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IMPACT OF SAND CONTAMINATED WITH CRUDE OIL ON CONCRETE'S ENGINEERING PROPERTIES

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Abstract- It was investigated how COIS (crude oil impacted sand) affected the compressive strength of concrete. All specimens with a w/c of 0.5 were intended to use the concrete mix, 1:1.8:2.7. Sand was contaminated with crude oil (2.5%, 5%, 10%, 15%, 20%, and 25%) by weight in order to create COIS concrete. Concrete cubes measuring 147 100 mm were made (with 21 control samples and 126 contaminated samples). The compressive strengths of the cubes were assessed at ages 3, 7, 14, 28, 56, 84, and 168 days after curing. In comparison to the control samples, the COIS concrete samples exhibited a slow rate of strength gain and a drop in strength. A loss of 18–90% compressive strength was experienced as a result of 2.5–25% crude oil contamination.
Keywords— Impact of Sand, Contaminated with Crude Oil, Concrete's Engineering Properties.

INTRODUCTION

The amount of hydrocarbon contamination in soil and the environment has steadily increased over the past 20 years, and it now makes up a sizeable portion of environmental trash. Oil spills, underground storage tank leaks, oil pipe vandalism, drilling, processing hydrocarbon exploration and production waste, and industry-generated hydrocarbon waste are a few of the major sources of hydrocarbon contamination. Nonetheless, certain waste can be utilised as a chemical admixture or addition to change or improve certain aspects of freshly-poured or freshly-hardened concrete. Moreover, this can help with soil remediation. The necessary qualities of the finished product determine whether or not Crude Oil Impacted Sand (COIS) is successfully used in concrete. Compressive strength is typically regarded as the most significant feature, and concrete quality is frequently assessed by its strength. The qualities of the components, the mix percentage, the compaction technique, the presence and level of impurities, as well as other controls during placement and curing, all affect the compressive strength of concrete. Contaminants and their level are one crucial component that impacts compressive strength. Concrete's constituents are contaminated both naturally and by human activity, however the degree of contamination may vary depending on the source of the ingredients. Large amounts of contamination in aggregates have an impact not only on the colour and smell of concrete, but also on how strong the concrete becomes. Several writers have studied the impact of crude oil on the compressive strength of concrete when it is used as the curing medium; this work, however, focuses on crude oil as a fine aggregate contaminant and examines the impact it has on typical Portland cement concrete. The situation in the Niger Delta region of Nigeria, where oil spills frequently contaminate soil and water, was actually patterned by this. Due to pipeline vandalism, numerous oil spill accidents have happened in the past and continue to this day. In some places, it could be challenging to get enough uncontaminated materials, yet contaminated aggregates are readily available.

Cement, fine and coarse aggregates, and water are combined to create concrete, which is without a doubt the most often used material in the construction of civil engineering constructions. The paste hardens due to hydration, and the slurry (cement and water) bonds the aggregates to a solid mass (i.e., the chemical reaction of the cement and water). It is a flexible building material that may be used for various needs. A variety of different substances, such as admixtures and additives, can be added to the concrete to change its properties and produce the desired outcome, depending on the specifications set forth by the engineer. As the need for crude oil as an energy source and a main raw material for industries has grown, so have its production, transportation, and refining, which has led to a severe increase in environmental pollution. When crude oil is released into the environment, either directly or indirectly, as a result of human activity, an unfavourable shift happens that puts the safety and wellbeing of all living things at peril. Poor ship and terminal design, operational errors, human error, oil well blowouts, and transportation are the main causes of oil pollution in the world. Oil spills in Nigeria can also be caused by sabotage, tanker and pipeline corrosion, and other factors. Crude oil contamination of the environment's sand results from this spilled occurrence. This contaminated sand is utilised to create the concrete that is used to build the structures in the neighbourhood and may also be transported to other locations as borrowed material. The level of contamination impacts the strength of sand-based concrete; the extent of this alteration can only be determined by experimentation. Concrete's flexural strength, compressive strength, durability, slump, compacting factor, water absorption, linear shrinkage, surface resistivity, and fire resistance may all be impacted by crude oil pollution.

RESOURCES OF CRUD EXPOSURE IN SANDS

(i) Emission of crude oil- The spillage that severely contaminates the environment is one of the most important environmental effects of the exploration, production, operation, and transportation of crude oil. Even though most oil spills are unintentional, this isn't always the case. For instance, in the Gulf in 1991, it was claimed that between August 1990 and February 1991, over 1.1 billion litres of crude oil were leaked into the Arabian Gulf, the Persian Gulf, and in the Kuwait desert. These are regarded as the biggest oil spills in recorded history. The result of this deliberate leaking was the pollution of 49 square kilometres of Kuwait's desert and 700 kilometres of shoreline between Kuwait and Saudi Arabia. In addition, the British petroleum BP deep water horizon drilling rig explosion in the Gulf of Mexico in 2010 resulted in an oil spill that impacted about 110 km of the Louisiana shoreline and resulted in an estimated 91 million litres of oil spill. Additionally, in order to prevent an explosion in the tank from the fire caused by a human error during annual maintenance, approximately 71 million litres of crude oil were purposefully released from oil storage tanks at the Harouge Oil Operation petrochemical and refining complex at the Ras Lanuf Terminal in Libya in August 2008.

Fig1- Oil contaminated sand caused by produced water

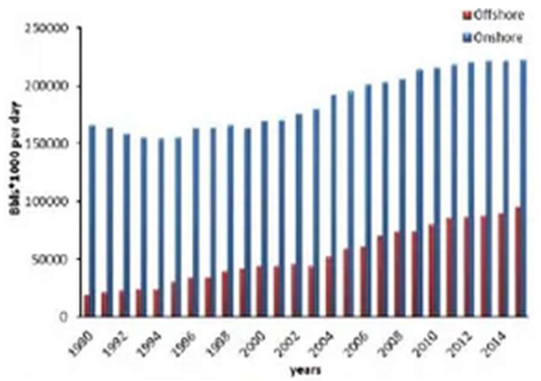

Fig2- Global onshore and offshore water production

(ii) Produced Water- Three barrels of water are used for every one barrel of oil in the oil and gas industry, making produced water the second biggest source of polluted sand. It exists because subsurface reservoirs containing formation water are used to produce oil and gas. According to estimates, the average daily production of generated water around the globe is 210 million barrels, or 77 billion barrels annually. While the anticipated overall production of offshore oil is 120 million barrels/day, the volume of generated water from offshore platforms around the world is roughly 107 million barrels/day. Over a 25-year period, Figure 2 compares produced water from onshore and offshore sources (from 1990-2014). According to Teodor, generated water is released into the ocean at a rate of more than 44 million barrels per day.

METHODOLOGY

(i) Data and Modeling Tool Used - In order to take advantage of the ever-increasing capability of computer hardware and operating systems, Qnet is a backpropagation neural modelling system. Based on the fictitious input vector created by the modeller and used in its training, Qnet is able to predict the compressive strength of concrete. The Qnet tool was tested and trained using the results of the previous experiment described in. The data set, which consists of 49 samples in total, displays the outcomes of casting concrete with contamination levels ranging from 2.5 to 25 percent of crude oil during a time range of 3 to 168 days. Three separate crude oil-contaminated sites Bomu, B-Dere, and Bodo city of Gokana LGA of Cross Rivers State in Nigeria were used in the experiment to collect soil samples. After saponification in methanolic KOH, extraction by n-Hexane, and separation by liquid chromatography, the total petroleum hydrocarbon (TPH) in the samples was calculated using gravimetry to quantify the percentages of crude oil in the contaminated sand samples. Also, it was done to determine the particle size distribution of the leftover dry sands in order to help choose the right sand for the main experiment.

(ii) Process of Training- The training, testing, and prediction sets of the data set utilised for this model were split into three groups in the ratio of 32:11:7. Notwithstanding the fact that the number was given, Qnet chose the testing data at random. The network was trained by feeding it a collection of experimental data that was formatted in a structured way. Each training pattern had an output set that contained the compressive strength and an input set that contained a set of two parameters reflecting days and contamination levels. The variable in the first training pattern's input vector is supplied to the network, which then performs the proper computation using the nodes in the hidden layers and predicts the proper outputs. Calculated and saved is the difference in error between the predicted and desired values. The second training pattern is then provided to the network, and so on until the network has processed all the data accessible to it.

			Crude oil content (%)					
S/No.	Age (days)	Control	2.5	5	10	15	20	25
			Compressive strength (N/mm^2)					
1	3	14.50	11.00	8.17	5.00	0.83	1.83	0.83
2	7	21.25	17.00	13.17	8.50	3.00	3.00	1.83
3	14	25.50	21.50	13.83	9.50	5.17	3.83	2.17
4	28	31.50	23.50	18.33	12.83	6.61	5.00	3.50
5	56	33.50	27.33	21.50	13.83	7.33	7.33	4.00
6	84	33.50	31.25	21.67	15.67	8.33	7.83	5.33
7	168	40.30	33.00	24.30	19.00	11.90	8.80	5.50

Table 1- Modeling data

(iii) Network Structure- The architecture chosen for use is a 2-2-1 network, which has one output layer representing compressive strength and two input nodes representing days and contamination level. There are also two nodes at the hidden layer. The TANH function has been chosen as the network's active function since it performs better than the sigmoid function. A maximum of 20,000 iterations with a momentum of 0.6 and a learning rate of 0.031056 were used. The mixing ratio of the concrete result employed was 1:1.8:2.7 for cement, sand, and granite, respectively, with a water-cement ratio of 0.5, as shown in Table 1 of the modelling data.

MATERIALS AND METHODS

(i) Materials

(a) Cement- Ordinary Portland Cement, the type of cement utilised for the experiment, has the ability to operate as a binding agent when there is water present.
(b) Water- During concreting, clean, potable water was used; the water helped the cement hydrate, which caused the concrete to set and harden.
(c) Aggregates- The largest size of the coarse material used was 10 mm. Ibadan, Oyo state, provided the natural sand for the fine aggregate. To guarantee that the water/ce-ment ratio is not impacted, the fine and coarse aggregates were both air dried to obtain saturated surface dry

conditions. Both coarse and fine aggregates meet the requirements of BS 882. In this study, the first step in the sieve analysis process was to determine the fine aggregate particle grading curve and the percentage of the fine aggregate that passed the 600 lm sieve for the concrete mix design. According to BS 812, sieve examinations of the aggregates were performed.

(d) Brent crude- The crude oil came from the Bomu oil field in the Nigerian state of Rivers' Gokana LGA. Its density is 62 lbs/cuft, specific gravity is 0.99, API gravity is 11.43, and its viscosity at 30 °C is 4.8 centipoise.

(ii) Methods

(a) Sample preparation- Three separate contaminated sites in Nigeria's Cross Rivers State Bomu, B-Dere, and Bodo city were used to collect soil samples for preliminary examination. After saponification in methanolic-KOH, extraction by n-Hexane, and separation by liquid chromatography, the Total Petroleum Hydrocarbon (TPH) in the samples was calculated using gravimetry to quantify the percentages of crude oil in the contaminated sand samples. The residual dry sands were also assessed to help with the selection of sand for the main experiment. Sand from the COIS was polluted with crude oil at a rate of 2.5%, 5%, 10%, 15%, 20%, and 25% by weight of sand in order to make it grade comparable to sand from the contaminated areas. In order to allow for the appropriate reaction of the combination and to replicate the conditions of an oil spill, the resulting COIS was air-dried for around five days.

Sample contamination (%)	Materials (kg/m^3)				
	Cement	Water	Aggregate		Crude oil
			Fine	Coarse	
0	400	200	720	1080	Nil
2.5	400	200	720	1080	18
5.0	400	200	720	1080	36
10.0	400	200	720	1080	72
15.0	400	200	720	1080	108
20.0	400	200	720	1080	144
25.0	400	200	720	1080	180

Table 2- Mix proportion

Oil Removal Technology	*Minimum size of particles removed (μm)*
API gravity separation	150
Corrugated plate separator	40
Induced gas flotation (no flocculants)	25
Induced gas flotation (with flocculants)	3-5
Hydroclone	10-15
Mesh coalesce	5
Media filter	5
Centrifuge	2
Membrane filter	0.01

Table 3- Oil and grease removal technologies based on the size of the particles removed

(b) Compressive strength test for concrete- For casting the concrete cubes, a concrete mix ratio of 1:1.8:2.7 at a water cement ratio of 0.5 was created using the British method of concrete design (see Table 2). The mix was created to produce concrete with a notional 28-day compressive strength of 30 N/mm 2. The manufactured cubes were 100 100 100 mm in dimension. Three layers of filler were manually crushed into the mould at a rate of 25 strokes each layer, using a metal rod with a 16 mm diameter. Thereafter, 147 concrete cubes made up of 21 controls and 126 samples polluted with crude oil were created. After casting for 24 hours, the cubes were demolded and cured in a water tank.

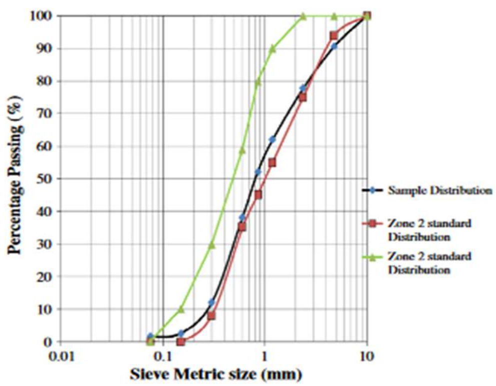

Fig3- Particle size distribution curve of fine aggregate

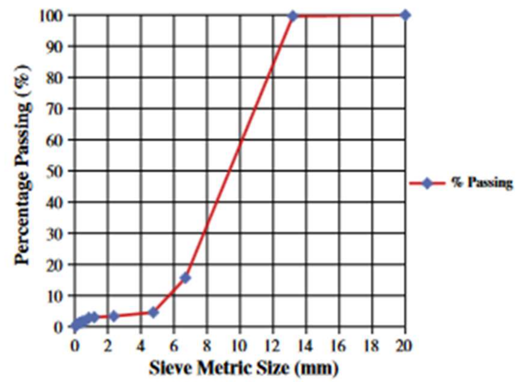

Fig4- Particle size distribution curve of coarse aggregate

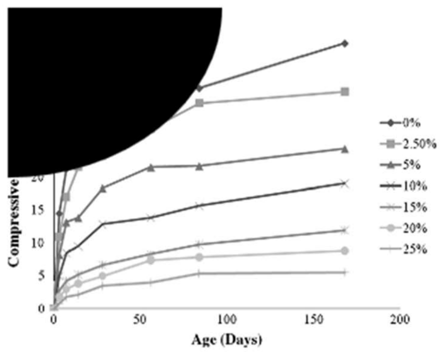

Fig5- Compressive strength development of concrete

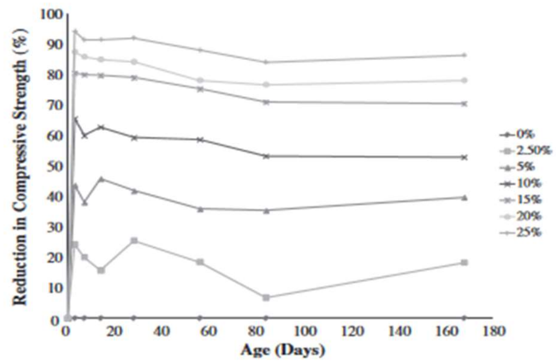

Fig6- Percentage reduction of concrete compressive strength

CONCLUSION

The quantity of crude oil in the sand determines how much the presence of COIS reduces the compressive strength of concrete. The strength reduction increases with increasing concentration. When compared to concrete that is cured in crude oil media, the usage of COIS as fine aggregate of concrete has a more significant impact on its compressive strength. Concrete loses more than 50% of its compressive strength when sands with more than 5% crude oil contamination are used. For low strength concrete, such as Sandcrete block, crude oil contamination between 5% and 10% should be taken into account. A design mix utilising 5% COIS is necessary to obtain the requisite strength.

REFERENCES

[1] Bilal SH, Ahmad AR, Mutassem E. Effect of used engine oil on properties of fresh and harden concrete. Department of civil and environmental engineering, American University of Beirut. Constr Build Mater 2003;17:311–8.

[2] Taylor BM. Bioremediation of hydrocarbon contaminated Soil. ECSOL Limited; 2007.

[3] British Cement Association. Computer aided learning for concrete. Version 2.3; 2001.

[4] Onabolu OA. Some properties of crude oil soaked concrete exposure at ambient temperature. ACI Mater J 1989:150–8.

[5] Ramzi BA, Azad AM. Compressive and tensile strength of concrete loaded and soaked in crude oil. Eng J Univ Qatar 2000;13.

[6] Ejeh SP, Uche OAU. Effect of crude oil spill on compressive strength of concrete materials. J Appl Sci Res 2009:1756–61.

[7] Badejo OT, Nwilo PC. Management of oil spill dispersal along the Nigerian Coasta areas. Department of surveying and geoinformatics, University of Lagos; 2004. p. 1.
[8] British Standards Institution. BS 12. Specification for ordinary and rapid- hardening Portland cement. London; 1978.
[9] British Standards Institution. BS 3148. Methods of test of water for making concrete. London; 1980.
[10] British Standards Institution. BS 1881: Part 108. Method for making test cubes from fresh concrete. London; 1983.
[11] British Standard Institution. BS 882. Aggregates from natural sources for concrete. London; 1983.
[12] British Standards Institution. BS 812: Part 103. Method of determination of particle size distribution. London; 1989.
[13] Teychenné DC, Franklin RE, Erntroy HC. DOE (BRE/DOE). Design of normal concrete mixes. Department of Environment. UK: Building Research Establishment; 1975 [revised Teychenné, Franklin, and Hobbs, 1988].
[14] Day KW. Concrete mix design, quality control and specification. 2nd ed. E & FN Spon; 1992.
[15] British Standard Institution. BS 1881: Part 1. Method for making test cubes from fresh concrete. London; 1983.
[16] British Standards Institution. BS 1881: Part 111. Method of normal curing of test specimens (20 °C method). London; 1983.
[17] British Standards Institution. BS 1881: Part 116. Method for determination of compressive strength of concrete cubes. London; 1983.