced from a drilled borehole, the source of drinking water for Students of the School of Engineering in The Federal Polytechnic, Ado- Ekiti was used as the control experiment. It was labelled "EW".The method of curing was by immersion in a water - filled tank for 3 days in line with the recommendations of Smith (1976) and Falade (1991).

Compressive strength gained was determined for samples using a compression testing machine conforming to BS EN 12390-4. The test specimen was 150mm X 150mm cube meeting the requirements of BS EN 12350-1, EN 12390-2 and EN 12390-3. Specimens were loaded till failure occurred for 3 samples at 7, 14, 21 and 28 days. The maximum load sustained by the specimen was recorded and the compressive strength of the sample was calculated. The average for the 3 samples was on each of the days recorded as the compressive strength.

Compressive strength= load (N) /area of the surface mm^2.

III. Findings And Discussions

The water samples were taken to the Chemistry laboratory of the School of Science and Computer studies, The Federal Polytechnic, Ado-Ekiti for analysis. The metallic ions, chlorides, sulphates and the organic matter contents were investigated. The results were recorded and analyzed with the aim to determine the presence of substances which could act as accelerators and /or retarders. The results are as presented in Table 1.0 below:

Table 1.0: Laboratory result of water used to cast concrete cube

Sample ID	pH	TDS PPM	K^+ PPM	Na^+ PPM	Mg^{++} PPM	Cu^{++} PPM	Zn^{++} PPM	Pb^{++} PPM
S1/EW	7.0	1.70	18.19	3.90	0.03	0.01	0.13	0.15
S2/UR	6.50	8.40	7.20	2.90	3.85	2.01	1.12	1.30

Source: field work 2020

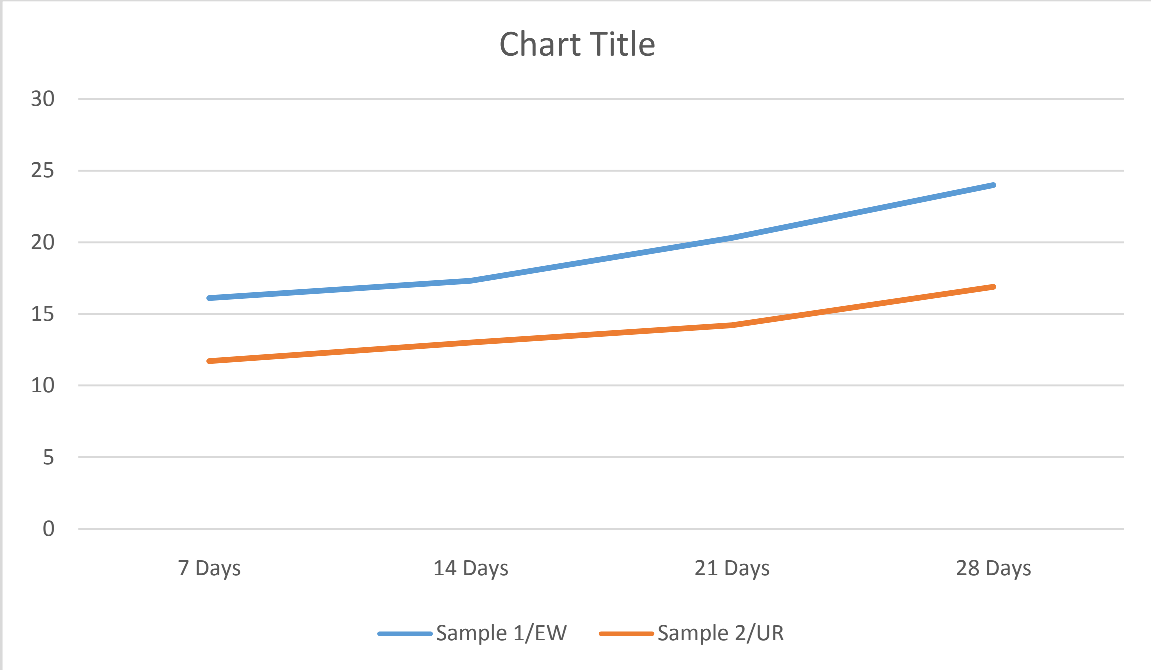
HINT: PPM: part per million; **TDS:** Total dissolved solid;**UR:**Ureje river;**EW:** Engineering water.

Table 1.0 above shows that the pH values for both falls within the acceptable limits of 6-8 mentioned earlier in this work. It is however observable that the TDS detected in Ureje water sample is about 5 times that of the borehole. This is still within the prescribed limits prescribed BSI and the ASTM. The water can thus be used for mixing concrete.

Table2.0: Average compressive strength of the samples

Water sample	7 DAYS	14 DAYS	21 DAYS	28 DAYS
Sample 1/EW	16.1	17.3	20.3	24.0
Sample 2/UR	11.7	13.0	14.2	16.9

SOURCE: field work, 2020



From Table 2 above, it is evident that there is a gradual increase in compressive strength of all concrete cubes cast with water from the sample 1/EW which is water from School of Engineering with an increase in curing age though at different rates. This agrees with the report Obi (2016) and that of Ochuko (2019). The sample 1/EW has the value of 24N/mm^{2}at 28 days while that of Ureje was 16.9N/mm^2. Similarly, the values recorded for the sample was higher every testing day. This result implies that that the water from Ureje river produces concrete of lower strength at 28days compared with water from the borehole. The implication of the foregoing is that concrete mixed with water from Ureje source, has a slightly highersetting time. The lower strength at 28 days also implies that such concrete product requires more than 28 days to be ready for loading if the estimated load exceeds 16.9N/mm^2.

IV. Conclusions

The results of the crushing strength test have shown clearly that the quality of water does influence the rate at which concrete develops strength. Waters in which much organic wastes have partially dissolved or are in suspension such as the Urejeriver studied in this paper has been shown to display a tendency to set develop somewhat more slowly. It was thus concluded that different water sources have different levels of impurities and these generally have significant impact on the strength of concrete. In addition, the compressive strength of concrete increases with age.

V. Recommendations

Based on the findings of this research, it was recommended as follows:

Since there is hardly any reliable treated water supply for the purpose of drinking from the mains in many places in Ado Ekiti and similar cities in Nigeria, major building projects should use water from the boreholes. Such high quality projects may not find water from sources like Ureje river good enough especially when ordinary Portland cement is used and time of completion is of essence.

Where there is a dearth of pipe borne water as is the case in the study area and the scope of the project is such that the cost of drilling a borehole cannot be accommodated, an effort should be made to test water samples from a number of proposed sources before use.

Tests may have to be extended beyond 28 days in some cases to be able to actually determine the period of time within which the estimated load can be safely imposed where water for mixing is suspected to contain impurities which may interfere with the process of strength development.

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