Standard Scientific Research and Essays Vol 11(4): 107-113, April, 2023 (ISSN: 2310-7502)
http://www.standresjournal.org/journals/SSRE

Research Article

Effect of salt water on the compressive strength of concrete

Uzuwuru Chinyere Esther, *Chijioke Chiemela and Chukwudi Prince EU

Department of Civil Engineering, Federal Polytechnic Nekede Owerri, Nigeria

*Corresponding Author E-mail: cchijioke@fpno.edu.ng

Accepted 25, April, 2023

Abstract

This research work is aimed at investigating the effect of salt water on the properties of concrete. The main property considered herein is Compressive Strength, other conjugate properties are highlighted too. Cement concrete cubes of 150mm x 150mm x 150mm were cast using clean water (as control) and seawater with mix ratio of 1:2:4. All the mixes were prepared using constant water cement ratio of 0.5 by weight. 30 concrete cubes were made in two batches; half of the cubes were made using fresh water and the other half-using seawater. The concrete cubes were cured in fresh and seawater, respectively. The curing was done for 7, 14 and 28days, and then crushed using the Compressive Strength Test Apparatus respectively. The average compressive strength of the cubes cast with clean water were 14Mpa, 16.13Mpa and 17.24Mpa for 7, 14, and 28 curing days respectively. While the average compressive strength of concrete cubes cast and cured with saline water were 18.13Mpa, 18.80Mpa and 16.49Mpa for 7, 14, and 28 curing days. The study shows that salt water (with the sample analysed) tends to compromise the compressive strength of concrete for a longer time duration.

Keywords: Concrete Cube, Seawater, Fresh Water, Compressive Strength.

INTRODUCTION

In the construction industry, concrete for centuries has been one of the most used construction materials. It is made up of these three components: cement, water, and aggregates. Water is an important component of concrete. Combining water with a cementation's material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and allows it to flow more freely. Less water in the cement paste will yield a stronger, more durable concrete; more water will give a free-flowing concrete with a higher slump (Preethi et al., 2014). Impurities and deleterious substances which are largely introduced from water used in mixing concrete are likely to interfere with the process of hydration, preventing effective bond between the aggregates and matrix. The impurities sometimes reduce the durability of the aggregate. Excessive impurities in mixing water may affect not only setting time, concrete strength, and volume stability (length change), but may also cause efflorescence (the formation of a powdery deposit on the surface because of loss of moisture on exposure to air.). Where conceivable, water with high concentrations of dissolved solids should be avoided. Salts or other lethal substances contributed from the aggregate or admixtures are additive to those that might be contained in the mixing water. These supplementary amounts are to be considered in estimating the acceptability of the total impurities that may be toxic to concrete (Oladipo, 2014). There are many sources of salt water. Among these sources, sea is the prevalent one. The primary chemical constituents of salt water are the ions of chlorine, sodium, magnesium, calcium, and potassium. The concentration of major salt constituents of salt water is given in weight Percentages (%) of salt as 78% NaCl, 10.5% $MgCl_2$, 5% $MgSO_4$, 3.9% $CaSO_4$, 2.3% K_2SO_4, and 0.3% KBr. It is evident from the above, that sodium chloride is by far the prime salt component of seawater (Obi, 2016). Sea water has a total salinity of about 3.5% (78% of the dissolved solids being Nacl and 15% $MgCl_2$ and MgSO4). Figure 1

Major Ions	Concentration (mg/l)								
	Black Sea	Marmara Sea	Mediterranean Sea	North Sea	Atlantic Ocean	Baltic Sea	Arabian Gulf	BRE** Exposure	Red Sea
Sodium	4,900	8,100	12,400	12,200	11,100	2,190	20,700	9,740	11,350
Magnesium	640	1,035	1,500	1,110	1,210	260	2,300	1,200	1,867
Chloride	9,500	14,390	21,270	16,550	20,000	3,960	36,900	18,200	22,660
Sulfate	1,362	2,034	2,596	2,220	2,180	580	5,120	2,600	3,050
TDS	17,085	26,409	38,795	33,060	35,370	7,110	66,650	32,540	40,960
TDS Ratio*	3.90	2.52	1.72	2.02	1.88	9.37	1.00	2.05	1.63

Source: Gopal (2010).

Figure 1. Concentration of major ions in some of the world seas

Largely, the paraphernalia on setting are inconsequential if water is satisfactory from strength consideration. Water encompassing large quantities of chlorides (sea water) tend to cause persistent dampness and surface efflorescence. Such water should not be used where appearance is important, or where a plaster- finish is to be applied (Obi, 2016)

MATERIALS AND METHOD

Materials

In this work, the materials used includes; cement, river sand, coarse aggregate, portable water and saline water from Woji (Rivers state).

Methods

Various tests were performed during this research; the sieving method adopted was dry sieving and a sample size of about 600g was used for the aggregate. This test was carried out on both aggregate to determine the particle size distribution. This test was done in the laboratory using sieve size of different diameter and were stacked according to the size of sieve, that is, the largest ones on top while the smaller at the bottom. Slump test was also carried out on the concrete. Other properties like specific gravity and density was also carried out. Batching of the materials was done by weight using a weighing balance of 50kg capacity. The inside surface of the moulds were coated lightly with medium viscosity oil and then placed on a clean, level and firm surface. The mould is made of metal. Mixing of the constituents was done manually using shovel and hand trowel. The production process involved collection of sand which was left to dry, the sand when completely dried were mixed cement until a uniform colour was achieved, then the coarse aggregate was added and mixed uniformly with it. Water was finally added and the mixing continued until the colour of the paste was uniform. The mixture was then loaded into the moulds and were compacted manually. All the concrete cubes produced were demolded and cured by immersion for twenty-eight days. The concrete cubes were crushed after 7, 14 and 28 days of curing (for compressive strength) using electrical Universal Testing Machine (UTM). The machine has a testing range of 0KN – 1000KN. The switch of the machine was turned on, and then force was applied to the concrete cube until it fails in compression. The strengths of the concrete cubes were determined using equation 1 below. Three samples each were tested for a particular mix number and the average value taken as the compressive strength for the mix.

$$\text{Compressive strength} = \frac{\text{crushing load}}{\text{cross sectional area}} \qquad (1)$$

RESULTS AND ANALYSIS

Results

The results are presented as follows:

Table 1. Grain size distribution of river sand

Observed				Calculated		
Sieve Size (mm)	Mass of Empty Sieve (g)	Mass of Sieve + Soil Retained (g)	Mass Retained (g)	% mass retained	Cumulative % mass retained	Cumulative % finer
2.36	429.9	461.2	31.3	5.22	5.22	94.8
2	538.6	555.5	16.9	2.82	8.04	92.0
1.7	407.9	429.1	21.2	3.53	11.57	88.4
1.18	362.9	432.9	70	11.67	23.24	76.8
0.85	374.1	474.8	100.7	16.79	40.03	60.0
0.6	336.6	490.1	153.5	25.59	65.62	34.4
0.423	301.7	363.4	61.7	10.29	75.91	24.1
0.3	322.4	376.7	54.3	9.05	84.96	15.0
0.212	282.7	343.3	60.6	10.10	95.07	4.9
0.075	264.3	272.6	8.3	1.38	96.45	3.6
Pan	244.6	265.9	21.3	3.55	100.00	0.0
Total Soil Mass(g)			599.8			

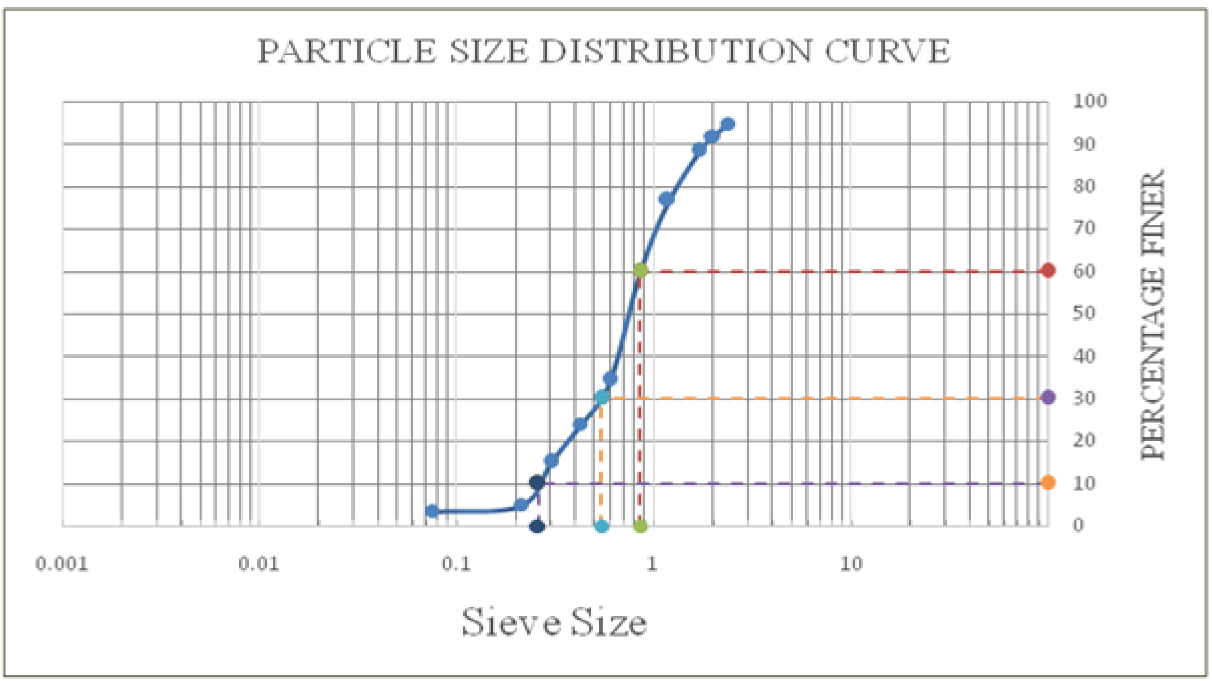

Figure 2. Particle size distribution curve

From the Figure 2, the values of D_{10}, D_{30}, and D_{60} for river sand are gotten and computed to get values for Coefficient of uniformity, (C_u) and Coefficient of gradation, (C_c)

$D_{10} = 0.32$
$D_{30} = 0.55$
$D_{60} = 1.2$

$$\text{Coefficient of uniformity, Cu} = \frac{D_{60}}{D_{10}} = 2.18$$

$$\text{Coefficient of gradation, Cc} = \frac{(D_{30})^2}{(D_{60} \times D_{10})} = 0.99$$

Table 2. Specific gravity of fine aggregate (sand)

Trial No.	Mass SSD sand sample in gm (A)	Mass of pycnometer + water in gm (B)	Mass of pycnometer +water + sand in gm(C)	Specific gravity = [A/(A+B-C)]
1	500	1351.6	1650.3	2.48
2	500	1352.4	1654.1	2.52
3	500	1352.5	1657.2	2.56
Average				2.52

Table 3. Specific gravity of coarse aggregate

Samples	Weight of Saturated - Surface Dry sample in Air (B)	Weight of saturated sample in air (C)	Specific gravity (in SSD base) = B/B-C
1	5078	3233	2.75
2	5036	3164	2.69
Average			**2.72**

Table 4. Result for analysis of water samples

S/N	Sample ID	Temperature (C^0)	Salinity (g/l)
1	Borehole	33.6	0.033
2	Sea water	33.6	11.134

Table 5. Slump and water used for each concentration of salt

Samples	Slump(mm)	Amount of water Used (L)	W/C ratio	Date:
Clean Water	45	2	0.5	
Salt Water	50	2	0.5	23/06/2021
Clean Water	45	2	0.5	
Salt Water	50	2	0.5	24/06/2021

Table 6. Results of Compressive Strength of cubes prepared by using clean water

Date Specimens were cast: 24/06/2021						
Description of test Specimens: Cube test						
Spec No.	**Days Cured**	**Weight (Kg)**	**Area (mm^2)**	**Load (KN)**	**Stress (Mpa)**	Test date
CW1		8.4	22500	360	16.00	01/07/2021
CW2		8.0	22500	350	15.56	01/07/2021
CW3	7	7.9	22500	340	15.11	01/07/2021
CW4		8.2	22500	360	16.00	01/07/2021
CW5		7.4	22500	250	11.11	01/07/2021
Average		**7.98**		**332**	**14.76**	
CW6		8.5	22500	380	16.89	08/07/2021
CW7		7.7	22500	340	15.11	08/07/2021
CW8	14	8.4	22500	375	16.67	08/07/2021
CW9		8.2	22500	370	16.44	08/07/2021
CW10		7.9	22500	350	15.56	08/07/2021
Average		**8.14**		**363**	**16.13**	
CW11		8.5	22500	425	18.89	22/07/2021
CW12		8.4	22500	400	17.78	22/07/2021
CW13	28	8.3	22500	355	15.78	22/07/2021
CW14		8.4	22500	410	18.22	22/07/2021
CW15		8.1	22500	350	15.56	22/07/2021
Average		**8.34**		**388**	**17.24**	

Table 7. Results of Compressive Strength of cubes prepared by using Salt water

Date Specimens were cast: 24/06/2021						
Description of test Specimens: Cube test						
Spec No.	**Days Cured**	**Weight (Kg)**	**Area (mm^2)**	**Load (KN)**	**Stress (Mpa)**	Test date
SW1	7	9.2	22500	470	20.89	01/07/2021
SW2		8.0	22500	420	18.67	01/07/2021
SW3		7.8	22500	380	16.89	01/07/2021
SW4		8.5	22500	450	20.00	01/07/2021
SW5		7.8	22500	320	14.22	01/07/2021
Average		**8.26**		**408**	**18.13**	
SW6	14	8.4	22500	410	18.22	08/07/2021
SW7		8.8	22500	430	19.11	08/07/2021
SW8		8.8	22500	505	22.44	08/07/2021
SW9		8.4	22500	400	17.78	08/07/2021
SW10		8.0	22500	370	16.44	08/07/2021
Average		**8.48**		**423**	**18.80**	
SW6	28	8.2	22500	375	16.67	22/07/2021
SW7		7.1	22500	355	15.78	22/07/2021
SW8		8	22500	360	16.00	22/07/2021
SW9		8.4	22500	390	17.33	22/07/2021
SW10		8.2	22500	375	16.67	22/07/2021
Average		**7.98**		**371**	**16.49**	

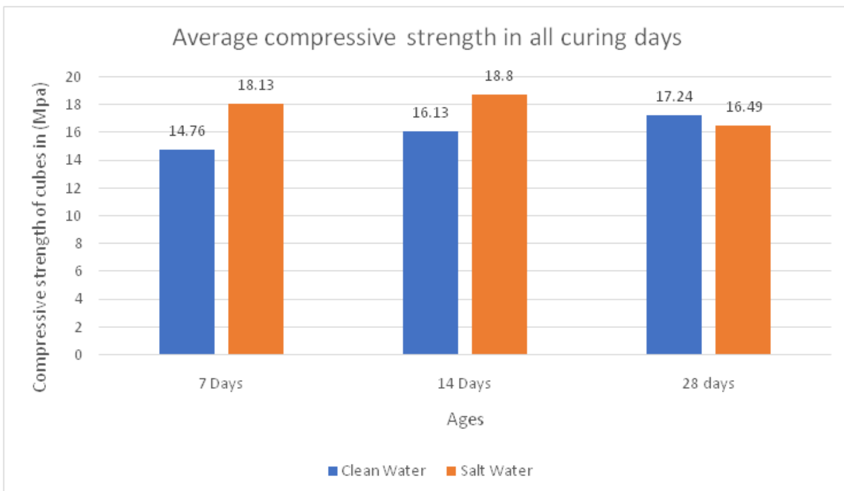

Figure 3. Summary of average Compressive Strength of concrete (i)

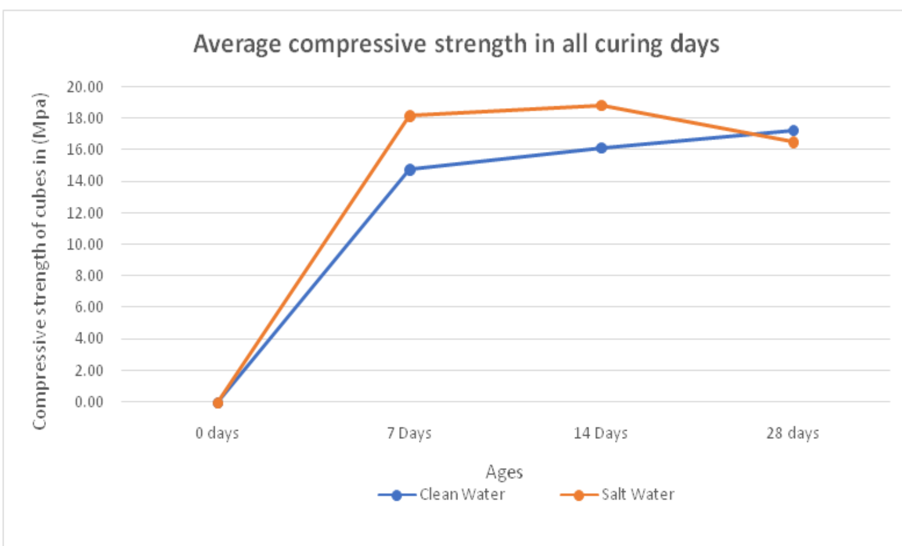

Figure 4. Summary of average Compressive Strength of concrete (ii)

Analysis of Sieve analysis results

Results of the sieve analysis show that both the river sand fall within Zone II of the grading of fine aggregates as given in BS-882, (1992). From Figure 2 the coefficient of uniformity (C_u) and coefficient of gradation (C_c) for the aggregate were calculated as 2.18 and 0.99 respectively. This result shows that the aggregate is well graded as stated in BS-882, (1992).

Analysis of Specific Gravity Test Results

The values for specific gravity for the fine aggregate and coarse aggregate shown in Table 2 and Table 3 is within the range for the respective materials. The values for the specific gravity for fine aggregate was found to be 2.52 while that of the coarse aggregate was found to be 2.72, and this value can be compared favourably with the values in the exiting literatures.

Analysis of salinity Test on water

From Table 4, the result of the salinity test conducted on the borehole water and seawater were 0.033 and 11.134 respectively. This shows that the seawater is actually a salt water.

Analysis of Compressive Strength Results

From Table 6, Table 7, Figure 3 and Figure 4. The compressive strength of concrete increased with the increase of concentration of salt in water up until the 28th curing days, when it took a decline.

The percentage increase in average compressive strength of concrete as the concentration of salt in water increases is 10.27% for 7 days curing time. The percentage increase in average compressive strength of concrete as the concentration of salt in water increases is 7.64% for 14 days curing time. However, the percentage increase in average compressive strength of concrete as the concentration of salt in water increases is -2.24% for 28 days curing time (which translates to a decrease of 2.24% for the 28 days curing time).

Even though there is an increase in compressive strength of concrete with an increase of salt in water, the percentage increase in compressive strength of concrete in 7days curing time (10.27%) is much larger than 14 days curing time (7.64%); while there was an evident decrease on the 28 days curing time (-2.24%)

Moreover, the rate of the strength gain in clean water cubes is faster (4.46% and 3.33%) as compared with the saltwater cubes (1.81% and -6.55%) when the curing time is changed from 7 to 14 days and 14 to 28 days respectively.

CONCLUSION

After the successful completion of this project, the following conclusions are made:

1. The compressive strength of concrete cubes both mixed and cured by using salt water were higher than that of concrete cubes both mixed and cured by using clean water for 7 and 14 curing days, while it was lower on the 28-curing day.
2. The compressive strength of concrete cubes both mixed and cured by using salt water were increased when the curing time changed from 7 to 14 days and reduces when the curing time changed from 14 to 28 days
3. The rate of the strength gain for concrete cubes both mixed and cured by using clean water was faster as compared with concrete cubes both mixed and cured by using salt water for all curing days.

Recommendations

a. As salt water (with the sample analysed) tends to compromise the compressive strength of concrete for a longer time duration. It would not be recommended for critical construction purposes.

b. Studies should be carried out for long term compressive strength test for further comparison among the concretes produced from different concentration of salt in water.

c. Studies should be carried out for large amount of sodium chloride salt in water.

References

Abebe D(2002). “Construction materials laboratory manual”, Addis Ababa university Department of civil Engineering.
American Association of State Highway and Transportation Officials (1982). “Standard Specifications for Transportation Materials and Methods of Sampling and Testing: part II – Methods of Sampling and Testing”, Thirteenth Edition, AASHTO, 444 North Capitol St., N.W., Suite 225 Washington,D.C. 20001.
American Concrete Institute (ACI), (2002). “Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.” ACI 211.1-91, ACI Committee 211.
American Concrete Institute (ACI), (2008). “Building code Requirements for Structural Concrete.” ACI 318-08, ACI Committee 318.
British Standards Institution BS 882, (1992). “Specification for Aggregate from Natural sources for Concrete” London.
Falah MW(2010). “Effect of seawater for mixing and curing on structural concrete”. J. IES. 3(4): 76-78. Guidelines on quality control and quality assurance of ready-mix concrete, RMCMA, 2008
Gopal Jakes (2010), “The effect of salt in concrete on compressive strength, water vapor transmission and corrosion of reinforcing steel”, Technical Report R306.
Haseeb K, Tabish I, Neha M, Abdul A(2016). “Effect of Saline Water in Mixing and Curing on Strength of Concrete”. Volume 2 Issues 5.
Mbadike EM, Elinwa AU(2011) “Effect of Salt Water in the production of Concrete”. Nig. J. Technol. Vol. 30, No. 2.
Nagabhushana DH, Nitin Akash SD, Mukesh K(2017). “Effect of Salt Water on Compressive Strength of Concrete”. Int. Res. J. Eng. Technol. Volume 04 Issue:05.
Obi LE(2016). “Empirical Investigation of the Effects of Water Quality on Concrete Compressive Strength”. Int. J. Constructive Res. Civil Eng. Volume 2, Issue 5.
Oladapo SA, Ekanem EB(2014). “Effect of Sodium Chloride (NaCl) on Concrete Compressive Strength”. Int. J. Eng. Res. Technol. Vol. 3 Issue 3.
Olutoge FA, Amusan GM(2014). The Effect of Sea Water on Compressive Strength of Concrete, Volume .3 Issue 7.
Preeti T, Rajiv C, Yadav RK (2014). “Effect Of Salt Water On Compressive Strength Of Concrete”. J. Eng. Res. Applications. Vol. 4, Issue 4.
Ravi TBG(2014). “Effect of sodium chloride on compressive strength of concrete containing sugarcane bagasse ash”, Gitam University, Gitam Institute of technology.