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# Addition of Lubricating Oil Residue in Concrete for Pavements

Marcelo Santana, maarcelosantana92@gmail.com
Maria da Consolação Fonseca de Albuquerque, sao@dec.feis.unesp.br
Michael Mello, michaeldemelo@hotmail.com
Aparecido Carlos Gonçalves, cido@dem.feis.unesp.br
Adress: Departamento de Engenharia Civil - UNESP - FEIS-Alameda Bahia, 550- Ilha Solteira, SP, CEP 15385-000

***Abstrac.*** *All equipment that works with moving parts or components suffers wear of its moving parts. To reduce the stresses generated by the equipment, lubricating fluids are used, reducing the friction between the parts. Such oils, depending on the normal use or accidental circumstances, end up degrading the point of no longer pay their purposes , yielding a hazardous waste with organic potentially carcinogenic polynuclear aromatic acids , compounds. Recycling of used oil is environmentally important because it avoids disposal in soil or water courses, avoiding environmental damage. In this work, we are seeking to obtain a new form of recycling waste lubricating oil. We know that the lubricating oil when added to concrete influences the mechanical properties. Therefore, we studied the behavior of tensile strength by diametric compression, replacing 10 % of the water by waste lubricating oil. To obtain the results, we performed two similar traits, one reference (without oil ) and the other using the oil. Assays were performed for various amounts of water in order to obtain the optimum moisture content and resistance trait. The results were promising for the development of a good Eco form of reuse of the waste lubricating oil.*

***Keywords:*** *Concrete, mechanical properties and recycling*

## 1. Introduction

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water, which after hardening resembles a rock. (Diab, 2012). Concrete is the most widely used material that any other man-made in the world. However, the production of Portland cement, an essential constituent of the concrete, causes a significant release of CO2 gas, contributing to the greenhouse effect. (Naik Moriconi, 2005).

(Naik and Moriconi, 2005) also state that despite the emission of harmful gases in the production of Portland cement, concrete is regarded as an environmentally sustainable material because it has the characteristics of durability, strength and low environmental impact, and contribute to social progress and economic growth.

(Mehta, 2001) asserts that only 6% of the materials produced approximately 500 million tons per year, is now completed as desirable products while most of the raw material returns to the environment as a harmful residue. These wastes are a major factor of existing environmental impacts due to their improper disposal in nature, polluting the environment.

The increased volume of waste oil has caused serious environmental problems. Only Brazil, is produced over 9 billion liters of vegetable oil a year, and of this total in a month, more than 200 million gallons of used oil go to galleries, rivers and lakes, significantly compromising the environment (Oil World, 2012). Pollution of rivers and lakes by oil is extremely harmful to nature, causing deoxygenation and impeding the continuation of marine life.

On the point of view of sustainable development, means and proposals of environmental impact reduction caused by this waste in nature is of utmost importance. Thus, concrete can be used as a means of disposal to reduce the impact of these oil residues.

(Pukhov, 2001) studied the effects of mineral oil on reinforced concrete structures in hydroelectric power plants. It was found that compounds lubricating oil (turbine oil, machine, transformer) are aggressive to concrete structures, but the level of aggressiveness depends on the quality of the concrete and its density. In this study, the compressive strength of the concrete impregnated with oil showed a reduction of 20-63% compared to the concrete without oil impregnation.

(Ejeh and Uche, 2009) prepared concrete samples with control of variable water / oil. The test samples were cured at room temperature at 3, 7, 28 and 56 days. It was observed that the concrete with oil residue was susceptible to aggressive solutions with different concentrations of oil, has low low strength development rate and corrosion rate when compared with samples that had no oil.

(Al-Attar, 2013) proposed a quantitative calculation to estimate tensile strength, which is mainly dependent on the uniaxial compression of the concrete. Al-Attar intentionally treated the coarse aggregates with engine oil and oil paint to investigate the effects of these wraps in the interphase connections. The author concluded that the effect of these aggregates covered with engine oil and paint, was the reduction in binding between aggregate and cement paste, i.e., the interfacial bonding, reducing considerably the mechanical properties.

(Diab, 2012) in his study about the influence on compressive strength of concrete submerged in oil, noted that the spillage of oil in old concrete structures has resulted in an improvement in the strength properties of the freeze-thaw, suggesting study of available waste oil within the concrete. The author suggests that the oil addition in concrete may be similar to the chemical addition to incorporation of air in concrete, improving some concrete properties like durability.

(Ajagbe et al., 2012) investigated some properties of fresh concrete and hardened to determine the influence of sand contaminated with oil into the concrete. The authors conducted tests on samples with different levels of oil contamination. The properties such as workability, compressive strength, flexural strength, water absorption, fire resistance, among others, were determined using standard methods. The results showed that the workability increased with contamination levels, whereas the properties regarding compression strength, tensile strength, fire resistance and water absorption decreased significantly with increasing sand contaminated with oil. The authors state that sand contaminated with oil below 10% by weight is suitable for use of structures with low mechanical request.

The aim of this study is to analyze the effects of lubricant oil waste, LOW, in particular by checking their mechanical properties in order to give a destination for this waste, if this is technically and economically feasible.

## 2. Materials and methods

### 2.1. Materials used

#### 2.1.1. Aggregates

The fine aggregates have a maximum dimension of 0.6 mm and density of 2.6 g / cm³. The coarse aggregates have a maximum dimension of 20 mm and density of 2.8 g / cm³. The aggregates were placed in an oven at 100 ° C for 24 hours to ensure that the water / cement ratio is not changed.

#### 2.1.2. Cement

The cement used was Portland cement (CPII - Z32), and was used as a binder in the mixture.

#### 2.1.3. Water

Potable water was used in the concrete mix. Its function was to react with the cement, moisturizing it, and then the mixture hardens.

#### 2.1.4. Lubricating oil waste

Lubricating oil residues were collected in gas stations in Ilha Solteira city, State of Sao Paulo. The residue specific mass is 0.9 g / cm³.

#### 2.1.5. Methods

#### 2.1.6. Preparation of samples

The samples were measured and shaped in cylindrical and prismatic forms with dimensions of 100x200 $mm^2$ (diameter and height) and 150x150x500 $mm^3$, respectively. Samples were prepared for two concrete formulations, a reference, or without oil, and one with addition of 10% oil on the mass of water placed in the reference concrete. The concrete mix using for the study was 1: 2.11: 3.68, with water cement ratio of 0.55.

The workability of fresh concrete was observed in concrete with oil and without oil.

#### 2.1.7. Mechanical tests

The mechanical tests that were performed in this study are: compressive strength, tensile flexion and traction for diametrical compression. The compressive strength test was obtained as ABNT-NBR 07215 (1996), the flexural tensile testing in accordance with the ABNT-NBR 12142 (1991), and tensile tests by diametral compression tests of cylindrical specimens were obtained from according to ABNT-NBR 7222 (2010).

## 3. Results and discussion

As noted in the work Ajgabe et al. (2012), this study also showed increased workability with the oil increase. To maintain a constant slump by adding 10% oil relative to water was necessary to withdraw 4% water in the concrete mixture to get an average slump of 6.25 cm.

### 3.1. Diametrical compression test

The cylindrical specimens were ruptured to 28 days. There were six specimens, three of them with the addition of 10% oil and three of them without oil. As shown in Figure 1, in this work it was also observed a reduction in compressive strength with the addition of oil in the concrete. This result is in agreement with the literature (Diab, 2002 Ajgabe 2012, Al-Attar, 2013 Pukhov, 2001).

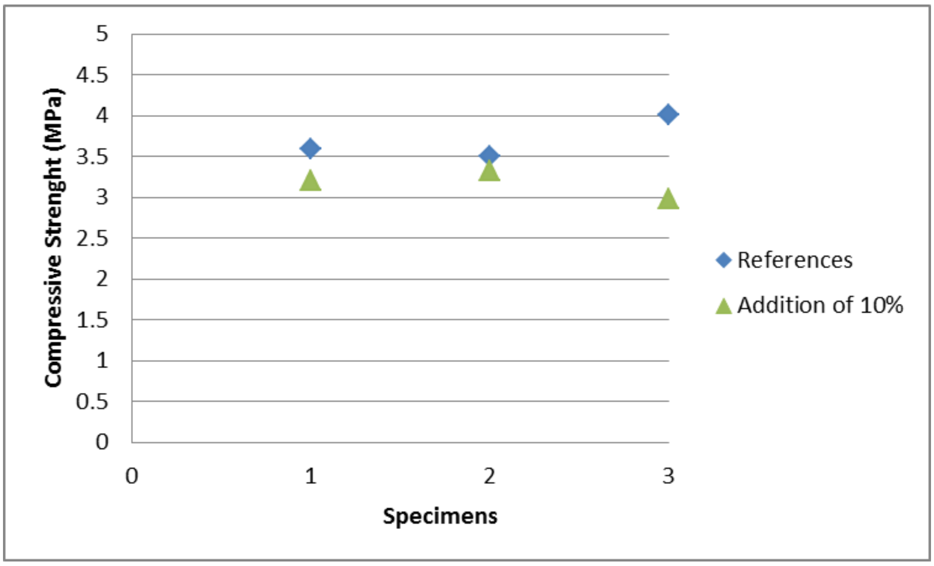


Figure 1: Diametrical compression test results of reference concrete and concrete with addition of 10% oil.

In this work, the compression strength of concrete with the addition of oil showed 15% reduction, as can be seen in Table 1.

Table 1. Maximum strength result for diametrical compression test

| Specimens | References (MPa) | Specimens with addition of 10% of oil (MPa) |
|---|---|---|
| Specimen 1 | 3.59 | 3.20 |
| Specimen 2 | 3.51 | 3.32 |
| Specimen 3 | 4.01 | 2.98 |
| Average | 3.70 | 3.16 |
| Standard Deviation | 0.27 | 0.17 |
| UTV* | 3.97 | 3.33 |
| LTV** | 3.43 | 3.00 |

* Upper Test Variation
** Lower Test Variation

### 3.2. Bending test

The prismatic specimens were ruptured to 28 days. There were six specimens, three of them with addition of 10% oil and three of them without oil. Referring to Figure 2, it can be noted that the tensile strength in bending was not sensitive to the increase of oil in concrete.

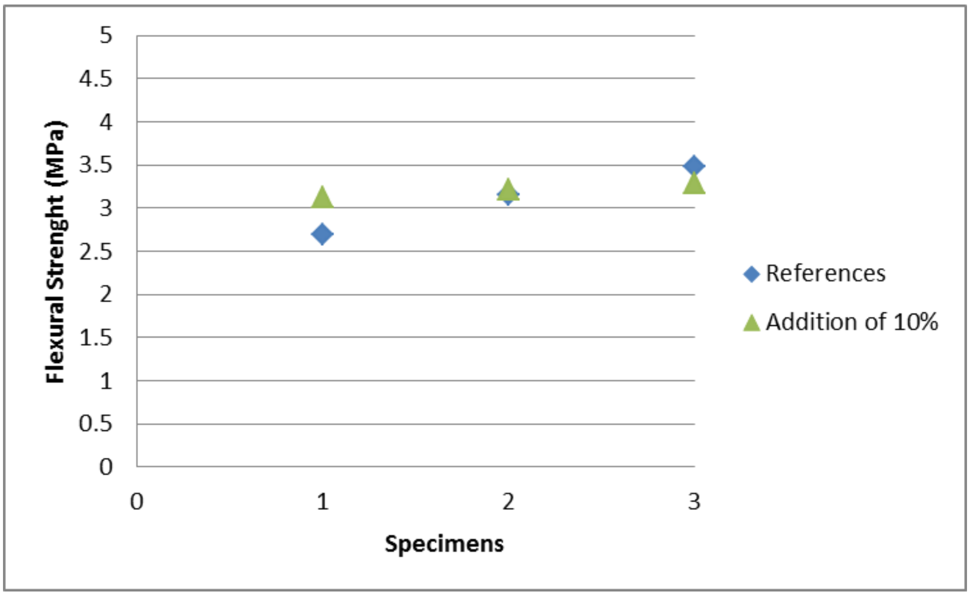


Figure 2: Bending test result to reference concrete and concrete with addition of 10% oil

Table 2 shows that the resistance values remained close, indicating that the replacement of oil by water does not influence the resistance in this case.

Table 2: Bending test result to reference concrete and concrete with addition of 10% oil

| Specimens | References (MPa) | Specimens with addition of 10% of oil (MPa) |
|---|---|---|
| Specimen 1 | 2.70 | 3.12 |
| Specimen 2 | 3.15 | 3.22 |
| Specimen 3 | 3.48 | 3.28 |
| Average | 3.11 | 3.21 |
| Standard Deviation | 0.39 | 0.08 |
| UTV* | 3.50 | 3.29 |
| LTV** | 2.71 | 3.13 |

* Upper test Variation
** Lower test Variation

### 3.3. Elasticity Modulus

The ruptures to elasticity modulus were performed on four specimens, two of them with the addition of 10% oil. The test indicated a 13% reduction in the value of elasticity modulus with oil, which is in agreement with the literature (Diab, 2002 Ajgabe 2012, Al-Attar, 2013 Pukhov, 2001). The test results are shown in Table 3 and in Figure 3.

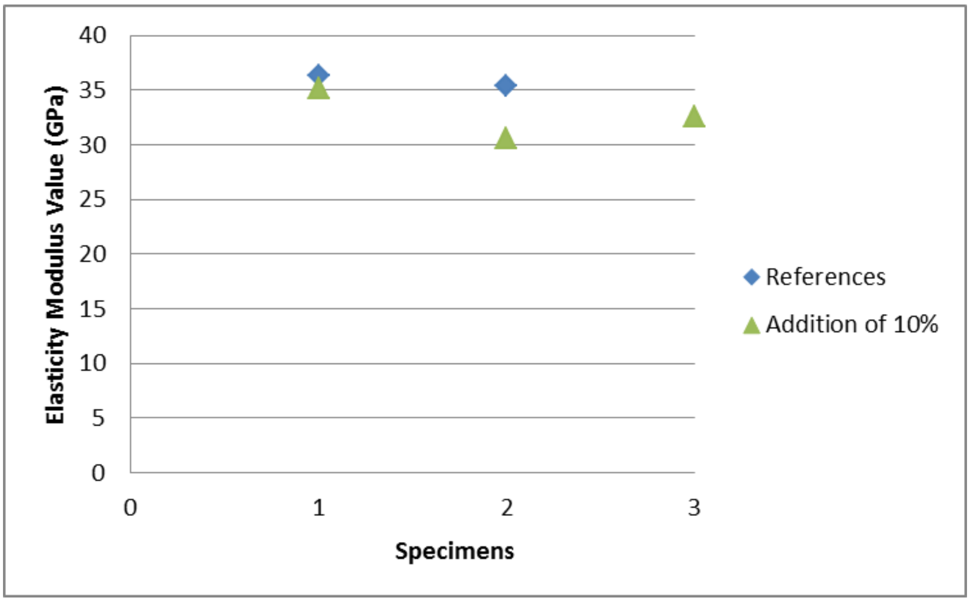


Figure 3: Elasticity Modulus Testing to specimens of reference concrete and the concrete with addition of 10% oil

Table 3: Elasticity Modulus Testing result to reference concrete and concrete with addition of 10% oil

| Specimens | Reference (Mpa) | Specimens with addition of 10% of oil (MPa) |
|---|---|---|
| Specimen 1 | - | 30513.86 |
| Specimen 2 | 36341.57 | 30559.12 |
| Specimen 3 | 35369.40 | 32521.59 |
| Average | 35855.49 | 31198.19 |
| Standard Deviation | 687.43 | 1146.32 |
| UTV* | 36542.91 | 32344.51 |
| LTV** | 35168.06 | 30051.87 |

* Upper test Variation
** Lower test Variation

The decrease in the elasticity modulus can be advantageous because it signals that should be occurring a drop in stiffness of the material, so we can imagine that there is an increase in the deformation capacity.

## 4. Conclusion

By adding 10% lubricating oil in concrete there was a decrease in the diametrical compression strength and elasticity modulus compared to concrete without oil. These results are in agreement with the literature. However, the same did not happen with the strength in bending. In this context, we can conclude that these factors indicate that the use of lubricating oil in the concrete can be an alternative for use in construction, because in addition to reduce the environmental impact, the reduction in modulus of elasticity is often beneficial and the concrete with oil showed no sensitivity in strength in bending. Therefore, depending on the application this can be used. It can also be used in structures with low request. However, it is fundamentally important studies related to leaching and solubility of concrete with addition of lubricating oil waste because it could presents heavy metals.

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