EFFECT OF CRUDE OIL CONTAMINATED SAND ON THE ENGINEERING PROPERTIES OF CONCRETE

BY

WASIU OLABAMIJI AJAGBE
B.Sc, M.Sc (Ibadan)

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University of Ibadan
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ABSTRACT

A considerable fraction of sand in Niger Delta Area of Nigeria is contaminated with crude oil. The contaminated sand is largely utilised by local contractors for the production of concrete. However, there is need to establish its suitability in concreting. Previous works have centered on hardened uncontaminated concrete in crude oil environment but not on concrete made with Crude Oil Contaminated Sand (COCS). This research was designed to evaluate the effect of COCS on some engineering properties of fresh and hardened COCS concrete.

Levels of crude oil contamination were determined using gravimetry method of Total Petroleum Hydrocarbon (TPH) test on nine sand samples randomly collected from some oil spill sites in Rivers State. Based on the test results, seven types of artificially contaminated sand were prepared with crude oil levels of 0.0, 2.5, 5.0, 10.0, 15.0, 20.0 and 25.0%. Workability (slump, compacting factor and flow), compressive strength, linear shrinkage, water absorption, and fire resistance were determined using concrete cubes, flexural strength using concrete beams, and surface resistivity using concrete cylinders in accordance with standard methods. Data obtained were analysed using ANOVA at $p = 0.05$. Eight models were developed using historic response surface methodology to predict the engineering properties of COCS concrete at water-cement ratio (w/c) of 0.5. Also, COCS concrete design mixes with contamination level and w/c ratio suitable for reinforced concrete were formulated.

The TPH varied from 8.6 ± 0.2 to $14.1 \pm 1.3\%$. The workability of concrete was improved by the presence of COCS. Slump, compacting factor and flow of the fresh concrete increased with increase in contamination from 30.0 to 200.0 mm, 0.5 to 0.9 and 15.0 to 85.0%, respectively. Compressive strength, flexural strength, linear shrinkage and water absorption of the hardened concrete reduced with levels of contamination from 31.5 ± 2.3 to 3.5 ± 0.0 N/mm^2, 5.9 ± 0.8 to 0.1 ± 0.0 N/mm^2, 0.1 ± 0.0 to 0.0 cm and 0.2 to 0.0 kg respectively. At a temperature of 200.0˚C, the percentage strength reduction increased from 18.4 to 94.8% for 2.5 to 25.0% contamination. Surface resistivity ranged from 25.1 ± 0.2 to 32.3 ± 0.2 kΩ-cm. The compressive and flexural strengths of COCS concrete were reduced by more than 50.0% at crude oil contamination level greater than 10.0%. The water absorption and surface resistivity values indicated that COCS concrete exhibited greater resistance to water and chloride penetration respectively, it shrank less when compared with the uncontaminated concrete, but exhibited poor fire resistance. Coefficient of determination, R^2, of the models developed ranged from 0.823 to 0.999. Concrete design mix ratio of 1part of cement to1.6 part of COCS (10.0% crude oil) to 2.4 part of coarse aggregate was found to be appropriate at 0.45 w/c. This mix gave minimum compressive strength of 21.0 N/mm^2 which is acceptable for reinforced concrete structures.

Concretes produced with sand contaminated with less than ten percent crude oil were found suitable for use in low strength structures. Mix re-design using lower w/c improved the strength of the concrete.

Keywords: Crude oil-contaminated sand, Concrete properties, Compressive strength.

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DEDICATION

This thesis is dedicated to my late father, and brothers and sisters on the path of ALLAH.

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CERTIFICATION

I certify that this work was carried out by W. O. Ajagbe in the Department of Civil Engineering, Faculty of Technology, University of Ibadan.

Supervisor

Prof. O. A. Agbede

B. Sc., M. Sc. (Ife), Ph.D. (London), MNSE

MNSE, MNMGS, MNAH, MIWEM, MAGID

Professor of Civil Engineering

Department of Civil Engineering,

University of Ibadan, Nigeria

Supervisor

Dr. B.I.O Dahunsi

B. Sc. (Ife), M. Sc., Ph.D. (Ibadan)

MNSE, AMASCE, M.INEnv, Reg. Engr. (COREN)

Senior Lecturer, Department of Civil Engineering,

University of Ibadan, Nigeria

TABLE OF CONTENTS

CHAPTER THREE: METHODOLOGY

CHAPTER FOUR: RESULTS AND DISCUSSION

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES