EFFECT OF SALT WATER IN THE PRODUCTION OF CONCRETE

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Abstract

In this research work, the effect of salt water in the production of concrete was investigated. A total of ninety (90) concrete cubes were cast for compression strength test i.e. forty five cubes were cast using fresh water and the other forty five cubes were also cast using salt water. Similarly, a total of ninety (90) concrete beams were cast for flexural strength test i.e. forty five beams were cast using fresh water and the other forty five beams were also cast using salt water. The concrete cubes and the beams were cured at 7,21,28,60 and 90 days respectively. The result of the average compressive strength of concrete obtained using fresh water of mix ratio (1 : 1.51 : 4.01), water cement ratio (0.47) ranges from 27.35-42.34*$\mathrm{N/mm^2}$ *while that of salt water ranges from 25.24-38.81*$\mathrm{N/mm^2}$ *for the hydration period of 7, 21, 28, 60 and 90 days. The flexural strength of concrete obtained using fresh water of the same mix ratio and water cement ratio ranges from 6.60 - 11.20*$\mathrm{N/mm^2}$ *for 7, 21, 28, 60 and 90 days hydration period while that of salt water ranges from 5.98-11.04*$\mathrm{N/mm^2}$ *for the same hydration period. For the mix ratio (1 : 1.61 : 4.03) and water cement ratio (0.55), the average compressive strength of concrete obtained using fresh and salt water ranges from 27.26 - 40.80*$\mathrm{N/mm^2}$ *and 24.68 - 39.13*$\mathrm{N/mm^2}$ *respectively while the flexural strength ranges from 6.55 - 11.13*$\mathrm{N/mm^2}$ *and 6.26 - 10.76*$\mathrm{N/mm^2}$ *for fresh and salt water respectively. For the mix ratio (1 : 1.66 : 4.24) and water cement ratio (0.50), the average compressive strength of concrete obtained using fresh and salt water ranges from 25.05 - 38.13*$\mathrm{N/mm^2}$ *and 23.58 - 36.03*$\mathrm{N/mm^2}$ *respectively while the flexural strength ranges from 6.18 - 9.88*$\mathrm{N/mm^2}$ *and 6.15 - 10.39*$\mathrm{N/mm^2}$ *for fresh and salt water respectively. The initial and final setting time of cement using fresh water is 50mins and 587mins while that of salt water is 55mins and 605mins respectively.

Keywords: fresh water, salt water, compressive strength, flexural strength, setting time

1. Introduction

Concrete is a mixture of cement, water and aggregates in a given proportions. Aggregates represent some 60-80% of the concrete volume. They are inert grains bound together by means of a binder which is cement. Although inert, they introduce an important contribution to these major characteristics which make concrete the most favoured building material [7]. Aggregates help to reduce shrinkage and heat dissipation during hardening and also contribute to the increase in the mechanical

strength of concrete [14]. Cement generally represent 12-14% of concrete weight. It plays an active part in the mixture by ensuring cohesion between aggregate grains and, in doing so, it introduces a decisive contribution to concrete mechanical strengths. During the hardening process, it generates shrinkage and heat dissipation phenomena which lead to material cracking [5]. Water occupies 6-8% of the composition of fresh concrete. It provides for cement hydration and for the workability of the fresh concrete mixture. When in excess, it determinately affects concrete porosity and mechanical strengths [6].

Water used in this research work is brack water. Brack water is water that has more salinity than fresh water, but not as much as sea water. The word 'brack' comes from the Middle Dutch root "brack" meaning "Salten" or "Salty". Brackish water is also the primary waste product of the salinity gradient power. Salinity gradient or Osmotic power is the energy retrieved from the difference in salt concentration between sea water and river water. Water is said to be salty if it contains chlorides and sulphates [13].

2. Methodology

The concrete cube size measuring 150×150×150mm in dimension was used. The batching of the concrete moulds was by weight. The concrete was produced using salt water and fresh water respectively. Three mixture proportions were considered in this research work. The first mixture was proportioned for a target cube strength of $43N/mm^2$ and had a cementitious material content of $340kg/m^3$, a fine aggregate content of $513kg/m^3$, a coarse aggregate content of $1387kg/m^3$ and a water cementitious ratio of 0.47. The second mixture was proportioned for a target cube strength of $39N/mm^2$ and had a cementitious material content of $310N/mm^3$, a fine aggregate content of $498kg/m^3$, a coarse aggregate content of $1250kg/m^3$ and a water cementitious ratio of 0.55. The third mixture was proportioned at $36N/mm^2$, $290kg/m^3$, $480kg/m^3$, $1230kg/m^3$ and 0.50 for target cube strength, cement content, fine aggregate content, coarse aggregate content and water cementitious ratio respectively.

The salt water in this research was obtained from Ebonyi State while the fresh water was obtained from bore hole. The fine aggregate used was clean river sand, free from deleterious substances with a specific gravity of 2.62 and a bulk density of $1533kg/m^3$. The coarse aggregate was obtained from a local supplier with a maximum size of 20mm, specific gravity of 2.65 and bulk density of $1467kg/m^3$. Both aggregates conforms to BS 877 of 1967 [3] and BS 3797 of 1964 [2] respectively for coarse and fine aggregates while the cement conforms to BS 12 of 1978 [1]. The cement used is Ordinary Portland Cement. The concrete cubes were lubricated with oil before the mixed concrete was placed inside it in order to reduce friction between the concrete and the cubes.

When the concrete was properly mixed using the salt water and fresh water respectively, the concrete cubes were filled to one third of their height and compacted 120 times. The cubes were later filled to two third of their height and finally filled completely. In each of the layer, the concrete cubes were compacted 120 times respectively. The concrete cubes were cast and cured for 7, 21, 28, 60 and 90 days respectively. For each of the hydration period, three cubes were tested and the average compressive strength recorded. The total number of concrete cubes cast was ninety (90) i.e. forty five cubes using salt water and forty five cubes using fresh water. Similarly, the flexural strength was determined using a beam mould of 150×150×600mm in dimension. The total number of beams cast was also ninety(90) i.e. forty five beams using salt water and forty five beams using fresh water. The setting time was also determined using Vicat apparatus.

3. Results and Discussion

Table 1 shows the result of the sieve analysis of fine aggregate used. The result shows that the aggregate falls into zone 2 of calibration graph.

Table 2 shows the result of the initial and final setting time of cement using fresh and salt water respectively. The initial setting time of cement using fresh water is 50mins while the final setting time is 587mins. The initial and final setting time of cement using salt water is 55mins and 605mins. The higher the setting time, the lower the strength of concrete produced. This is because salt water increases the setting of cement which indicates that the strength of concrete produced is reduced.

Table 3-6 shows the result of the average compressive and flexural strength of concrete produced using fresh and salt water of mix ratio (1 : 1.51 : 4.01) and water cement ratio of 0.47. The result of the average compressive strength of concrete produced using fresh water ranges from 27.35-42.34N/mm^2 while that of the salt water ranges from 25.24-38.81N/mm^2.

Similarly, the result of the average flexural strength of concrete produced using fresh water of the same mix ratio and water cement ratio ranges from 6.60 - 11.20N/mm while that of salt water ranges from 5.98-11.04N/mm^2. The result shows that the average compressive and flexural strength of concrete produced using fresh water is higher than that of the salt water.

Table 7 shows the result of the physical and chemical analysis of fresh and salt water used in this research work. Table 8-11 shows the result of the average compressive and flexural strength of concrete obtained using fresh and salt water of mix ratio (1:1.61:4.03) and water cement ratio of 0.55. The result of the average compressive strength ranges from 27.26-40.80N/mm^2 and 24.68-39.13N/mm^2 for fresh and salt water respectively while the flexural strength ranges from 6.55-11.13N/mm^2 and 6.26-10.76N/mm^2 for fresh and salt water respectively.

Table 1: Result of sieve analysis of fine aggregate.

Standard sieve size	**Mass of sample retained** (g)	**Mass of sample passing** (g)	**Percentage retained** (g)	**Percentage passing** (g)
8mm	0.00	250.00	0.00	100.00
5mm	11.60	238.40	4.64	95.36
2.36mm	44.20	194.20	17.68	77.68
1.18mm	32.90	161.30	13.16	64.52
600μm	77.05	84.25	30.82	33.70
300μm	56.25	28.00	22.50	11.20
150μm	15.90	12.10	6.36	4.84
Pan	12.10	0.00	4.84	0.00

Table 2: Initial and final setting time of OPC/Fresh water and OPC/Salt water.

Type of water	**Initial setting time** (mins)	**Final setting time** (mins)
Fresh	50	587
Salt	55	605

Table 12-15 shows the result of the average compressive and flexural strength of concrete obtained using fresh and salt water of mix ratio (1 : 1.66 : 4.24) and water cement ratio of 0.50. The result of the average compressive strength ranges from 25.05 - 38.13N/mm^2 and 23.58-36.03N/mm^2 for fresh and salt water respectively while the flexural strength ranges from 6.18-9.88N/mm^2 and 6.15-9.55N/mm^2 for fresh and salt water respectively.

The above results shows that there is a decrease in the strength of concrete produced when salt water is used. The decrease is due to the presence of chlorides and sulphates in the salt water.

Table 3: Result of compressive strength obtained using fresh water of mix ratio (1:1.51:4.01), water cement ratio (0.47).

Cube size (mm)	**Age of cube** (days)	**Test load** (kN)	**Compressive strength** (N/mm2)	**Average compressive strength** (N/mm^2)
150x150x150	7	700	31.11	27.35
150x150x150	7	550	24.44	
150x150x150	7	596	26.49	
150x150x150	21	855	38.00	31.26
150x150x150	21	604	26.84	
150x150x150	21	651	28.93	
150x150x150	28	950	42.22	35.70
150x150x150	28	760	33.78	
150x150x150	28	700	31.11	
150x150x150	60	880	39.11	39.85
150x150x150	60	1010	44.88	
150x150x150	60	800	35.56	
150x150x150	90	908	40.36	42.34
150x150x150	90	935	41.56	
150x150x150	90	1015	45.11	

Table 4: Result of compressive strength obtained using salt water of mix ratio (1 : 1.51 : 4.01), water cement ratio (0.47).

Cube size (mm)	**Age of cube** (days)	**Test load** (kN)	**Compressive strength** (N/mm2)	**Average compressive strength** (N/mm^2)
150x150x150	7	640	28.44	25.24
150x150x150	7	510	22.67	
150x150x150	7	554	24.62	
150x150x150	21	794	35.29	29.08
150x150x150	21	600	26.67	
150x150x150	21	569	25.29	
150x150x150	28	830	36.89	33.47
150x150x150	28	705	31.33	
150x150x150	28	724	32.18	
150x150x150	60	878	39.02	37.61
150x150x150	60	895	39.78	
150x150x150	60	766	34.04	
150x150x150	90	950	42.02	38.81
150x150x150	90	880	39.11	
150x150x150	90	790	35.11	

Table 5: Result of the flexural strength of concrete obtained using fresh water of mix ratio (1 : 1.51 : 4.01), water cement ratio (0.47).

Cube size (mm)	**Age of cube** (days)	**Test load** (kN)	**Compressive strength** (N/mm2)	**Average compressive strength** (N/mm^2)
150x150x150	7	40.50	7.20	6.60
150x150x150	7	35.10	6.24	
150x150x150	7	35.80	6.36	
150x150x150	21	43.60	7.75	7.85
150x150x150	21	40.00	7.11	
150x150x150	21	48.80	8.68	
150x150x150	28	50.00	8.89	9.09
150x150x150	28	49.20	8.75	
150x150x150	28	54.10	9.62	
150x150x150	60	52.60	9.35	10.21
150x150x150	60	59.10	10.51	
150x150x150	60	60.50	10.76	
150x150x150	90	60.90	10.83	11.20
150x150x150	90	66.70	11.86	
150x150x150	90	61.30	10.90	

Table 6: Result of the flexural strength of concrete obtaining using salt water of mix ratio (1 : 1.51 : 4.01), water cement ratio (0.47).

Cube size (mm)	**Age of cube** (days)	**Test load** (kN)	**Compressive strength** (N/mm2)	**Average compressive strength** (N/mm^2)
150x150x150	7	33.00	5.87	5.98
150x150x150	7	33.80	6.01	
150x150x150	7	34.10	6.06	
150x150x150	21	38.80	6.90	6.91
150x150x150	21	37.60	6.68	
150x150x150	21	40.20	7.15	
150x150x150	28	45.00	8.00	8.08
150x150x150	28	48.90	8.69	
150x150x150	28	42.50	7.56	
150x150x150	60	52.40	9.32	9.65
150x150x150	60	50.70	9.01	
150x150x150	60	59.70	10.61	
150x150x150	90	59.90	10.65	11.04
150x150x150	90	63.55	11.30	
150x150x150	90	62.86	11.18	

Table 7: Result of the physical and chemical analysis of fresh and salt water.

S/No	**Parameter**	**Standard distilled and deionized water**	**Sample of bore hole water**	**Sample of salt water**
1	Colour	0.00	0.002	0.022
2	Odour	Unobjectionable	Unobjectionable	Unobjectionable
3	Taste	Insipid	Not detected	Not detected
4	pH	7.00	6.4	7.5
5	Temperature (℃)	28.00	28.00	28.00
6	Conductivity	0.00	0.24	410.00
7	Salinity (mg/l)	0.00	0.00	875.00
8	Total dissolved solid (mg/l)	0.00	21	1300
9.	Total suspended solid (mg/l)	0.00	0.04	59.00
10	Turbidity	0.00	0.08	46.70
11	Dissolved oxygen (mg/l)	0.00	0.06	4.5
12	Total hardness $CaC0_3$ (mg/l)	0.00	5.20	20.90
13	Alkalinity (ppm)	0.00	1.04	4.01
14	Chemical oxygen demand (mg/l)	0.00	0.03	2.02
15	Total petroleum hydrocarbon (mg/l)	0.00	0.00	1.5
16	Total hydrocarbon content (mg/l)	0.00	0.00	1.15
17	Biochemical oxygen demand (mg/l)	0.00	2.2	14
18	Nitrate ion ($N0_3^{2-}$) mg/l	0.00	0.002	0.186
19	Phosphate (mg/l)	0.00	0.08	0.20
20	Phenols (mg/l)	0.00	0.00	0.51
21	Sulphate (mg/l)	0.00	6.7	180
22	Lead (mg/l)	0.00	¡0.02	¡0.01
23	Iron (mg/l)	0.00	0.04	0.42
24	Copper (mg/l)	0.00	0.34	0.61
25	Nickel (mg/l)	0.00	¡0.002	0.90
26	Vanadium (mg/l)	0.00	0.96	¡0.002
27	Zinc (mg/l)	0.00	¡0.001	0.03
28	Cadmium (mg/l)	0.00	0.00	¡0.001

Table 8: Result of the compressive strength of concrete obtained using fresh water of mix ratio (1 : 1.61 : 4.03), water cement ratio (0.55).

Cube size (mm)	**Age of cube** (days)	**Test load** (kN)	**Compressive strength** (N/mm2)	**Average compressive strength** (N/mm^2)
150x150x150	7	660	29.33	27.26
150x150x150	7	670	29.78	
150x150x150	7	510	22.67	
150x150x150	21	744	33.01	29.67
150x150x150	21	690	30.67	
150x150x150	21	570	25.33	
150x150x150	28	700	31.11	31.88
150x150x150	28	682	30.31	
150x150x150	28	770	34.22	
150x150x150	60	767	34.09	34.92
150x150x150	60	696	30.93	
150x150x150	60	894	39.73	
150x150x150	90	889	39.51	40.80
150x150x150	90	960	42.69	
150x150x150	90	905	40.22	

Table 9: Result of the compressive strength of concrete obtained using salt water of mix ratio (1 : 1.61 : 4.03), water cement ratio (0.55).

Cube size (mm)	**Age of cube** (days)	**Test load** (kN)	**Compressive strength** (N/mm2)	**Average compressive strength** (N/mm^2)
150x150x150	7	580	25.78	24.68
150x150x150	7	608	27.02	
150x150x150	7	478	21.24	
150x150x150	21	582	25.87	26.74
150x150x150	21	720	32.00	
150x150x150	21	503	22.36	
150x150x150	28	791	35.16	31.38
150x150x150	28	618	27.47	
150x150x150	28	709	31.51	
150x150x150	60	784	34.84	34.08
150x150x150	60	662	29.42	
150x150x150	60	855	38.00	
150x150x150	90	840	37.33	39.13
150x150x150	90	922	40.89	
150x150x150	90	881.50	39.16	

Table 10: Result of the flexural strength of concrete obtained using fresh water of mix ratio (1:1.61:4.03), water cement ratio (0.55).

Cube size (mm)	**Age of cube** (days)	**Test load** (kN)	**Compressive strength** (N/mm2)	**Average compressive strength** (N/mm^2)
150x150x150	7	34.80	6.19	6.55
150x150x150	7	30.60	5.44	
150x150x150	7	45.10	8.02	
150x150x150	21	40.06	7.12	7.44
150x150x150	21	38.40	6.83	
150x150x150	21	47.00	8.36	
150x150x150	28	49.80	8.85	8.24
150x150x150	28	49.01	8.71	
150x150x150	28	40.95	7.28	
150x150x150	60	50.50	8.98	10.07
150x150x150	60	53.20	9.46	
150x150x150	60	66.15	11.76	
150x150x150	90	59.60	10.60	11.13
150x150x150	90	55.90	9.94	
150x150x150	90	72.20	12.84	

Table 11: Result of the flexural strength of concrete obtained using salt water of mix ratio (1:1.61:4.03), water cement ratio (0.55).

Cube size (mm)	**Age of cube** (days)	**Test load** (kN)	**Compressive strength** (N/mm2)	**Average compressive strength** (N/mm^2)
150x150x150	7	31.10	5.53	6.26
150x150x150	7	36.00	6.40	
150x150x150	7	38.55	6.85	
150x150x150	21	30.87	5.49	6.31
150x150x150	21	34.67	6.15	
150x150x150	21	41.05	7.30	
150x150x150	28	44.00	7.82	8.18
150x150x150	28	50.30	8.94	
150x150x150	28	43.70	7.77	
150x150x150	60	50.08	8.90	9.31
150x150x150	60	57.20	10.17	
150x150x150	60	49.89	8.86	
150x150x150	90	55.90	9.94	10.76
150x150x150	90	76.10	13.53	
150x150x150	90	49.55	8.81	

Table 12: Result of the flexural strength of concrete obtained using salt water of mix ratio (1:1.61:4.03), water cement ratio (0.55).

Cube size (mm)	**Age of cube** (days)	**Test load** (kN)	**Compressive strength** (N/mm2)	**Average compressive strength** (N/mm^2)
150x150x150	7	601.50	26.73	25.05
150x150x150	7	515.00	22.89	
150x150x150	7	574.20	25.52	
150x150x150	21	708.40	31.48	29.24
150x150x150	21	652.10	28.98	
150x150x150	21	613.05	27.25	
150x150x150	28	697.20	30.99	33.14
150x150x150	28	728.10	32.36	
150x150x150	28	811.80	36.08	
150x150x150	60	751.00	33.38	33.56
150x150x150	60	688.10	30.58	
150x150x150	60	826.40	36.73	
150x150x150	90	818.60	36.38	38.13
150x150x150	90	771.10	34.27	
150x150x150	90	984.00	43.73	

Table 13: Result of the compressive strength of concrete obtained using salt water of mix ratio (1:1.66:4.24), water cement ratio (0.50).

Cube size (mm)	**Age of cube** (days)	**Test load** (kN)	**Compressive strength** (N/mm2)	**Average compressive strength** (N/mm^2)
150x150x150	7	499.07	22.18	23.58
150x150x150	7	586.50	26.07	
150x150x150	7	506.15	22.50	
150x150x150	21	561.00	24.93	26.56
150x150x150	21	709.60	31.54	
150x150x150	21	522.10	23.20	
150x150x150	28	694.85	30.88	32.22
150x150x150	28	714.00	31.73	
150x150x150	28	766.30	34.06	
150x150x150	60	640.00	28.44	33.44
150x150x150	60	801.10	35.60	
150x150x150	60	816.00	36.27	
150x150x150	90	730.00	32.44	36.03
150x150x150	90	888.20	39.48	
150x150x150	90	813.70	36.16	

Table 14: Result of the flexural strength of concrete obtained using fresh water of mix ratio (1:1.66:4.24), water cement ratio (0.50).

Cube size (mm)	**Age of cube** (days)	**Test load** (kN)	**Compressive strength** (N/mm2)	**Average compressive strength** (N/mm^2)
150x150x150	7	29.80	5.30	6.18
150x150x150	7	31.10	5.53	
150x150x150	7	43.35	7.71	
150x150x150	21	37.05	6.59	6.48
150x150x150	21	41.30	7.34	
150x150x150	21	30.98	5.51	
150x150x150	28	50.00	8.89	9.07
150x150x150	28	51.20	9.10	
150x150x150	28	51.93	9.23	
150x150x150	60	61.50	10.93	9.76
150x150x150	60	54.20	9.64	
150x150x150	60	48.96	8.70	
150x150x150	90	66.00	11.73	9.88
150x150x150	90	49.95	8.88	
150x150x150	90	50.81	9.03	

Table 15: Result of the flexural strength of concrete obtained using salt water of mix ratio (1:1.66:4.24), water cement ratio (0.50).

Cube size (mm)	**Age of cube** (days)	**Test load** (kN)	**Compressive strength** (N/mm2)	**Average compressive strength** (N/mm^2)
150x150x150	7	30.00	5.33	6.15
150x150x150	7	36.18	6.43	
150x150x150	7	37.55	6.68	
150x150x150	21	33.60	5.97	7.33
150x150x150	21	53.05	9.43	
150x150x150	21	37.00	6.58	
150x150x150	28	46.10	8.20	8.39
150x150x150	28	58.00	10.31	
150x150x150	28	37.45	6.66	
150x150x150	60	53.63	9.53	9.00
150x150x150	60	51.10	9.08	
150x150x150	60	46.98	8.35	
150x150x150	90	58.30	10.36	9.55
150x150x150	90	50.00	8.89	
150x150x150	90	52.86	9.40	

4. Conclusion and Recommendations

The conclusion of the study can be summarized as follows:

a. The strength development in the concrete produced increases with the increase in the hydration period.

b. The higher the setting time, the lower the strength of concrete produced

c. The use of salt water in concrete production will reduce the strength of concrete produced to approximately 8%.

d. Curing is very necessary in concrete in order to ensure the complete hydration of cement

e. The strength development in concrete depends on the percentage chemical composition of cement.

f. The presence of chlorides and sulphates in salt water reduces strength of concrete.

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