International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 418-434 www.ijaem.net ISSN: 2395-5252

Effect of Crude Oil in Saline Water on the Properties of 10mm Gravel Aggregate Concrete

[1]Iboroma Z. S. Akobo, [2]Barisua E. Ngekpe, [3]Teinbo-ofori Isaac Wokoma

Senior Lecturer, Department of Civil Engineering, Rivers State University, Rivers State, Nigeria.
, Lecturer 1, Department of Civil Engineering, Rivers State University, Rivers State, Nigeria.
Graduate Student, Department of Civil Engineering, Rivers State University, Rivers State, Nigeria.

Submitted: 02-02-2021 Revised: 18-02-2021 Accepted: 22-02-2021

ABSTRACT: This is a study on the combined effect of crude oil and sodium chloride salt on the compressive strength and workability of concrete using locally sourced 3/8" (10mm) all-in gravel aggregate. This is in consideration of the present condition of the coastal area of the Niger Delta region of Nigeria. The water of the coastal area of the Niger Delta region of Nigeria which naturally contains sodium chloride salt content is been polluted with crude oil due the crude oil exploration activities, illegal refine of the crude oil product and so on within the region. The available water of the Niger Delta region of Nigeria for decades now exists as a mixture crude oil product and sodium chloride salt with significant quantity of the crude oil product in the sodium chloride salt water which is enough to have effect on concrete production within the area. In this study, the crude oil and sodium chloride salt contaminants' contents are varied alternatively from 2.5%, 5%, 10% and 15% of the mass of the water content required for the concrete mix and then used as partial replacement of the water content. The test samples are cured in same water mixture conditions used for the test concrete sample production. The combine effect of these contaminants reduced the compressive strength of the concrete from 32N/mm^2 at 0% contaminants to 8N/mm^2 at 15% equal proportion of contaminants which indicates 75% compressive strength loss at 28 days' test. The workability factor from the slump test is increased from 8mm to 25mm at which the concrete constituents segregated and collapsed, this also indicates a negative effect. Physical assessment test on the concrete showed gradual colour differences from light grey-ash known as concrete colour to dark grey colour as the percentages of the contaminants are increased. When the hardened concrete test samples after curing are air dried in the atmosphere, crude oil is observed flowing out of the hard concrete leading to void spaces within the hardened concrete samples, this makes the hardened concrete fragile and brittle.

I. INTRODUCTION

Concrete is the most commonly used material for the construction of infrastructures and buildings. Concrete is a mixture of cement, fine aggregate, coarse aggregate and water in a certain proportion according to the desired strength requirement. The demand for concrete that would withstand the negative effect of chemical pollutants in the environments is on the rise as concrete structures are being used for different purposes in today's modern world such as storage tanks and canal lining in salt water coastal areas. Crude oil in sodium chloride salt water effect is a common effect within the coastal areas of the Niger Delta region of Nigeria which includes Angulama community and its environs in Asari-Toru Local Government Area of Rivers State. The water in the coastal and offshore areas of the Niger Delta region of Nigeria is naturally salt water such as the Angulama community and its environs. Decades now, this salt water environment is experiencing hydrocarbon pollution caused by the activities of crude oil exploration, illegal refine of crude oil, crude oil spillage and careless disposal of seized crude oil products. It is now evident that the salt water and the crude oil products exist together within the environment and the people here are faced with no other choice than to live with this mixture of available water source. Hence, the need for a research on the effect of crude oil products in sodium chloride salt water on the properties of concrete such as workability and compressive strength. Water content with its nature is a very important factor in the determination of workability

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 418-434 www.ijaem.net ISSN: 2395-5252

of fresh concreteand compressive strength of hardened concrete. Crude oil and sodium chloride salt (saline) are both chemical contaminants which are added into the fresh concrete's water content as partial replacement of the water content at varying percentages alternatively from 2.5%, 5%, 10% and 15% and test done at 7 days, 14 days and 28 days. Concrete cube specimens of 150mm by 150mm by 150mm size are used, total of 162 concrete cube specimens are produced and cured in same water condition which serves to provide similar polluted environmental water condition for the concrete during curing.

Aim and Objectives of the Study

The aim of this research work is to analyze the compressive strength and slump as the workability factor of 3/8" (10mm) all-in gravel aggregate concrete produced with crude oil and sodium chloride salt as partial replacement of the water content for mixing, cured in the same sodium chloride salt water crude oil mixture, and compare the results obtained to required standards. The objectives of this research work are as follow;

(a) To conduct concrete Mix design based on Council for the Regulation of Engineering in Nigeria (COREN)concrete mix design manual, 1st edition, 2017 which isin line with the Design of Normal Concrete Mixes, 2nd edition, 1997 by the Building Research Establishment (BRE)to obtain optimum compressive strength value of 3/8" (10mm) all-in gravel aggregate concrete.
(b) To conduct compressive strength test of 3/8" (10mm) all-in gravel aggregate concrete with fresh water as control specimen.
(c) To conduct compressive strength test of 3/8" (10mm) all-in gravel aggregate concrete with alternating percentages of sodium chloride salt and crude oil as partial replacement of water content as test specimens.
(d) To compare results of control specimens to test specimens.

Justification of the Research

i. To improve in fresh and hardened concrete production in sodium chloride salt water with crude oil contaminated areas of the coastal region of the Niger Delta of Nigeria.
ii. To deduce the effect of crude oil in sodium chloride salt water on the compressive strength and slump of concrete
iii. To give professional information.

Scope of the Study

This study involves the use of 3/8" (10mm) all-in gravel uncrushed aggregate, cement and fresh water as the control specimen. A mix design analysis is conducted for control specimens. Crude oil and sodium chloride salt at varying and alternating percentages of 2.5%, 5%, 10% and 15% by mass of the water content as partial replacement of the water content required for the fresh concrete mix is used. Workability factor is obtained from the slump test. 150mm x 150mm x 150mm concrete cube specimens' size, compressive strength tests at 7 days, 14 days and 28 days ages with a total of 162 concrete cubes produced. All tests are carried out in the laboratory of the Civil Engineering Department of the Rivers State University and the results are recorded.

II. LITERATURE REVIEW

The study of the effects of crude oil and crude oil impacted sand on the workability and compressive strength of concrete in some decades now has drawn the attention of researchers in environmental engineering, highway engineering and structural engineering. This is because crude oil products are now significant environment pollutants in crude oil producing states and regions of the world, the researchers are being drawn in to provide comprehensive solution to the adverse effect of crude oil products in concrete production for construction work (Faiyadh, 1985). Ajagbe et al (2013), state that due to the occurrence of crude oil spillage, construction material such as sand in the environment gets contaminated with crude oil. It is this contaminated sand that is used in concrete production to erect infrastructure and building. The degree of contamination affects the strength of the concrete produced with the impacted sand and that the compressive strength of concrete is also affected by water cement ratio, volume of entrained air, type of cement and the curing conditions. The extent of effect of such impact on the compressive strength of concrete can only be known by experiment. Such concrete properties that are affected due to contamination from the use of crude oil impacted sand include flexural strength, compressive strength, durability, slump, compacting factor, water absorption, linear shrinkage, surface resistivity and fire resistance. They placed enfaces in their research on effect on compressive strength of concrete with regards to its importance in quality control of concrete, the compressive strength of concrete is considered the most important property in quality control of concrete. Matti (1976) did a research on shrinkage of oil soaked concrete and (1983) did another research on effect of oil soaking on the dynamic modulus of concrete, states that the volume of concrete decreases when it comes in contact with

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 418-434 www.ijaem.net ISSN: 2395-5252

crude oil, this implies that the presence of crude oil in concrete causes a shrinking effect and this could also lead to a brittle state. In addition, Faiyadh (1985) in his investigation on the bond characteristics strength of oil saturated concrete, showed that, the average bond strength of the specimen when soaked in crude oil decreases with the soaked period.

Mbadike and Elinwa (2011) state that Water occupies about 6% to 8% of the composition of fresh concrete and the water content provides for cement hydration and the workability of the fresh concrete. They concluded that, the effect of saline water in the production of concrete are; (a) salt water in concrete production will reduce the compressive strength of the concrete to approximately 8%, (b) the presence of chlorides and sulphates in salt water reduces the compressive strength of concrete and (c) Curing is necessary in concrete for the complete hydration of cement.

III.MATERIAL AND METHOD

The materials used in this research work include; (i)Portland limestone cement (PLC) of grade 42.5 in accordance to NIS 444-1: 2013. Cement part I: composition, specification and conformity criteria for common cements. (ii) Aggregate used is 3/8" (10mm) all-in gravel aggregates which is a naturally occurring uncrushed aggregate in accordance to EN 445-2002+A1: 2008. Aggregate for concrete and EN 12620 for natural uncrushed aggregates conformity. (iii) The Waterused is in accordance with BS3048:1980. Use of potable water for concrete production. (iv) Sodium Chloride Salt is the normal cooking salt (v) Crude Oilsourced from Angulama in Asari-toru local government area of Rivers state of Nigeria.

Method;

The method includes (a) experimental plan which is shown in table 3.1 below. Each set of mix is for 9 test specimen cubes which are tested for compressive strength at 7days, 14 days and 28 days at 3 test specimen cubes per test age (days) and each set of 9 test specimen cubes is unique with its unique water content mixture. Each set of 9 test specimen cubes are cured separately in its' unique water mixture condition. 1 set of 9 trial test specimen cubes, 1 set of 9 control test specimen cubes and 16 sets of 9 test specimen cubes which summed up to a total of 162 test specimen cubes.

Table 3.1 Experimental Plan

S/N	Condition for test specimen mix	Number of Cubes per Age 7days	14days	28day	Water Mixture constituents	Curing water condition
1	Trial Specimen Water + Cement + Fine Agg. + Coarse Agg.	3	3	3	Potable water	Potable water
2	Control Specimen Water + Cement + Fine Agg. + Coarse Agg.	3	3	3	Potable water	Potable water
3	Test Specimen 1 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 2.5% Crude oil =2.5% Water = 95%	Salt = 2.5% Crude oil = 2.5% Water = 95%
4	Test Specimen 2 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 2.5% Crude oil = 5% Water = 92.5%	Salt = 2.5% Crude oil= 5% Water = 92.5%
5	Test Specimen 3 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 2.5% Crude oil = 10% Water = 87.5%	Salt = 2.5% Crude oil = 10% Water = 87.5%
6	Test Specimen 4 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 2.5% Crude oil = 15% Water = 82.5%	Salt = 2.5% Crude oil = 15% Water = 82.5%
7	Test Specimen 5 Water mixture +	3	3	3	Salt = 5% Crude oil =2.5%	Salt = 5% Crude oil = 2.5%

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 418-434 www.ijaem.net ISSN: 2395-5252

	Cement + Fine Agg. + Coarse Agg.				Water = 92.5%	Water = 92.5%
8	Test Specimen 6 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 5% Crude oil = 5% Water = 90%	Salt = 5% Crude oil = 5% Water = 90%
9	Test Specimen 7 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 5% Crude oil = 10% Water = 85%	Salt = 5% Crude oil = 10% Water = 85%
10	Test Specimen 8 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 5% Crude oil = 15% Water = 80%	Salt = 5% Crude oil = 15% Water = 80%
11	Test Specimen 9 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 10% Crude oil =2.5% Water = 87.5%	Salt = 10% Crude oil = 2.5% Water = 87.5%
12	Test Specimen 10 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 10% Crude oil = 5% Water = 85%	Salt = 10% Crude oil = 5% Water = 85%
13	Test Specimen 11 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 10% Crude oil = 10% Water = 80%	Salt = 10% Crude oil = 10% Water = 80%
14	Test Specimen 12 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 10% Crude oil = 15% Water = 75%	Salt = 10% Crude oil = 15% Water = 75%
Cont.						
15	Test Specimen 13Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 15% Crude oil =2.5% Water = 82.5%	Salt = 15% Crude oil = 2.5% Water = 82.5%
16	Test Specimen 14 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 15% Crude oil = 5% Water = 80%	Salt = 15% Crude oil = 5% Water = 80%
17	Test Specimen 15 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 15% Crude oil = 10% Water = 75%	Salt = 15% Crude oil = 10% Water = 75%
18	Test Specimen 16 Water mixture + Cement + Fine Agg. + Coarse Agg.	3	3	3	Salt = 15% Crude oil = 15% Water = 70%	Salt = 15% Crude oil = 15% Water = 70%
	Total Concrete Cube Specimen per test age	54	54	54		54
	Total Concrete Cube Specimen					162

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 418-434 www.ijaem.net ISSN: 2395-5252

(b) The experimental Procedure for this research work is aligned asparticle size distribution test of the 3/8" (10mm) all-in gravel aggregate, density test of the aggregate, specific gravity test of the aggregate, concrete mix design, slump and compressive strength test of trial specimen, control specimen and test specimen.The 3/8" (10mm) all-in gravel aggregate is washed with potable water from the Rivers State University Civil Engineering laboratory water mains to be sure that this material is completely free of contaminants from the source and then air dried in conformity to the requirements of BS 1881: PART 125. This British standard allows the use of aggregates in air dried condition.The Particle size distribution test was carried out using the dried 3/8" (10mm) all-in gravel aggregate. This was sieved using the standard sieves and the result taken. This is followed by the density and specific gravity tests of the aggregate.

Concrete Mix Design. Adopting the COREN method and procedure for the concrete mix design calculation which is in line with BRE method; the mix design procedure is divided into five segments, each segment is a particular aspect of the mix design procedure which gives an important parameter.

Table 3.2 Concrete Mix Design Form for Trial Concrete Specimens

Stage	Item	References or calculation	Values
1	1.1 Characteristic strength	Specific	25 N/mm^2 at 28 days
	1.2 Standard deviation		Proportion defection ……1.64……..….5% …1.64 x 5 = 8.2N/mm^2 or no data N/mm^2
	1.3 Margin	C 1 Or Specific	K = 1.64, 1.64 x 5 = 8.2 N/mm^2 25 + 8.2 = 33.2 N/mm^2 42.5
	1.4 Target mean strength	C 2 Specific	uncrushed uncrushed
	1.5 Cement strength class	Appendix B 2 Specific	0.59 use 0.59
	1.6 Aggregate type coarse		
	1.7 Aggregate type fine		
	1.8 Free water/cement ratio		
	1.9 Maintain the freewater/cement ratio		
2	2.1 Slump	Specific	Same 10-30 mm or vebe time …….s
	2.2 Maximum aggregate size	Specific Appendix B 2	10mm
	2.3 Free water content		…… 180kg/m^3
3.	3.1 cement	C 3	180 x 0.59 = 305.08 kg/m^3
	3.2 maximum cement content	Specific Specific	…… 305.08 kg/m^3 ……kg/m^3
	3.3 maximum cement content		305.08kg/m^3
	3.4 free water/cement ratio		
4.	4.1 relative density of aggregate	C 4	2.6
	4.2 Concrete density		2380 kg/m^3
	4.3 total aggregate content		2380 - 305.08 - 180 = 1894.92
5.	5.1 Grading of fine agg.	Percentagepassing	850µm 48% 36.60%
	5.2 Proportion of fine	C 5	1894.92 x 0.48 = 909.56

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 418-434 www.ijaem.net ISSN: 2395-5252

agg.							
5.3 Fine aggregate content			1894.92 – 909.56		985.35		
5.4 Coarse aggregate content							
Quantities	Cement (kg)		Water (kg)		fine aggregate (kg)		coarse aggregate (kg)
Per m^3	305.08		180		909.561		985.358
Per trial mix of 0.0304 m^3	9.7302		5.408		29.0096		31.4266
Mix proportion	1	:	0.5900	:	2.9814	:	3.2298

Table 3.3 Summary of Concrete Mix Proportion

Material	Cement	Fine Aggregate	Coarse Aggregate
Quantity in kg/m^3	305.0800	909.5616	985.3584
Mix Proportion	1	2.9814	3.2298

Trial Specimen Test

The trial test specimen cubes are 3 specimen cubes per test age of 7 days, 14 days and 28 days. Therefore, there is a total of 9 test specimen cubes cast for the trial test.

The batching of the constituent materials are done in strict compliance to normal practices in weighing, using the laboratory weighing equipment. The aggregate is allowed to soak in about half the water content required for some minutes, this is to enable the aggregate take up most of the water it will ultimately absorb, this is in conformity with BS 1881: Part 125. The cement is later added and then the remaining water content is added to make up for the complete water content required. The concrete mixing machine is allowed to mix the fresh concrete thoroughly for some minutes.

Slump Test and Concrete Density Test

The fresh concrete is completely mixed and the slump test is done in accordance to BS 1881: Part 102.

Density test of specimen concrete cubes;The density test is done in accordance to BS 1881: Part 107. A mould of 150mm x 150mm x 150mm is used to take the fresh concrete sample. The mould is first weighed empty and recorded, it is then filled with the concrete sample and then vibrated mechanically using the laboratory's concrete vibrating machine and the top of the fresh concrete is made leveled to the top of the mould. The mould with the well vibrated and compacted fresh concrete is weighed and recorded. The density of the fresh concrete is calculated as the mass per unit volume.

Mathematically;Density of concrete specimen = (Mass of mould with fresh concrete sample – mass of mould) ÷ volume of mould.

Control Sample Test. The control specimen cubes are produced and tested after the conclusion of proper test of the trial sample cubes. Similar to the production of the trial sample, the control sample are produced and tested under standard control, practices and procedures.

Test Specimens are produced in conformity with the relevant parts of the BS 1881 and other standards as stated. The same mix proportion is used. The only modification made in the production of the test specimen concrete cubes is the addition of sodium chloride salt and crude oil contaminants to the water content as partial replacement of the water content. These are added in 2.5%, 5%, 10% and 15% alternatively. The contaminants contents in the water mixture are varied by mass as partial replacement of the water content but the total mass of the water mixture content remained the same and equal to the mass of the water content required for the normal concrete mix as stated in the mix design proportion (Water content = 5.7408kg).

Summary of the masses of constituents for a set of 9 test specimens cubes are presented in table 3.4. There are 9 test specimen concrete cubes produced per water mixture content.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 418-434 www.ijaem.net ISSN: 2395-5252

Table 3.4 Summary of Constituents' Proportion Per Set of 9 Test Specimen Cubes

Material	Water content	Cement content	Fine Aggregate content	Coarse Aggregate content
Ratio or proportion	0.5900	1.0000	2.9814	3.2298
Quantity (kg)	5.7408	9.7302	29.0096	31.4266

Masses of Concrete Constituents' Contents with Contaminants for Each Concrete Mix

The masses of crude oil, sodium chloride salt and potable water content that made up the water mixture contents are presented in table 3.5.

Table 3.5 Summary of Test Specimen Concrete Mix

S/N	Condition for test specimen mix	Material Estimate (kg)	Number of Cubes per Age 7days	14days	28day	Water Mixture constituents	Curing water condition
1	Trial Sample Water + Cement + Fine Agg. + Coarse Agg.	Water content = 5.7408 Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266	3	3	3	Potable water	Potable water
2	Control Sample Water + Cement + Fine Agg. + Coarse Agg.	Water content = 5.7408 Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266	3	3	3	Potable water	Potable water
3	Test Specimen 1 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.1435Crude oil cont = 0.1435 Water cont = 5.4538	3	3	3	Salt = 2.5% Crude oil=2.5% Water = 95%	Salt = 2.5% Crude oil =2.5% Water = 95%
4	Test Specimen 2 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.1435Crude oil cont = 0.2870 Water cont = 5.3103	3	3	3	Salt = 2.5% Crude oil = 5% Water = 92.5%	Salt = 2.5% Crude oil = 5% Water = 92.5%
5	Test Specimen 3 Water re + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.1435Crude oil cont = 0.5741 Water cont = 5.0232	3	3	3	Salt = 2.5% Crude oil =10% Water = 87.5%	Salt = 2.5% Crude oil = 10% Water = 87.5%
6	Test Specimen 4 Water mixture +	Cement content = 9.7302 Fine Agg.	3	3	3	Salt = 2.5% Crude oil= 15%	Salt = 2.5%

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 418-434 www.ijaem.net ISSN: 2395-5252

	Cement + Fine Agg. + Coarse Agg.	= 29.0096 Coarse Agg. = 31.4266 Salt content = 0.1435Crude oil cont = 0.8611 Water cont = 4.7362				Water = 82.5%	Crude oil = 15% Water = 82.5%
7	Test Specimen 5 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.2870Crude oil cont = 0.1435 Water cont = 5.3103	3	3	3	Salt = 5% Crude oil=2.5% Water = 92.5%	Salt = 5% Crude oil = 2.5% Water = 92.5%
8	Test Specimen 6 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.2870Crude oil cont = 0.2870 Water cont = 5.1668	3	3	3	Salt = 5% Crude oil = 5% Water = 90%	Salt = 5% Crude oil = 5% Water = 90%
9	Test Specimen 7 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.2870Crude oil cont = 0.5741 Water cont = 4.8797	3	3	3	Salt = 5% Crude oil =10% Water = 85%	Salt = 5% Crude oil = 10% Water = 85%
10	Test Specimen 8 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.2870Crude oil cont = 0.8611 Water cont = 4.5927	3	3	3	Salt = 5% Crude oil =15% Water = 80%	Salt = 5% Crude oil = 15% Water = 80%
11	Test Specimen 9 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.5741Crude oil cont = 0.1435 Water cont = 5.0232	3	3	3	Salt = 10% Crude oil=2.5% Water = 87.5%	Salt = 10% Crude oil = 2.5% Water = 87.5%
12	Test Specimen 10 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.5741Crude oil cont = 0.2870 Water cont = 4.8797	3	3	3	Salt = 10% Crude oil = 5% Water = 85%	Salt = 10% Crude oil = 5% Water = 85%

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 418-434 www.ijaem.net ISSN: 2395-5252

13	Test Specimen 11 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.5741Crude oil cont = 0.5741 Water cont = 4.5926	3	3	3	Salt = 10% Crude oil =10% Water = 80%	Salt = 10% Crude oil = 10% Water = 80%
14	Test Specimen 12 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.5741Crude oil cont = 0.8611 Water cont = 4.3056	3	3	3	Salt = 10% Crude oil =15% Water = 75%	Salt = 10% Crude oil = 15% Water = 75%
15	Test Specimen 13 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.8611Crude oil cont = 0.1435 Water cont = 4.7362	3	3	3	Salt = 15% Crude oil=2.5% Water = 82.5%	Salt = 15% Crude oil = 2.5% Water = 82.5%
16	Test Specimen 14 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.8611Crude oil cont = 0.2870 Water cont = 4.5927	3	3	3	Salt = 15% Crude oil = 5% Water = 80%	Salt = 15% Crude oil = 5% Water = 80%
17	Test Specimen 15 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.8611Crude oil cont = 0.5741 Water cont = 4.3056	3	3	3	Salt = 15% Crude oil =10% Water = 75%	Salt = 15% Crude oil = 10% Water = 75%
18	Test Specimen 16 Water mixture + Cement + Fine Agg. + Coarse Agg.	Cement content = 9.7302 Fine Agg. = 29.0096 Coarse Agg. = 31.4266 Salt content = 0.8611Crude oil cont = 0.8611 Water cont = 4.0186	3	3	3	Salt = 15% Crude oil =15% Water = 70%	Salt = 15% Crude oil = 15% Water = 70%
	Total Test Concrete Cubes		=			**54 + 54 + 54**	= **162**

Every test specimen concrete cube is produced and cured with its unique water mixture. That is, the trial and control specimensare produced and cured with potable water. In same way, the test specimen concrete cubes produced with water mixture of 2.5% sodium chloride salt content and 2.5% crude oil content and 95% potable water content are cured in the same mixture content.

The compressive strength test is carried out in conformity with BS 1881: Part 116. The test

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 418-434 www.ijaem.net ISSN: 2395-5252

specimen cubes are first removed from the curing water mixture and allowed to dry naturally in the air, the specimen cubes are weighed when air dried and the masses recorded. The compressive strength tests (crushing) are carried out in the structural engineering laboratory of the Civil Engineering Department of the Rivers State University using the compressive strength testing (machine) equipment.

IV RESULT AND DISCUSSION

Result All test specimens' results are presented in table 4.1. The specimen cubes were crushed at 7 days, 14 days and 28 days of ages for the respective compressive strengths, the detailed values are given in table 4.1.

Table 4.1 Summary of Compressive Strength Test Results for All Concrete Specimens

S/N	Test specimen mix type	Mass of dried concrete (kg) 7days	14days	28days	Compressive Strength N/mm^2 7day	14day	28day	Slump mm Workability	Mass after 24hrs kg
1	Trial Specimen Water + Cement + Fine Agg. + Coarse Agg.	7.80	7.70	7.50	25.78	26.22	32.00	8.00	7.80
2	Control Specimen Water + Cement + Fine Agg. + Coarse Agg.	7.80	7.70	7.50	25.78	26.22	32.00	8.00	7.80
3	Test Specimen 1 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 2.5% Crude oil =2.5% Water = 95%	7.80	7.70	7.64	19.56	18.00	22.22	10.00	7.80
4	Test Specimen 2 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 2.5% Crude oil = 5% Water = 92.5%	7.80	7.80	7.60	16.44	16.00	17.78	15.00	7.90
5	Test Specimen 3 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 2.5%	7.80	7.80	7.60	16.37	16.89	17.78	17.00	7.90

	Crude oil = 10% Water = 87.5%								
6	Test Specimen 4 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 2.5% Crude oil = 15% Water = 82.5%	7.80	7.80	7.60	12.89	7.56	11.80	22.00	7.90
7	Test Specimen 5 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 5% Crude oil =2.5% Water = 92.5%	7.85	7.80	7.60	12.00	9.33	13.60	13.00	7.90
8	Test Specimen 6 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 5% Crude oil = 5% Water = 90%	7.85	7.80	7.60	11.11	8.00	13.30	15.00	7.90
9	Test Specimen 7 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 5% Crude oil = 10% Water = 85%	7.85	7.80	7.60	14.67	6.22	11.00	20.00	7.90
10	Test Specimen 8 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 5% Crude oil = 15% Water = 80%	7.85	7.80	7.60	15.11	8.00	12.20	24.00	7.90

Cont.

11	Test Specimen 9 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 10% Crude oil =2.5% Water = 87.5%	7.85	7.80	7.70	18.67	21.56	26.00	15.00	7.90
12	Test Specimen 10 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 10% Crude oil = 5% Water = 85%	7.85	7.80	7.70	17.56	8.00	12.50	17.00	7.90
13	Test Specimen 11 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 10% Crude oil = 10% Water = 80%	7.85	7.80	7.60	18.67	8.80	12.50	22.00	7.90
14	Test Specimen 12 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 10% Crude oil = 15% Water = 75%	7.85	7.80	7.70	18.67	8.80	12.50	25.00	7.90
15	Test Specimen 13 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 15% Crude oil =2.5% Water = 82.5%	7.85	7.80	7.70	16.45	8.77	13.00	15.00	7.90
16	Test Specimen 14 Water mixture	7.85	7.80	7.70	15.79	8.60	12.40	17.00	7.90

	+ Cement + Fine Agg. + Coarse Agg. Salt = 15% Crude oil = 5% Water = 80% Cont.								
17	Test Specimen 15 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 15% Crude oil = 10% Water = 75%	7.85	7.80	7.70	13.78	7.78	10.23	25.00	7.90
18	Test Specimen 16 Water mixture + Cement + Fine Agg. + Coarse Agg. Salt = 15% Crude oil = 15% Water = 70%	7.85	7.80	7.70	13.78	6.08	8,00	25	7.90

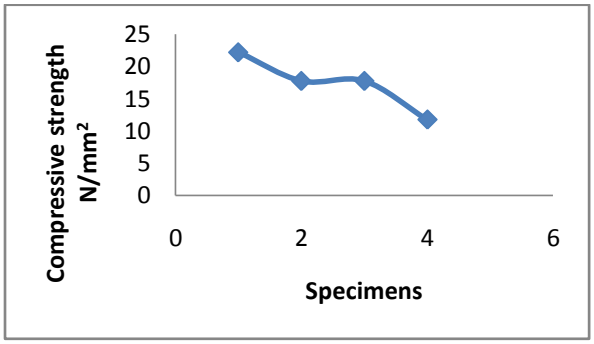

Figure 4.1: Specimen 1, to 4 Vs 28 Days Compressive Strength

Figure 4.1: is a graphical representation of 2.5% sodium chloride content with alternating percentages of crude oil contents in the fresh concrete mix.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 418-434 www.ijaem.net ISSN: 2395-5252

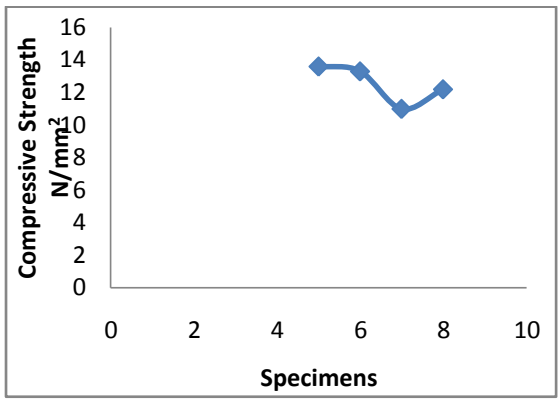

Figure 4.2: Specimen 5 to 8 Vs 28 Days Compressive Strength

Figure 4.2: is a graphical representation of 5% saline content with alternating percentages of crude oil contents in the fresh concrete mix.

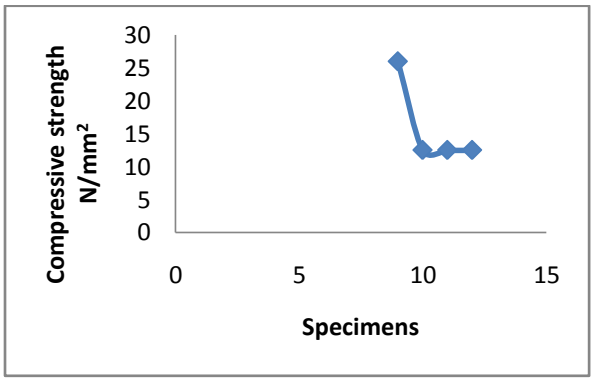

Figure 4.3: Specimen 9 to 12 Vs 28 Days Compressive Strength

Figure 4.3 is a graphical representation of 10% saline content with alternating percentages of crude oil contents in the fresh concrete mix.

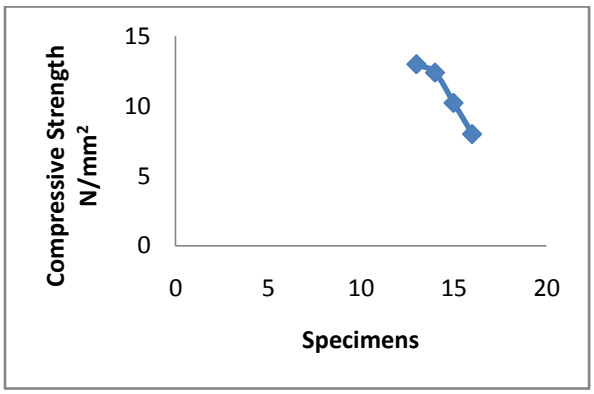

Figure 4.4: Specimen 13 to 16 Vs 28 Days Compressive Strength

Figure 4.4 is a graphical representation of 15% saline content with alternating percentages of crude oil contents in the fresh concrete mix.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 418-434 www.ijaem.net ISSN: 2395-5252

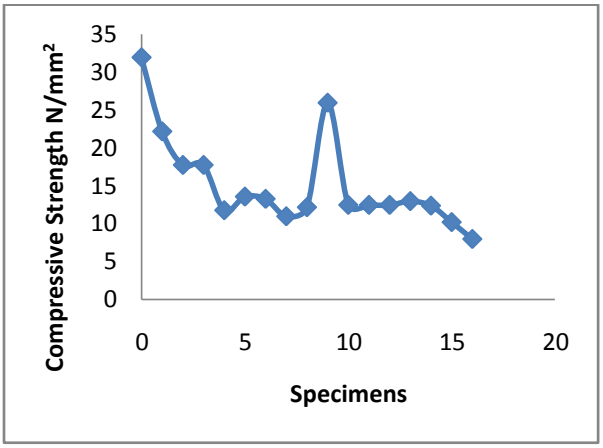

Figure 4.5 Specimens Vs 28 Days Compressive Strength

Graphical presentation of the compressive strength test of the test specimen cubes at 28 days test.

Discussion

After careful study of the processes and results taken, the observation and deductions made are as follow;

(a) The fresh control concrete specimen with 0% contaminants has slump of 8.00mm and mass of 8.0325kg with grey colour. The compressive strength of the hard control concrete specimen at 28 days is 32N/mm^2.

(b) Fresh concrete mixwith 2.5% Sodium Chloride and 2.5% crude oil has mass 8.0325kg and slump of 10mm. It coloured slightly dark shiny grey withslightly slippery surface and less sticky on tools compared to the control specimen. The mass at 28 days is 7.64kg with compressive strength of 22.22N/mm^2 which gives a loss of 9.78N/mm^2 when compared to the control specimen.

(c) As the contaminants percentages are increased,the fresh test concrete specimens become darker and less sticky on tools used and increase in the slump is observed. At fresh mix with 15% sodium chloride salt content and 15% crude oil content, the slump failed and segregation of constituent materials of the fresh concrete is observed. The top surface becomes shinier with a soft swollen top like jell observed when placed in the cube box whichgot flattened as the concrete sets with time. When hard, the specimens chattered on failure during the compressive strength test.

(d) The result of the compressive strength test and the graphical presentation showed that the compressive strength decreases as the contaminants contents are increased but a sharp rise in the compressive strength to 26N/mm^{2}is observed at 10% sodium chloride salt content and 2.5% crude oil content. From a maximum 32.00N/mm^2 to an initial fall to 22.22N/mm^2 which is 30.56% compressive strength loss at 2.5% sodium chloride salt content and 2.5% crude oil content, a second fall to 17.78N/mm^2 which is 44.44% compressive strength loss at 2.5% sodium chloride salt content and 5% crude oil content. The compressive strength fall again to 11.82N/mm^2 which is 63.06% strength loss at 2.5% sodium chloride salt content and 15% crude oil content, a slight rise to 13.60N/mm^2 was observed which is 57.50% compressive strength loss at 5% sodium chloride salt content and 2.5% crude oil content andthen fall to 13.33N/mm^2 which is 58.34% compressive strength loss at 5% sodium chloride salt content and 5% crude oil content a next fall to 11.02N/mm^2 which is 65.56% compressive strength loss at 5% sodium chloride content and 10% crude oil content to a slight rise again to 12.22N/mm^2 which is 61.81% compressive strength loss at 5% sodium chloride salt content and 15% crude oil content to a maximum rise of 26.00N/mm^2 which is 18.75% compressive strength loss at 10% sodium chloride salt content and 2.5% crude oil content after which a sharp decline to 12.49N/mm^2 which is 60.97% compressive strength loss was observed at 10% sodium chloride salt content and 5% crude oil content, same 12.49N/mm^2 which is 60.97% compressive strength loss was recorded at 10% sodium chloride salt content with 10% crude oil content and at 10% sodium chloride salt content and 15% crude oil content to a slight rise of 13.02N/mm^2 which is 59.31% compressive strength loss at 15% sodium chloride salt content and 2.5% crude oil content then a fall to 12.40N/mm^2 which is 61.25% compressive strength loss at 15%

sodium chloride salt content and 5% crude oil content to another fall to 10.22N/mm^2 which is 68.06% loss of compressive strength at 15% sodium chloride salt content and 10% crude oil content. Finally fall to 8.00N/mm^2 which is 75% compressive strength loss at 15% sodium chloride salt content and 15% crude oil content.

V. CONCLUSION AND RECOMMENDATION

Conclusion

After careful examination of the results taken in the laboratory, it could be deduced that crude oil in sodium chloride salt water has negative effect on the compressive strength and workability of concrete.The effects are as follow;

The slump result which is the workability factor is increased alongside with the segregation of the concrete's constituent materials as the contaminants' contents are increased and finally failed at 15% of both contaminants, segregation is an initial indication that the hardened concrete would be brittle in nature and loss of mass of the concrete specimen indicates presence of voids in it because the excess sodium chloride salt not used in the hydration process dissolved in the curing water and Crude oil on its part is not used in the hydration process but moved out of the hardened concrete when drying leaving. All these lead to the reduction in the total bonding surfaces hence subsequent reduction in the total bond strength (Bensted 2014 & West 1996). The conclusive evaluations are as follow;

(a) A maximum rise in the compressive strength of 26.00N/mm2 which is 18.75% compressive strength loss of the specimen is recorded.
(b) The minimum compressive strength recorded is 8.00N/mm2 which is 75% compressive strength loss.
(c) The hardened concrete specimens are brittle and increases with increase in contaminants.
(d) The fresh concrete specimen's constituents segregate with increase in contaminants.

Recommendation

The crude oil producing states and region have to live withcrude oil contaminant in sodium chloride salt water. Thus the people of the Niger Delta region have to adapt and profound measures on how to use the contaminated water in the construction industry. Therefore more research work to be done from this combination.

Contribution to Knowledge

This research work has brought an opened knowledge into the work of fresh and hardened concrete production and construction work in the Niger Delta crude oil explored region. It has brought to knowledge the combined negative effect of crude oil in sodium chloride salt water on the compressive strength and workability of fresh concrete.

REFERENCE

[1]. Abdul, Ahad & Ramzi B., (2000). Compressive and Tensile Strength of Concrete Loaded and Soaked in Crude Oil. Engineering Journal of Qatar University. Vol. 13. Pp. 123-140.
[2]. Ajagbe, W. O., Ganiyu, A. A., Labiran, J. O. & Owoyele, M. O., (2013): Modeling the Effect Crude Oil Impacted Sand on the Properties of Concrete Using Artificial Neural Networks. Hindawi Jublishing Corporation, ISRN Civil Engineering. Vol. 2013, Article ID. 609397.
[3]. Bensted, J., (2014). Hydration of Portland Cement. Blue Circle Industries Limited, Research Division. Greenhithe. U.K.
[4]. British Standard Code of Practice, BS 1881: Part 111. Condition for Curing Concrete
[5]. BS 1881: Part 125. Use of Aggregate in Air Dried Condition.
[6]. BS 1881: Part 102. Test of Slump.
[7]. BS 1881: Part 107. Aggregate Density Test.
[8]. BS 1881:Part 116. Compressive Strength Test.
[9]. Chandak, Rajeev, Verma, Ajay, & Yadav, R. K., (2012). Negative Effects of Salt Contents in the Production of Concrete.
[10]. Chijoke, Basil Onuoha, Ebong, Intoro Bassey & Henry, Ufomba, (2018). The Impact of Crude Oil Exploration and Environmental Degradation in the Niger Delta Region of Nigeria: A Study of Oil Producing Communities in Akwa-Ibom State. Global Journal of Human Social Science; F. Political Science. Vol. 18. Issue 3.
[11]. Concrete mix design manual,(2017). Council for the Regulation of Engineering in Nigeria, (COREN). 1st edition. Abuja, Nigeria.
[12]. Dutton, A. John, (2018). The Chemical Constitution of Crude Oil. Penn State College of Earth and Mineral Science.
[13]. Elinwa, A. U. & Mbadike, E. M., (2011). Effects of Salt water in the Production of Concrete. Nigerian Journal of Technology, Vol. 30, No. 2.
[14]. European Standards. EN 12350-2: 2009. Testing Fresh Concrete, Slump Test.

[15]. EN 12390-3: 2009. Testing Hard Concrete, Compressive Strength of Test Specimens.
[16]. EN 206: 2013. Concrete Specification, Performance, Production and Conformity.
[17]. EN 445-2002+A1: 2008. Aggregate for Concrete.
[18]. Faiyadh, F. I., (1985). Investigating the Bond Characteristics of Oil Saturated Concrete. International Journal of Cement Composites and Light Weight Concrete.Vol. 7. No. 2.
[19]. Girish, S. Kulkarni, Prakash, K. B., & Nandini M. Naik, (2014). Negative Impact of Diesel and Used Engine Oil on the Compressive Strength of Concrete. International Journal of Advance Research in Science and Engineering (IJARSE), Vol. No. 3, Special Issue No. 01.
[20]. Iniemem, J. Inim, Moshood, N. Tijani & Saheed, O. Adetu, (2015). Experimental Study of Influence of Seawater on Strength of Concrete Structures.
[21]. Kosmatka, Steve, & Panarese, William, (1988). Design and Control of Concrete Mixes. Portland Cement Association, Skokie, Ill. PP. 205.
[22]. Mamlouk, Michael, & Zaniewski, John, (1999). Materials for Civil and Construction Engineers. Addison Wesley Longman, Inc.
[23]. Matti, M. A., (1983). Effect of Oil Soaking on the Dynamic Modulus of Concrete. International Journal of Cement Composites and Light Weight Concrete.Vol. 5 No. 4.
[24]. Matti, M. A., (1976). Shrinkage of Oil Soaked Concrete. University of Sheffield, U.K.
[25]. Nigerian Industrial Standards. NIS 444-1: 2013. Cement part 1: Composition, Specifications and Conformity Criteria for Common Cements.
[26]. Normal concrete mix design. (1997). Building Research Establishment (BRE). 2nd Edition.
[27]. Nwaogazie, L. Ify, (2011). Probability and Statistics for Science and Engineering Practices. Lagos, Nigeria.
[28]. Osuji, S. O. (2015). Effect of crude oil contamination on compressive strength of concrete.
[29]. Sidney, Mindess, & Young, J. Francis, (1981). Concrete. Prentice-Hall Inc.. Englewood Cliffs, N.J. Pp. 671.
[30]. West, Graham, (1996). Alkali-Aggregate Reaction in Concrete Roads and Bridges. Ice Virtual Library, Essential Engineering Knowledge.

International Journal of Advances in Engineering and Management
ISSN: 2395-5252

IJAEM

Volume: 03 Issue: 02 DOI: 10.35629/5252

www.ijaem.net
Email id: ijaem.paper@gmail.com