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# Physical and mechanical properties of cement mortar containing fine sand contaminated with light crude oil

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**Abstract**

Oil contaminated sand resulting from oil leakage has continuously been a major environmental concern worldwide. This problem affects the physical and chemical properties of the surrounding soil. Due to prohibitive cost of the existing remediation methods for oil contaminated sand, mixing them with cement and using in construction is considered as a cheaper alternative. In this study, the effect of light crude oil contamination on the physical and mechanical properties of cement mortar was investigated. Fine sand with different percentages of light crude oil by weight ranging from 0% to 10% was mixed with Ordinary Portland cement and cured in a fog room. The compressive strength of the cement mortar was then determined at 7, 14 and 28 days. Results showed that the workability and the total porosity of the cement mortar increased as the amount of crude oil increases. Moreover, the compressive strength increased with the increasing curing time for all specimens. The cement mortar containing fine sand with 1% light crude oil exhibited the highest compressive strength, which is 18%, 30% and 17% higher than the uncontaminated samples at 7, 14 ad 28 days, respectively. Interestingly, the cement mortar with up to 2% oil contamination has higher compressive strength than the 0% oil contamination while increasing the crude oil content more than 2% and up to 10% cause a reduction in the compressive strength by 50%. Still, the strength properties of mortar with oil contaminated sand up to 10% are suitable for landfill layering and production of bricks results indicating their high potential and beneficial use as a sustainable material in civil engineering and construction.


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## 1. Introduction

Crude oil contamination in sand is considered as a significant source of waste materials in the environment [1]. This contamination is normally caused by oil leakage, pipelines vandalism, wars, drilling, exploration and production of crude oil, and oily produced water [2]. Due to prohibitive cost of the existing remediation methods for oil contaminated sand, mixing them with cement and using in construction is considered as a cheaper alternative [3]. Earlier studies showed that the properties of fresh and hardened concrete can be enhanced by addition of waste used as chemical admixture and additives [4]. While a number of researchers [2, 5, 6] suggested that mixing oil contaminated sand with cement is a clever civil engineering solution to reduce the remediation cost and environmental impact, there are very limited studies conducted to investigate the properties of contaminated sand and its concrete in order to substantiate their beneficial use in construction.

The successful use of crude oil contaminated sand as a construction material depends on the required properties of the produced concrete. Compressive strength of concrete, a vital element of structural design, is the most important mechanical property which characterizes the quality of the produced concrete. The strength depends upon many factors, e.g. quality and quantity of cement, water cement ratio (w/c) and aggregates; mixing; placing, compaction and curing and the presence of contaminants and their degree [2]. Among those factors the presence of contaminants and its degree is considered as one of the most important factors that affects the compressive strength of concrete. The presence of contaminant at high level does not only affect the appearance of concrete but also may affect the strength developed of concrete [7]. Thus, before it is considered as a sustainable material in building and construction further investigation was needed to evaluate the effects of oil contamination on the mechanical properties the produced cement mortar/concrete. This paper presents an investigation on the physical and mechanical properties of cement mortar containing fine sand with different levels of light crude oil contamination.

## 2. Materials and methods

### 2.1 Preparation of the specimens

Air dried fine sand, with particle size less than 2.36 mm, was used due to its similarity to sand in the Libyan Desert where the first author came from. On the other hand, mineral Fork w2.5 motor cycle oil was used because its density and viscosity are similar to light crude oil [8, 9]. The samples were prepared by mixing dry sand with different percentages of light crude oil (0.5, 1, 2, 4, 6, 8 and 10 %) by the weight of dry sand. In addition, uncontaminated (0%) sand was prepared as a control sample. These percentages were selected based on the previous investigation on the mechanical properties of fine sand contaminated with light crude oil [10]. The oil was mixed manually with the dry sand and then the samples were placed inside a plastic container for 72 hours to allow the mixture to attain a homogenous condition. A lid was placed on the plastic container to prevent the crude oil from evaporating during this period of incubation.

### 2.2 Preparing, Casting and curing

A total of 72 specimens covering three samples for each specimen type were prepared. All laboratory work was conducted at a room temperature around 22ºC. The indicative workability of the cement mortar was measured using NL 3016 X / 002 Flow Table Apparatus following the procedures specified in ASTM C1437-07 (2007). The cement mortar were then placed in plastic moulds (50mm diameter and 100mm high) and cured in a fog room (FR) set at 25 ºC and 85% humidity. The specimens were kept in the fog room until they are ready for testing. Figure 1 shows the protocol of sample preparation based on the AS 2350.12 [11]. The composition of the mortar was based on AS 2350.12-2006 [11] with mix proportions of 1 part cement and three parts sand (by mass).