Pak. j. sci. ind. res. Ser. A: phys. sci. 2012 **55** (3) 169-171

Short Communication

Water Quality and the Compressive Strength of Concrete–A Case Study of Hydrogen Point Concentration

Ogheneale Umukoro Orie
Civil Engineering Department, University of Benin, Benin City, Nigeria

(received November 2, 2010; revised June 30, 2011; accepted July 25, 2011)

Abstract. Concrete samples of standard mix of 1:2:4:0.55 with water of different pH values ranging from 1 to 12 were cured in a water tank containing distilled water for 7, 14 and 28 days at room temperature after which they were tested for compressive strength. Results showed that the compressive strength of concrete decreased as the value of the hydrogen ion concentration increased and as the basicity of the mix water was increased, the strength of concrete was reduced. The highest compressive strength of 33.5 kN/mm^2 was achieved at a mix water pH of 7.

Keywords: hydrogen ion, water pH, concrete, compressive strength

Concrete is made up of: fine aggregates, coarse aggregates, cement, water, and sometimes admixtures (Orie, 2008). Concrete cured in water, develops to its optimal strength rather than that not cured in water due to the constituent cement requiring sustained water content for complete hydration. Temperature of curing water and its quality, to a large extent contributes to the quality of concrete produced. Potable water is recommended for a good quality concrete (BS 3148:1980).

Ehigie (1994) studied that the waters collected from the different sources gave different compressive strength results; similarly Kliegar (1956) showed that cubes cured at higher temperatures had higher compressive strength during the first few days after casting, but the situation changed after seven days. Dodson and Rajagopalan (1979) showed that, for a 5% increase in temperature, there was a decrease in compressive strength of 1.9 mm^{-2}. Bentur and Jaegermann (1991) noted that inadequate curing in a hot, dry environment may have only a small detrimental effect on strength but a marked negative influence on the performance of the skin.

Saricimen *et al*. (1992) recommended that, in the aggressive and severely corrosive environmental conditions of the Arabian Gulf countries, utmost emphasis should be given to produce dense and impermeable concrete, to extend the service life of structures. Esegine (2010) recommended using calcium nitrate in concrete structures in acidic environment to mitigate the effect of the acid.

E-mail: ogheneale@yahoo.com

Mufazalov and Demidov (1977) showed that the seepage of water through concrete and reinforced concrete structure promoted the leaching of calcium oxide which led to the breakdown of the silicates making up the mortar and also to corrosion of the reinforcement resulting in weakening of the reinforced concrete.

Several other factors from the inherent composition of the concrete constituents to the mix proportion and their effect on its mechanical properties were studied by the earlier researchers (Burubia and Dagogo, 2007; Paul *et al*., 2001; Pavlik, 2000 & 1994; Yilanaz *et al*., 1998; Kompen, 1997; Soroushian *et al*., 1991).

The present study examines the effect of pH of water on the compressive strength of concrete.

Preliminary tests were carried out on the particle size distribution and specific gravity of the aggregates materials used. Ordinary Portland cement conforming to ASTM C 150, the coarse and fine aggregates from Ofosu and Okhuahe rivers, respectively and sulphuric acid and sodium hydroxide for preparing media of specific pH.

All the pH values were recorded with the acid of the pH meter. Two sets of sample cubes were made in accordance with ATMC 109 -92. (100 mm × 100 mm × 100 mm), with a standard mix ratio of 1:2:4:0.55 (cement, fine aggregate: coarse aggregate: water) the first set with the water of pH varying from 1-12 and the second with distilled water which served as control.

The particle size distribution of the aggregates was according to AHSTO classification (Hogentogler and

Terzaghi, 1929) with fine aggregate belonging to zone 5 of the classification, whereas the maximum diameter of the coarse aggregate was 20 mm, the average specific gravity of the fine aggregate was 2.61 and that of the coarse aggregate was 2.66. The fine aggregate had a bulk density of 1.62 g/cm^3. Tables 1-3 present the numerical result of the compressive strength test. Three replication samples were tested for each pH and the average compressive strength determined.

The curves of Fig. 1 show that the compressive strength of the concrete samples increased with increase in age. The compressive strength of the concrete decreased as the pH of the mix water increased. This is attributable to the alkali -silica reaction (ASR) between the hydroxyl (OH^-) ions in the pure solution and certain siliceous components of the aggregates. The presence of the high concentration acid medium in the pure solution resulted in a high OH^- concentration and thus high pH that led

Table 1. Compressive strength of concrete in acidic medium

pH	7 days (N/mm^2)	Average (N/mm^2)	14 days (N/mm^2)	Average (N/mm^2)	28 days (N/mm^2)	Average (N/mm^2)	Materials (kg/m^3)			
							Cement	Fine agg.	Coarse agg.	Mix water
1	100		165		210					
1	155	15.5	170	16.7	210	20.8	380	512	1349	190
1	155		165		215					
2	160		170		200					
2	165	16.7	175	17.5	220	21.5	380	512	1349	190
2	175		180		225					
3	175		200		230					
3	185	18.0	210	20.8	225	23.0	380	512	1349	190
3	180		205		235					
5	200		220		270					
5	205	20.5	230	23.0	275	27.0	380	512	1349	190
5	210		240		265					

Table 2. Compressive strength of concrete in basic medium

pH	7 days (N/mm^2)	Average (N/mm^2)	14 days (N/mm^2)	Average (N/mm^2)	28 days (N/mm^2)	Average (N/mm^2)	Materials (kg/m^3)			
							Cement	Fine agg.	Coarse agg.	Mix water
9	228		270		300					
9	210	213	250	259	290	295	380	512	1349	190
9	200		257		295					
10	220		265		300					
10	230	220	285	273	290	303	380	512	1349	190
10	210		270		320					
11	200		250		280					
11	230	222	250	260	300	300	380	512	1349	190
11	235		270		320					
12	190		240		290					
12	195	195	280	245	300	290	380	512	1349	190
12	195		245		280					

Table 3. Compressive strength of concrete in neutral medium

pH	7 days (N/mm^2)	Average (N/mm^2)	14 days (N/mm^2)	Average (N/mm^2)	28 days (N/mm^2)	Average (N/mm^2)	Materials (kg/m^3)			
							Cement	Fine agg.	Coarse agg.	Mix Water
7	220		280		330					
7	230	225	275	282	240	235	380	512	1349	190
7	225		200		235					

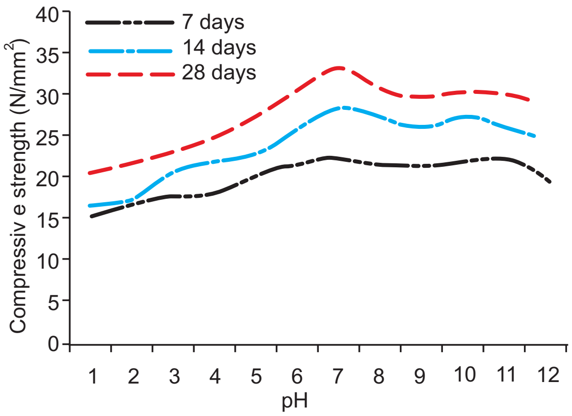

Fig. 1. Relationship between compressive strength and pH of mix water.

to the initial breakdown of reactive silica components in the aggregates which weakened them. The alkali also ultimately contributed to the exposure of the aggregates to ASR gel formation, hence the lower compressive strength of the concrete within the region where the pH was greater than 7. The highest compressive strength of 33.5 kN/mm^2 was achieved at a mix water pH of 7, that is, neutral. This result is in agreement with BS 1348 recommendations. It is recommended that water containing dissolved chemicals should be avoided in concrete, as these may lead to low compressive strength. Water of pH 7 is recommended for use as mix water in concrete design and production.

References

Bentur, A., Jaegermann, C. 1991. Effect of curing and composition on the properties of the outer skin of concrete. *Journal of Materials in Civil Engineering*, **3:** 252-262.

BS 3148: 1980. *Methods of Test of Water for Making Concrete*, British Standards Code, London, UK.

Burubai, W., Dagogo, G. 2007. Comparative study of inhibitors on corrosion of mild steel reinforcement in concrete. *Agricultural Engineering International*, **9:** 1-10.

Dodson, C.J., Rajagopalan, K.S. 1979. Field tests verify temperature effects on concrete strength. *Concrete International*, **12:** 26-30.

Ehigie, E.O.K. 1994. The effect of water quality on the strength of concrete, *M. Eng. Thesis*, University of Benin, Benin city, Nigeria.

Esegine, O.M. 2010. The Effect of Hydrogen Point Concentration of Mixing Water on the Compressive Strength of Designed Concrete, *B. Eng. Project*, University of Benin, Benin city, Nigeria.

Hogentogler, C.A., Terzaghi, K. 1929. Interrelationship of load, road and subgrade. *Public Roads*, pp. 37-64.

Kompen, R. 1997. Corrosion of metals in association with concrete. *Journal of Technological Advancement*, **33:** 40-45.

Kliegar, P. 1956. Effects of mixing and curing temperature on concrete strength. *Journal of American Concrete*, **54:** 1063-1082.

Mufazalov, M.G., Demidov, V.V. 1977. *Controlling Water Seepage Through Concrete*, Plenum Publishing Corporation, USA.

Orie, O.U. 2008. Five-Component-Concrete Mix Optimization Using Scheffe's Theory -A Case Study of Mound Soil as a Mix Component, *PhD Thesis*, University of Benin, Benin City, Nigeria.

Paul, K., Joseph, F., Lamon, D. 2001. Significance of test and properties of concrete and concrete making materials, pp. 71-76, *American Society for Testing and Materials Publication*, USA.

Pavlik, V. 2000. Effect of carbonate on the corrosion rate of cement mortars in nitric acid. *Cement and Concrete Research*, **30:** 481-489.

Pavlik, V. 1994. Corrosion of hardened cement paste by acetic and nitric acids. *Cement and Concrete Research*, **24:** 551-562.

Saricimen, H., Maslehuddin, M., Al-Mana, A.I., Eid, O. 1992. Effect of field and Laboratory curing on the durability characteristics of plain and pozzolanic Concrete. *Cement and Concrete Composites*, **14:** 169-177.

Soroushian, P., Aouadi, F., Nagi, M. 1991. Latex modified carbon fiber reinforced mortar. *ACI Materials Journal*, **88:** 11-18.

Yilanaz, A.B., Yazici, B., Erbil, M. 1998. The effect of sulphate ion on concrete and reinforced concrete. *Cement and Concrete Research*, **27:** 1271-1279.