PERFORMANCE MEASURE OF CONCRETE AND SANDCRETE BLOCKS CURED IN CRUDE OIL

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Abstract
Performance measure of concrete and sandcrete blocks soaked in crude oil over a period of days was examined. Concrete and sandcrete structures built around areas suffering from oil spillage can have significant changes in their strength as a result of long exposure to the crude oil spills. Various cubes of different mix ratios for concrete and sandcrete were soaked in water as the control and crude oil in the laboratory for a maximum period of 28 and 42 days respectively. A scenario of crude spillage was achieved by soaking samples into crude oil medium. It was observed that the samples soaked in crude oil had reduced compressive strengths the longer the remained in the medium when compared with the controlled samples. 20-32% and 30-43% compressive strengths were lost from concrete and sandcrete samples due to crude oil exposure for 28 and 42 days respectively.

Keywords: Compressive strength, Concrete, Sandcrete, Crude oil, water/cement ratio.

1.0 Introduction

Concrete is a composite material composed of coarse aggregate, granular material (sand) embedded in a hard matrix of material (the cement or binder) that fills the space between the aggregate particles and glues them together (Fuller & Thompson,1908). Concrete is the most widely used construction material, communities around the world rely on concrete as safe, strong and simple building material It is used almost in all areas of construction (Eldhose et al, 2013). It is versatile i.e. the ease with which fresh concrete in its plastic state may be molded to take up shapes required for various structural forms (Zongjin, 2011). The property of concrete that measures its performance is its compressive strength, which is considered its most important property. The quality of concrete is often determined by its compressive strength and it depends on the properties of its ingredients, the proportion of mix, the method of compaction, the presence of contaminants and their degree, and other controls during placing and curing (Ajagbe et al, 2011).

Sandcrete block is a precast masonry unit, assembled and bounded by cementations materials to form a wall which can be either load bearing wall, enclosed wall or back up wall (Dov, 1991). According to BS 6073 (Specification for Precast Concrete masonry Unit Part 1), three types of blocks are displayed and recognized, which are: solid, hollow and cellular blocks. Sandcrete block is predominantly used and suitable for load and non-load bearing walls, or for foundations. The material constituents, their mix, presence of admixtures and the manufacturing process are important factors that determine the properties of sandcrete blocks. In Nigeria, 95% of walling materials in buildings are made of sandcrete blocks (Anthony et al, 2015). They have adequate strength and stability, provide good resistance to weather and ground moisture, durable and easy to maintain. They also provide reasonable fire, heat, airborne and impact sound resistance. As material for walls, its strength is less than that of fired clay bricks, but sandcrete is considerably cheaper (Anwar et al, 2000).

Crude oil or petroleum is a naturally occurring liquid that can be distilled or refined to make fuels, lubricating oils, asphalts and other valuable products. It is a hydrocarbon composed mainly of hydrogen and carbon, along with minor impurities like sulphur, nitrogen and oxygen (Ejeh & Uche, 2009). One component of all crude oil type that can attack concrete is their sulphurous compound which is an aggressive medium for cement based materials (Kline, 2004).

One very important factor that affects the compressive strength of concrete is exposure to hazardous environment and their degree. The presence of contaminant in concrete mix and its effect on the compressive strength of concrete had been investigated by some authors (Osuji & Nwankwo, 2015; Ajagbe et al, 2011). This paper, however, focuses on the performance measure of concrete when cured in crude oil medium. This actually modeled the condition in the Niger Delta area of Nigeria where oil spillage is a regular occurrence soaking the foundations of existing structures. This forms the basis for this study

2.0 Materials and Method

2.1 Materials

2.1.1 Cement: The Ordinary Portland Cement used is Dangote 3x, 42.5 grade, from Ibese plant was used.

2.1.2 Aggregate: The coarse aggregate used had a maximum size of 12 mm(1/2 inch). Fine aggregate was natural sand obtained from the Okhuahe river. Both were supplied to the Civil Engineering laboratory, University of Benin for experimental purpose. Both aggregates were air dried to obtain saturated surface dry condition to ensure that water/cement ratio is not affected. Coarse and fine aggregates conform to BS 882 specification. In this research, sieve analysis was conducted to obtain the particle grading curve of fine aggregate and its percentage passing 600µm sieve for concrete mix design. Sieve analyses for the aggregates were conducted in accordance to BS 812-103. The result of the analyses are shown in Figure 1 and 2.

2.1.3 Crude Oil: The crude oil used was obtained from the oil spills from Ugbokodo Community river of Delta State in the Niger Delta region of Nigeria. It has API gravity at 150^0C >35.00, specific gravity at 150^0C of 0.812, melting point of wax at 57^0C and viscosity at 21^0C of 6.81 centipoise as shown in Table 1.

2.1.4 Water: The water used was from the borehole water obtained from the faculty of engineering, University of Benin.

2.2 Method

2.2.1 Concrete compression test

Three mix ratios were batched by mass for the concrete cube test which were 1:1.5:3,1:2:4 and 1:3:6 with water / cement ratios of 0.5, 0.5 and 0.65 respectively. The concrete cubes produced were of size 150mm x 150mm x 150mm. The freshly mixed concrete was filled into already prepared moulds in two layers, each layer was vibrated for about 20 sec to 1 min depending on the water/cement ratio and the grades of the concrete that was mixed. Each batch produced twenty four cubes making a total of 72 cubes for the three mixes. 36 cubes were cured under the control medium (water) and the other 36 cubes were cured under crude oil for 7, 14, 21, 28 days for the different mix ratios. Compression test was conducted according to BS:1881-108 and BS:1881-116,1983 with a compression testing machine having a capacity of 2000kN and a constant load application rate of 15kN/s.

2.2.2 Sandcrete compression test

Three mix ratios were batched by volume for the sandcrete cube test which are 1:6, 1:8 and 1:10 with water – cement ratios of 0.6, 0.65 and 0.7 respectively. The sandcrete cubes produced were of size 150mm x 150mm x 150mm. The freshly mixed concrete was filled into already prepared moulds in two layers, each layer was compacted with exactly 25 strokes of the compacting bar, uniformly distributed over the cross section of the mould. Each batch produced six cubes making a total of 18 cubes for the three mixes ratios. Three cubes each were cured under the control medium (water) for the different mix ratios and the remaining cubes were cured under crude oil for 42 days also for the different mix ratios. Compression test was conducted according to BS:1881-108 and BS:1881-116,1983 with a compression testing machine having a capacity of 2000kN and a constant load application rate of 15kN/s.

3.0 Result and Discussion

3.1 Sieve Analysis

Figs. 1 and 2 show the particle size distribution of the coarse and fine aggregates, respectively. From the particle size distribution curve of the fine aggregate, it could be deduced that the fine aggregate falls in zone 2 consisting of 5% fine, 65% medium and 30% coarse sand which shows that the fine aggregate is well graded and it conforms to BS 812-103.

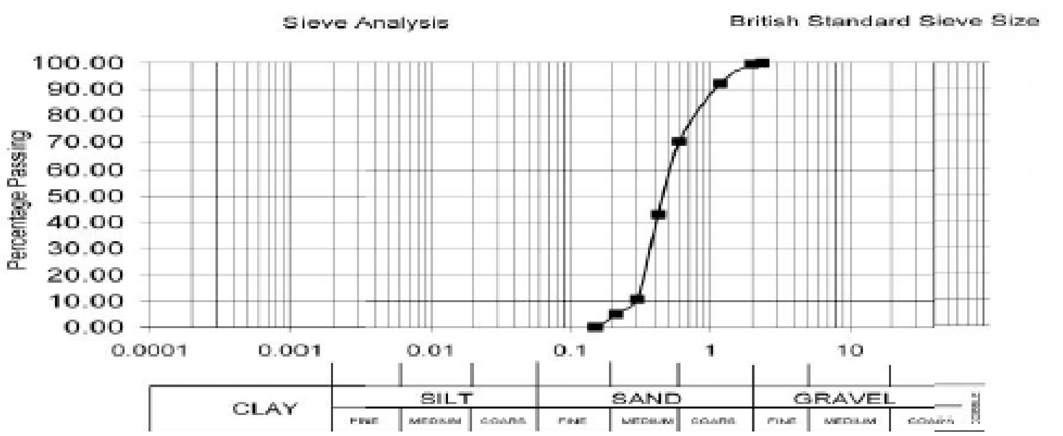

Figure 1: Grading Curve of Fine Aggregate

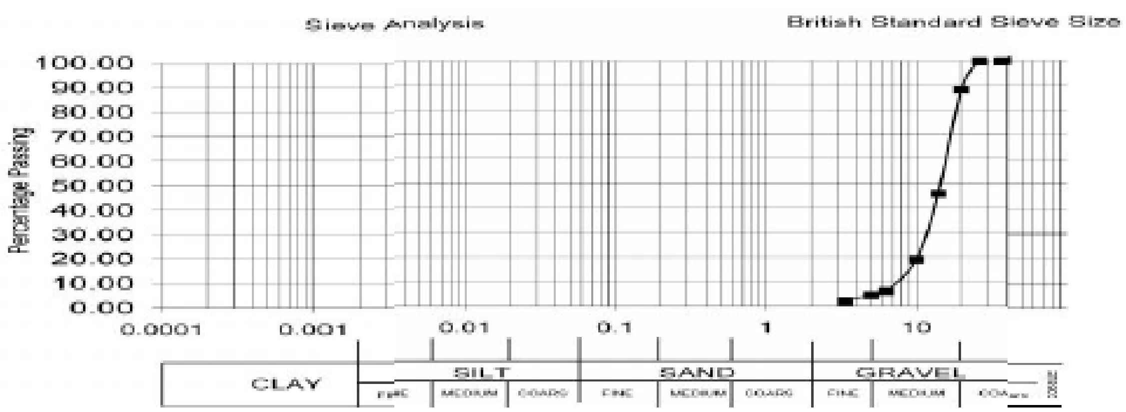

Figure 2. Grading Curve of Coarse Aggregate

Table 1: Properties of Nigeria Crude Oil (Ejeh & Uche, 2009)

S/N	Parameters	Magnitude
1	Specific gravity @150ºC	0.812
2	API gravity @ 150ºC	>35.00
3	Viscosity @ 21ºC	6.81
4	Sulphur content % by weight	0.30
5	Melting point of wax ºC	57
6	Acidity (mg KOH/g)	0.05
7	Wax content % by weight	7.0
8	Moisture content % by volume	0.40
9	Carbon residue % by weight	2.10

3.2 Compressive Strength of Concrete Cubes

Figs. 3, 4 and 5 revealed that the compressive strengths of the concrete cubes for the different mix ratios cure in crude oil medium were affected by it as established by previous researchers (Osuji & Nwankwo, 2015; Ajagbe et al, 2011). The cubes cured in crude oil medium displayed increase in strength but at lower values when compared with the controlled cubes which progressively increased with higher values as the curing age increased, typical of a water curing medium. The low strength observed could be related to the curing age of the cubes, as the crude oil prevented absorption of water by the concrete cube the longer they remained in it, compared to when cured in water, which effected the hydration of cement thus weakening its binding property.

The controlled cubes with mix ratios of 1:1.5:3, 1:2:4 and 1:3:6 at 28days attained the compressive strength of 21.56N/mm^2 (M20), 17.78N/mm^2(M15) and 12.67N/mm^2 (M10) respectively as shown in Table 2 and Figs. 3,4,5. The values of cubes cured in crude oil medium reduced by: 28% to 15.55N/mm^2(M15) for 1:1.5:3 mix, 20% to 14.22N/mm^2 (M10) for 1:2:4 mix, 32% to 8.67N/mm^2 (M7.5) for 1:3:6 mix at 28 days as shown in Table 3 and Figs. 3,4,5,6. The percentage reduction in strength of concrete cubes cured in crude oil medium implies that their original design purpose have been alternated thus making them unfit for the desired use. The strength reduction here is lower than when concrete is contaminated with crude oil medium as seen in Osuji & Nwankwo (2015). Thus 32% strength reduction for 1:3:6 mix at 28 days gave a concrete with compressive strength less than 10N/mm^2 which may not be put to any use particularly where strength is of necessity.

Table 2: Comparing the Average Compressive Strength of both Media for the three Mixes

Concrete Medium	Curing Medium	Average Compressive Strength (N/mm^2) Curing Period			
		7 Days	14 Days	21 Days	28 days
1:1.5:3	Water	13.11	14.67	18.22	21.56
	Crude Oil	10.89	11.56	12.67	15.56
1:2:4	Water	12.67	13.78	16.44	17.78
	Crude Oil	11.11	11.56	12.67	14.22
1:3:6	Water	8.67	9.55	10.89	12.67
	Crude Oil	6.22	7.11	7.56	8.67

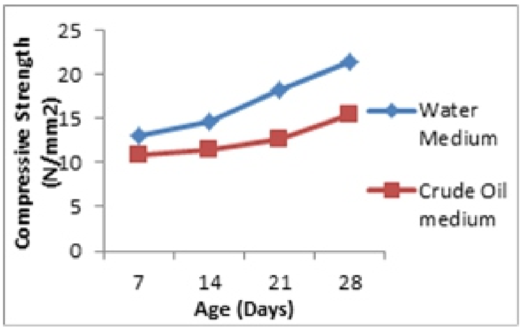

Figure 3: Rate of Development of Compressive Strength of Concrete for 1:2:4 Mix Design

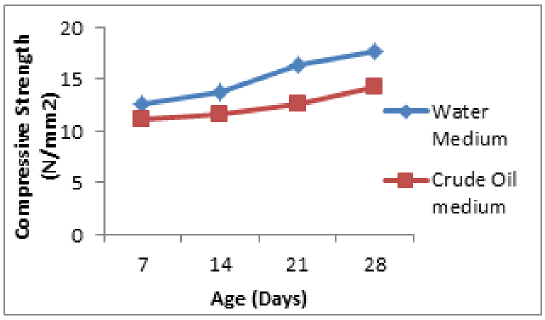

Figure 4: Rate of Development of Compressive Strength of Concrete for 1:1.5:3 Mix Design

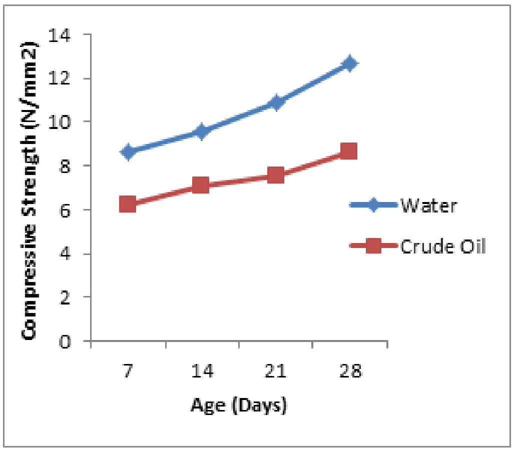

Figure 5: Rate of Development of Compressive Strength of Concrete for 1:3:6 Mix Design

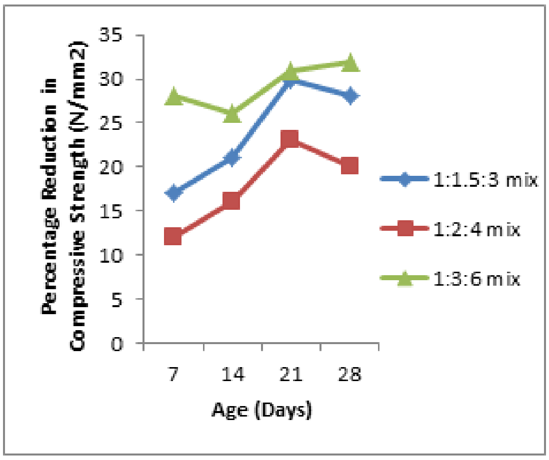

Figure 6: Percentage Reduction of Compressive Strength for the different mix ratios

Table 3: Percentage Reduction in Average Compressive Strength for the three Different Concrete mixes considered

Concrete Mix	Percentage Reduction in Average Compressive Strength (%)			
	Curing Period			
	7days	14days	21days	28days
1:1.5:3	17	21	30	28
1:2:4	12	16	23	20
1:3:6	28	26	31	32

3.3 Compressive strength of Sandcrete cubes

The result for the average compressive strength and the percentage reduction in the compressive strength of the various sandcrete mixes was given in Table 4 and Figure 7 for both curing media. It was observed that the compressive strength of the sandcrete decreased as the mix ratio increased for both curing media. The crude oil medium drastically reduced the compressive strength of the samples for the various mix as compared to the control medium (water).The crude oil medium inhibits absorption of water by the sandcrete which affects cement hydration thus weakening the compressive strength of the cubes.

Table 4: Percentage Reduction in Compressive Strength of the Sandcrete mixes at 42 days

Sandcrete mix	Curing Medium	Average Compressive Strength (N/mm^2)	Percentage Reduction in Strength (%)`
1:6	Water	7.33	29.60
	Crude Oil	5.16	
1:8	Water	3.20	41.86
	Crude Oil	1.80	
1:10	Water	2.80	42.86
	Crude Oil	1.60	

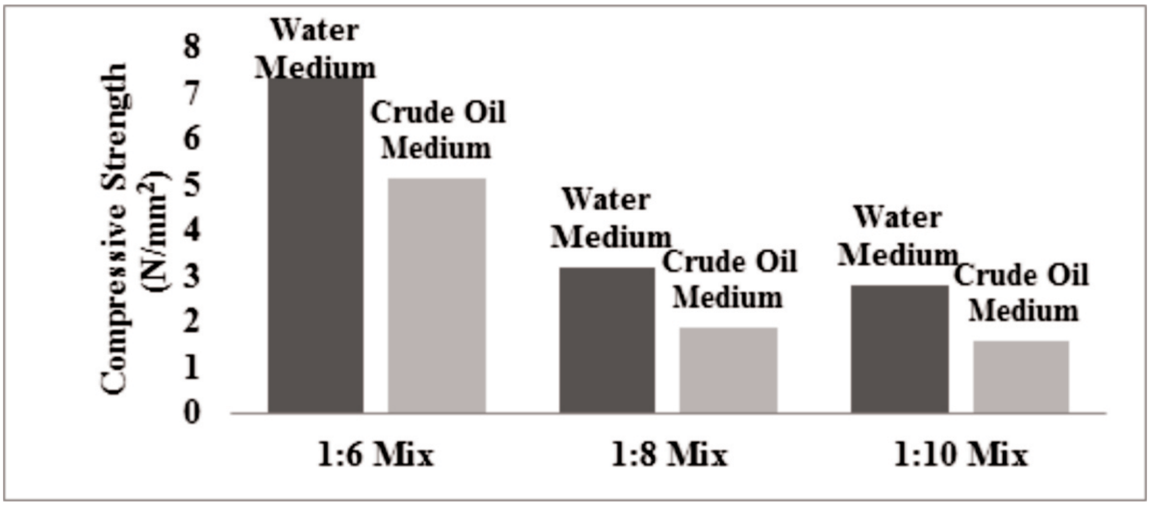

Figure 7: Average Compressive Strength of Sandcrete for both curing media and the three mixes Considered at 42days

Conclusion

The Performance measure of concrete cured in cured in crude oil was examined and the following conclusions drawn:

a) Increased curing age of concrete and sandcrete in crude oil leads to consistent decrease in the compressive strength of the concrete and sandcrete.
b) The mix ratios of 1:1.5:3 and 1:2:4 of concrete cubes soaked crude oil at 28 days gave concrete that can be used for normal concrete and foundation works.
c) The mix ratio of 1:3:6 of concrete cubes in crude medium at 28 days can be used as low strength concrete like sandcrete blocks.
d) The crude oil is a compressive strength inhibitor as it offers no water of absorption to the concrete when compared to the controlled cubes.

References

Ajagbe, o.w., Omokehinde, O. S., Alade, G. A., Agbede, O. A.(2011). 'Effect of Crude Oil Impacted Sand on compressive strength of concrete'. Construction and Building Materials, 26: 9–12

Anthony, B.S., Olabosipo, I. F., and Adewuyj, P.A.(2015). 'Sandcrete Block and Brick Production In Nigeria - Prospects And Challenges'. IIARD International Journal of Environmental Research, 1(4) : 1-17.

Anwar, M., Miyagawa, T., Gaweesh, M. (2000). 'Using rice husk ash as a cement replacement material in concrete'. Waste Manage. Series, 1: 671-684.

BS 1881: Part 108.(1983). 'Method for making test cubes from fresh concrete'. British Standards Institution London.

BS 882.(1983). 'Aggregates from natural sources for concrete'. British Standard Institution London.

BS 812: Part 103.(1989). 'Method of determination of particle size distribution'. British Standards Institution London.

BS 1881. Part 1.(1983). 'Method for making test cubes from fresh concrete'. British Standard Institution London.

BS 1881: Part 111. (1983). 'Method of normal curing of test specimens (20^0C method)'. British Standards Institution London.

BS 1881: Part 116. (1983). 'Method for determination of compressive strength of concrete cubes'. British Standards Institution London.

Dov, K.(1991). 'Design and Construction Failures'. McGraw-Hill Inc. United State of America.

Ejeh, S.P and Uche, O.A.U. (2009). 'Effect of Crude Oil Spill on Compressive Strength of Concrete Materials'. Journal of applied science research 5 (10): 1756- 1761.

Eldhose, M. M., Shaji, M.J., Ranjan, A.(2013). 'Weathered Crystalline Rock: Suitability As Fine Aggregate In Concrete – A Comparative Study'. International Journal of Innovative

Research in Science, Engineering and Technology, 2 (4).

Fuller, W.B. and Thompson, E., (1908). 'The Laws of Proportioning Concrete'. ASCE Transactions: 67-118.

Kline, T.R.,(2004). 'Sulfur Pit Assessment and Repair Strategies'. Structural PreservationSystems Inc, Houston, Texas.

Osuji, S.O. and Nwankwo, E., (2015). 'Effect of Crude Oil Contamination on the Compressive Strength of Concrete'. **Nigerian Journal of Technology (NIJOTECH)** 34(2): **259 – 265.**

Zongjin, L.L.(2011). 'Advanced Concrete Technology'. John Wiley & Sons, Inc., Hoboken, New Jersey.