Journal of Engineering and Applied Sciences
MEDWELL PUBLICATIONS SINCE 2000

Effect of Crude Oil products on the Compressive Strength of NSC

Wisam K. Tuama, Nameer A. Alwash and Mohammed M. Kadhum
Department of Civil Engineering, College of Engineering, Babylon University, Babylon, Iraq

Key words: Crude oil, Normal Strength Concrete (NSC), compressive strength, NDT, resistance

Corresponding Author:
Wisam K. Tuama
Department of Civil Engineering, College of Engineering, Babylon University, Babylon, Iraq

Page No.: 2332-2336
Volume: 15, Issue 10, 2020
ISSN: 1816-949x
Journal of Engineering and Applied Sciences

Abstract: This study includes detailed information of the compressive resistance of the hardened normal concrete mix (NSC) are exposed to crude oil products for the period (180 days). The study also deals with conducting Non-Destructive Tests (NDT) for a ground foundation in one of the oil sites and knowing the influence of crude oil on the compressive resistance. The results showed that the compressive strength of the NSC mix is decreasing where it lost about (17.35 and 20.20%) compared with reference NSC mix after exposure to crude oil products (kerosene and gas oil), respectively. The results of the non-destructive testing of the actual size floor slab at the site showed that the compressive resistance of the area exposed to crude oil lost about (56.02%) compared with the unexposed area at the age of 7 years.

INTRODUCTION

The action of oil on concrete is still obscure and the recent vast growth of crude oil production from the off shore fields (North Sea) and the Middle East countries, together with the problems arising frame transportation and storage necessitate a quantitative study of the properties of concrete in contact with oil.

The compressive strength of hardened concrete is most common property required for the structural use[1-3]. The leakage of oils, especially, the lighter products through the pore structure, shrinkage cracks and joints is the major problems that restrict the successful use of concrete to store crude oil[4]. Reinforced concrete elements in case of underground structures, garage buildings and manufacturing constructions are subjected to contamination of different materials, i.e., water, chemical and oil products. Oil products affect tank walls, foundations and other constructions supporting machines and storage floors, therefore, the range of the problem is wide and the subject should be considered of great technical importance, especially when regarding industrial construction. Oil leakage from machines above foundation has been considered the prime factor in the deterioration of reinforced concrete elements supporting machines[5, 6].

In the service of concrete oil, stores shall control the cracks and permeability. In general, concrete suffers from tensile properties and a tendency to crack under tensile pressure resulting from external loads, shrinkage, creep, or thermal gradients. In most of the time, long-term loading extends the magnitude of cracks in both plain and reinforced concrete[7, 8].

MATERIALS AND METHODS

Experimental work in laboratory

Concrete mix design: The quantities of constituents of NSC mixture were as shown in Table 1 and Fig. 1. The ordinary portland cement type 1 was used in mixture according to IQS[9]. In this study, local normal fine aggregate by maximum size (4.75 mm). The sand was speared out and left in the air to dry before use. Results indicate that fine aggregate grading is within the requirements of the Iraqi specification[10]. The sulfate content, fine materials, specific gravity, fineness modulus and absorption of the fine aggregate were carried out in accordance with (IQS).

The coarse aggregate used for NSC was natural rounded gravel with a maximum size of 10 mm which was also obtained from the local sources in Iraq. Results revealed that coarse aggregate used in this research is complying with[8] specifications. The gravel is washed and released in air to dry the surface and then stored in containers to keep the saturated and surface dry condition before use.

Water used for the mix and in the curing of samples is the drinkable tap water available on the college campus.

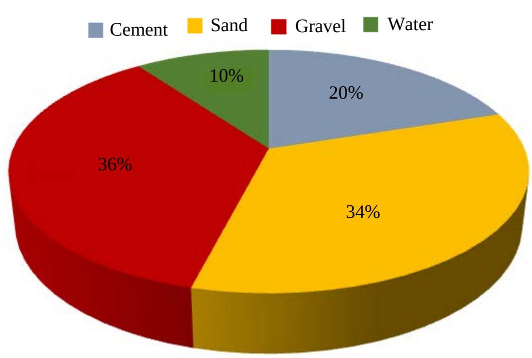

Fig. 1: Materials proportion employed in NSC mixture (% of total mix weight)

Table 1: NSC mix design (1 m^3) concrete

Cement ($kg\ m^{-3}$)	Fine aggregate ($kg\ m^{-3}$)	Coarse aggregate ($kg\ m^{-3}$)	W/cm
456	776	825	0.5

The water is clean with no strange material in it that can disturb the hydration process of cement. The temperature of the mixing water was maintained at (25±2°C).

Exposure to crude oil products: Two types of oil products were used in the present investigation (kerosene and gas oil). They were obtained from were length is 13 mm and diameter 0.2 mm Al-Durra refinery and stored in air tight, Iron and plastic containers, so that, there are no losses and contamination. Table 2 offers the characteristics of oil products utilized.

After the period of curing, the samples were left in the air to dry for 2 days. The first set of samples was then immersed in kerosene and the second group immersed in the gas oil to age (180 days) while the third group was left in the air.

Site observation: In addition to the mechanical properties investigation of RPC and NSC, measurements were made on actual size NSC floor slab (foundation) of a constructed closed drain at age 7 years with different degrees of crude oil saturation at Garraf oil field in Iraq, Thi-Qar city. The measurements covered, length, width and thickness of slab, amount and distribution of reinforcement as shown in Table 3. Whereas the amount and distribution of reinforcement and thickness of the slab were taken from their design engineering drawings. The compressive strength was evaluated directly on the slab by NDT test (Schmidt hummer).

Rebound hammer test: A Schmidt hammer was used to estimate the surface hardness of the concrete slab (actual size) by recording the rebound number which represent an indication to the compressive strength of concrete.

The Schmidt hammer rebound number was recorded at 16 distributed points on the top face of the slab. The

Table 2: Properties of used crude oil products*

Oil Inspection data	Kerosene results	Gas oil results
Humidity content % by size	0%	0%
Sulfur content % by weight	0.2%	1%
pH	7.6	6.3
Specific gravity (gm/cm^3) at:	0.801	0.85
Viscosity (centipoises) at 25°C	1.092	3.960
Flash point (min)	38	54
Char value $mg\ kg^{-1}$ (max)	20	-
Diesel index (min)	-	55

* Oil test was carried out by the Laboratory of Al-Durra Refinery

Table 3: Details of actual size slab (in site)

Length (m)	Width (m)	Thickness (cm)	Diameter and distribution of reinforcement bar	Compressive strength at 28 days (MPa)
22	7	60	Ø 16 @ 15 cm (T and B) for (2 layers)	35

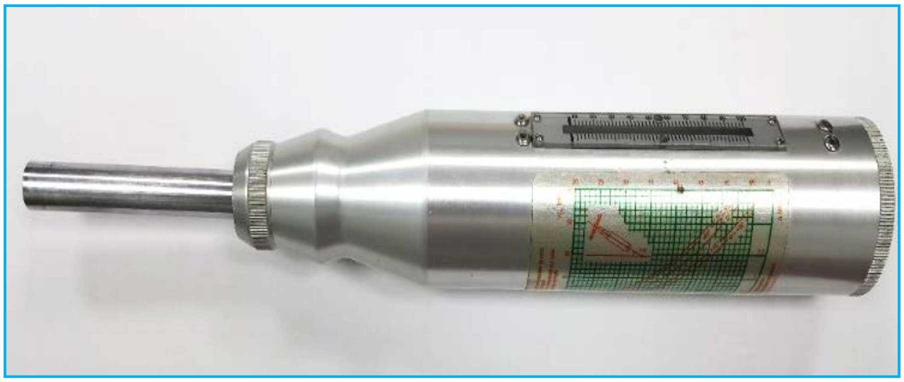

Fig. 2: The schmidt hammer

Fig. 3: Location of the structure

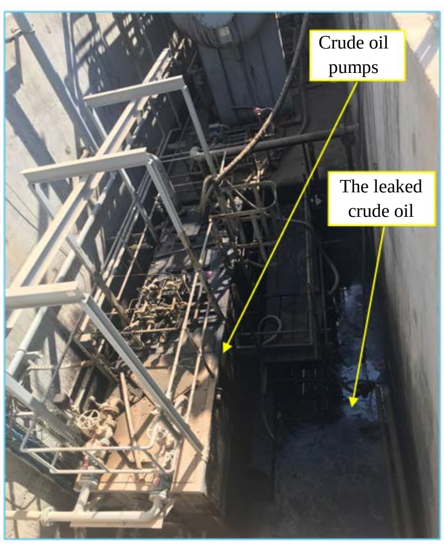

Fig. 4: Inside closed drain

mean rebound number was calculated for each area of slab (exposed and unexposed to crude oil). The Schmidt hammer was used as shown in Fig. 2. The test method is prescribed by Anonymous[11]. Figure 3 shows the location of the structure and its surroundings and Fig. 4 shows inside closed drain.

RESULTS AND DISCUSSION

Results of the experimental work: This investigated in order to estimate the resistance of NSC to crude oil products. The reference samples were cured 28 days. After the age of 28 days tested samples were grouped into three series. The first cured in air, meanwhile, the second cured with kerosene and the third with gas oil up to the age of test (180) days.

Table 4 displays the compressive strength development of all investigated mixes for different exposure conditions. All amount in the table reflect the average value of three samples so as to reduce errors. This table shows the values of the compressive strength of the mixtures at age (7, 28, 180 days). It can be seen that the compressive strength value has significantly decreased when the NSC samples is exposed to kerosene compared to the open air samples.

Table 4: Results of the test of (compressive strengths) of NSC sample of submerged and unsubmerged cubes in crude oil products

Age by days	Compressive resistance fcu (MPa)		
	NSC		
7	30.90		
28	44.00		
Type of exposure	Air	Kerosene	Gas oil
180	49.00	40.50	39.10
fcu/fcu (at air) (%)	100	82.65	79.80
Change in fcu (%)	-	-17.35	-20.20

Table 5: Rebound number and compressive strength for exposed and unexposed actual size NSC slab to crude oil

	Compressive Strength fcu (MPa)			
	Exposed		Unexposed	
No. of reading	Rebound number	fcu	Rebound number	fcu
1	32	28	36	35
2	28	22	46	52
3	26	18	36	35
4	24	16	40	42
5	26	18	42	46
6	30	25	40	42
7	30	25	40	42
8	24	16	34	31
9	20	10	40	42
10	22	13	32	28
11	22	13	32	28
12	26	18	38	38
13	28	23	44	50
14	22	13	46	52
15	22	13	40	42
16	24	16	42	46
Average of fcu	17.9		40.7	
Change in fcu (%)	-56.02 %	-		

The results shown in this tables also showed that the decrease in the compressive strength of the NSC samples exposed to gas oil was slightly more than that of kerosene.

$$\text{Change in (Fc)\%} = \left(\frac{\text{(Fc)}}{\text{(Fc (at air)}}\times 100-100\right)\% \quad (1)$$

Results test of foundation: The compressive resistance of the concrete foundation was assessed by the “Schmidt rebound hammer”. The readings of the rebound number were recorded for the exposed and unexposed area of the foundation to crude oil. The Schmidt rebound number could be used as a measurement of the degradation degree of concrete surface.

From Table 5, it can be visible that the exposed area of the foundation to crude oil decreased the rebound number comparison with unexposed, thus, reducing compressive strength by 56.02%. The reduction in the rebound number can be attributed to the fact that crude oil decreased the surface hardness of concrete.

$$\text{Change in fcu\%} = \left(\frac{\text{fcu}}{\text{fcu (unexposed)}}\times 100-100\right)\% \quad (2)$$

CONCLUSION

Founded on the outcomes reached in this study using the practical part of the NSC samples exposed to crude oil products and non-destructive tests on site, the conclusions can be drawn as the following the reduction in the compressive strength of NSC cubes when exposed to crude oil products at age 180 days where the results recorded maximum reduction in cube compressive strength NSC is 20.2% when exposed to gas oil.

The results shown that the decrease in the compressive strength of the NSC samples exposed to gas oil was slightly more than that of kerosene.

It’s concluded that crude oil influence on the construction in the site is more severe where concrete lost about (56.02%) of the design compressive strength for the same age 7 years.

REFERENCES

01. Kadhum, M.M., 2014. Effect of metakaolin and fly ash on properties of self compacting concrete through: Accelerated curing. Intl. J. Sci. Eng. Res., 5: 885-895.

02. Kadhum, M., 2015. Prediction of mechanical properties of reactive powder concrete by using artificial neural network and regression technique after the exposure to fire flame. Jordan J. Civ. Eng., 3: 381-399.
03. Kadhum, M.M., J. Saeed and S.J. Moham,q 2015. Structural behavior of modified reactive powder concrete beams reinforced with rebars and steel mesh. Intl. J. Struct. Civ. Eng. Res., 4: 10-27.
04. Lea, F.M., 1970. The Chemistry of Cement and Concrete. 3rd Edn., Edward Arnold Publishers Limited, Glasgow, United Kingdom.
05. Blaszczynski, T., 2011. Assessment of RC structures influenced by crude oil products. Arch. Civ. Mech. Eng., 11: 5-17.
06. Diab, H., 2011. Effect of mineral oil on reinforced concrete structures, part I: Deterioration of compressive strength. J. Eng. Sci. Assiut Univ., 39: 1321-1333.
07. Al-Ameer, S.A.A., 2011. Effect of petroleum products on steel fiber reinforced concrete. MCS Thesis, University of Baghdad, Baghdad, Iraq.
08. ASTM., 2017. Standard specification for portland cement. ASTM International, West Conshohocken, Pennsylvania, USA.
09. IQS., 1984. The 1984 for aggregates of natural resources used for concrete and construction. IQS, Inc., North Olmsted, Ohio.
10. ASTM., 2006. Standard specification for concrete aggregates ASTM C33. ASTM International, West Conshohocken, Pennsylvania, USA.
11. Anonymous, 1986. BS. 1881: Part 202; Recommendation for surface hardness testing by rebound hammer. British Standards Institution, UK.