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Effect of used engine oil on structural behavior of reinforced concrete elements

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Abstract

This paper reports on the second phase of a research program started at the American University of Beirut (AUB) to study the effects of used engine oil on concrete properties and concrete behavior. In the first phase, the effect of used engine oil on properties of fresh and hardened concrete was investigated. Results indicated that used engine oil acted as an air-entraining agent by improving the slump and fluidity of the concrete mix, and enhancing the air content of fresh concrete. Reductions in the strength properties of hardened concrete due to the incorporation of oil were not as significant as when a commercial chemical air-entraining admixture was used. Results of the first phase of the AUB study instigated further investigation reported in this paper. The objective was to evaluate the effect of used engine oil on structural behavior of reinforced concrete elements. Six full-scale beam specimens were tested in three sets. The difference between the three sets was the mode of failure of the beams: flexure; shear; or bond. The two companion beams in each set were identical except for the use of engine oil in one of them. The beams were tested in positive bending. Results showed that regardless of the mode of failure, used engine oil did not have any significant effect on the ultimate load or load-deflection behavior of the beams.

Keywords: Concrete technology; Used engine oil; Waste; Structural behavior

1. Introduction

The leakage of oil into the cement in older grinding units has been reported to result in concrete with greater resistance to freezing and thawing [1]. Accordingly, adding used engine oil to the fresh concrete mix could be similar to adding an air-entraining chemical admixture, thus enhancing some durability properties of concrete while serving as a technique of disposing the oil waste. However, lack of experimental data to support this hypothesis led to designing a multi-phase research program at the American University of Beirut (AUB) to evaluate the effect of used engine oil on concrete behavior.

In the first phase of the program, 20 concrete mixes were prepared to check the effect of adding used engine oil to concrete on the properties of fresh and hardened concrete. The study was reported in a paper sent to the 'Construction and Building Materials Journal' for review and possible publication [2]. The variables were the type of the air-entraining agent: commercial air-entraining chemical admixture, used engine oil, or new engine oil; the dosage of the air-entraining agent measured as percentage by weight of cement = 0.075, 0.15 or 0.30%; the mixing time as measured after all ingredients including the air-entraining agent were in the mixer = 2 or 5 min; and the water cement ratio = 0.62 or 0.59. The tested properties of fresh concrete included slump and air content. The tested properties of hardened concrete were the compression strength measured at 3, 7, 28 and 90 days; and the modulus of rupture or the flexural strength, the splitting tensile strength, and the modulus of elasticity, all measured at 28 days. All properties were tested according to ASTM procedures [3].

When the water cement ratio was 0.62 for all companion mixes, identical except for the use of an air-entraining agent (none, commercial chemical air-

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Table 1
Test parameters and test results

Set no.	Mode of failure	Beam notation	Percentage of used engine oil[a] (%)	Slump (mm)	Concrete compressive strength f_c (MPa)	Measured ultimate load (kN)	Deflection at midspan (mm)	Data normalized by $(f_c)^{1/2}$	
								P_{max} (kN)	Bond stress u_t (MPa)
1	Flexure	F0	0	120	30.1	113.0	19.8	112.9	–
		F15	0.15	190	24.5	99.2	15.4	109.8	–
2	Shear	S0	0	110	29.9	54.9	5.4	55.0	–
		S15	0.15	190	22.3	44.6	4.2	51.7	–
3	Bond	B0	0	100	30.3	55.5	4.7	55.2	4.45
		B15	0.15	210	24.6	46.6	3.9	51.4	4.15

[a] The percentage of used engine oil is by weight of cement.

entraining admixture, used engine oil, or new engine oil), the following conclusions were made:

1. The performance of the used engine oil and the new engine oil mixes were similar.
2. Used engine oil acted as a chemical plasticizer improving the fluidity and almost doubling the slump of the concrete mix.
3. Used engine oil increased the air content of the fresh concrete mix (almost double), whereas the commercial chemical air-entraining admixture almost quadrupled the air content.
4. Used engine oil resulted in average losses of 21, 17 and 6% in the values of the flexural strength, splitting tensile strength, and modulus of elasticity, respectively. The corresponding losses when the chemical air-entraining admixture was used were 33, 42 and 35%, respectively.
5. Used engine oil maintained the concrete compressive strength whereas the chemical air-entraining admixture caused a loss of approximately 50% in compressive strength at all ages.

When a water cement ratio of 0.59 was used for the oil mixes, the following conclusions were made after assessing and comparing the test results of these oil mixes with the control mix of a water cement ratio of 0.62:

1. The performance of the used engine oil and the new engine oil mixes were similar.
2. The fluidity of the used engine oil mix, as measured by the slump test, was maintained similar to that of the control mix.
3. The air content of the used engine oil mix was almost double that of the control mix.
4. Used engine oil with a water cement ratio of 0.59 maintained the flexural strength, splitting tensile strength, and modulus of elasticity of the control mix with water cement ratio of 0.62.

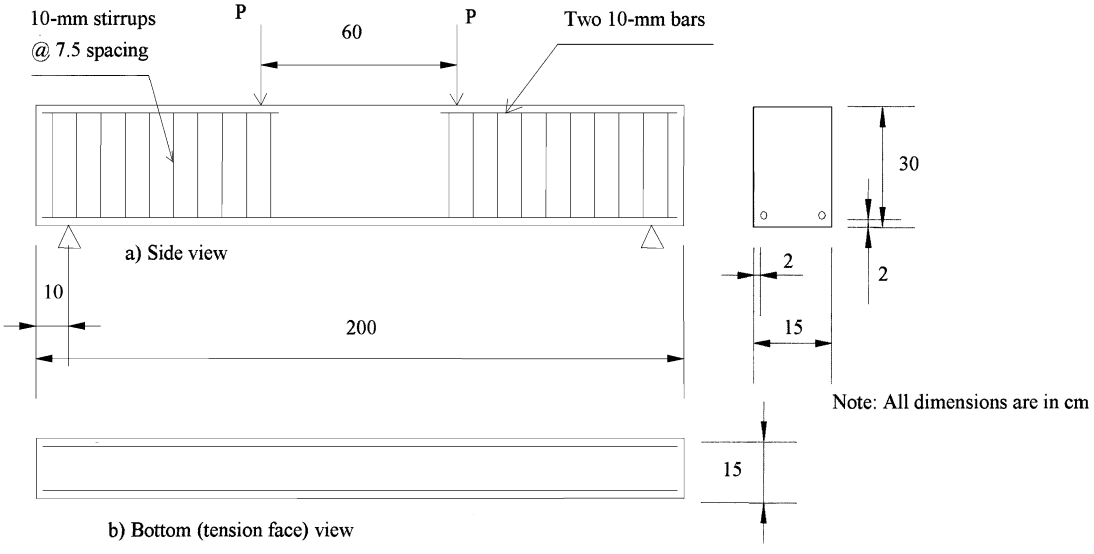

Fig. 1. Longitudinal and cross-sectional details of beams F0 and F15 of set 1.