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USING OF INDUSTRIAL WASTE AS A GREEN CHEMICAL ADMIXTURE IN CONCRETE

Dr. Shatha Sadiq Hussen[1]

[1] Lecturer, Building and Construction Engineering Department, University of Technology, Baghdad, Iraq. E-mail: ***Shatha_sadiq@yahoo.com***

ABSTRACT

In the modern construction practices, industrial wastes or by-products are largely used as raw materials in cement and concrete. It imparts positive environmental effect because the waste materials are not released to the environment; therefore, this research study was conducted to investigate the effects of used engine oil on properties of fresh and hardened concrete. The main variables included the type and dosage of admixture (commercially air entraining agent, used engine oil, and new engine oil), consistency, rate of slump loss, setting time and compressive and splitting tensile strength. Results showed that performance of used engine oil and the new engine oil mixes were similar. Results of this study also showed that used engine oil acted as a chemical plasticizer by improving the fluidity and the slump of the concrete mix. The used engine oil decreases the initial setting time and increases the consistency and rate of fluidity loss of ordinary Portland cement concrete. Effects of engine oil on the concrete compressive and splitting tensile strength were negative with respect to the control/reference mixes. However, engine oil concrete has a higher compressive and splitting tensile strength than the corresponding concrete mixes containing dosage of commercial air entraining agent.

KEYWORDS: Concrete, Splitting Tensile Strength, Compressive Strength, Used Engine Oil, Green Chemical Admixture, Setting Time, Slump

استخدام المخلفات الصناعية كمضافات كيميائية للخرسانة

م. د. شذى صادق حسن

قسم هندسة البناء والانشاءات، الجامعة التكنولوجية، بغداد، العراق

الخلاصة

في التطبيقات الانشائية الحديثة تستخدم المخلفات الصناعية والثانوية كمواد اولية في السمنت والخرسانة. وهذا الاستخدام اعطى تاثيرا ايجابيا للبيئة وذلك لان مخلفات هذه المواد لن تعاد مرة اخرى للبيئة لذلك دراسة هذا البحث ترشدنا للتحري عن تأثيرات استخدام زيت المحركات على خواص الخرسانة الطرية والمتصلبة . تضمنت المتغيرات الرئيسية نوع وجرعة المضاف (سواء كان مضاف الهواء المقصود التجاري او زيت المحركات المستعمل او زيت المحركات الجديد) وكذلك التماسك و معدل الفقدان بالهطول وزمن التجمد وكذلك مقاومة كل من الانضغاط والشد الغير مباشر . بينت النتائج هناك تشابه في سلوك الخلطات التي استعمل فيها الزيت المستعمل والزيت الجديد. بينت النتائج لهذه الدراسة ايضا انه زيت المحركات المستعمل عمل كملدن كيميائي بتحسين خواص الانسيابية والهطول للخلطات الخرسانية. زيت المحركات المستعمل قلل من زمن التجمد الابتدائي وزاد من قوام ومعدل فقدان اللدونة لخرسانة السمنت البورتلاندي الاعتيادي . تاثير زيت المحركات على كل من مقاومة الانضغاط والشد الغير مباشر للخرسانة كان سلبيا بالمقارنة مع الخلطة المرجعية ومع ذلك خرسانة زيت المحركات تمتلك مقاومة اعلى للانضغاط والشد الغير المباشر نسبة الى الخلطات الخرسانية التي تحتوي على جرعات من مضاف الهواء المقصود التجاري.

1. INTRODUCTION

Over the years, it has been increasing of industrial wastes and by-products either solid based and/or liquid based chemical in all over the world. Pollution towards environment can caused unstable ecosystem, harm humans and caused disorder in living organisms (Chinchalkar S. 1996). Oil is one of the contributors towards water pollution which causes nearly a quarter of all pollution incidents (Tendring District Council 2011).

Waste material can be defined as any material which is unused and rejected as worthless, unwanted and requiring disposal. Used engine oil is waste lubricant generally produced from the refined base-stocks of heavy fractions of crude oil or other hydrocarbons. One of the largest applications for lubricants is motor oil, to protect the internal combustion engines of motor vehicles and power-driven equipment. During servicing, part or all of the lubricant may be consumed as the balance becomes contaminated with water, metal particles, rust, dirt, carbon, lead and other by-products of the combustion or industrial process (El-Fadel M. and R. Khoury 2001).

However, successful use of industrial by-products or wastes in concrete depends mainly on the requisite properties of the end product. Several by-products or wastes have been reported in literature to be used in concrete and construction industry; such as recycled concrete aggregate, pozzolans, fly ash, blast furnace slag, silica fume, rice husk ash, waste-derived fuels, organic fiber materials, etc. Economical factors would ultimately determine if potentially beneficial waste could be used as an ingredient in concrete. These factors are generally influenced by the cost of waste disposal, the cost of transportation of waste to a manufacturing site, and existing environmental regulations (Samarin, A. 1999).

A lubricant (engine oil) can be defined as an oil products that separates the metal parts of an engine, reduce friction and keep it clean. Lubricant deals with the application of lubricating oil to machine. Lubricants were at one time exclusively animal or vegetable oils of fats, but modern requirement in both nature and volume have petroleum as the main source of supply, lubricating oil can be produced by modern method of refining from most crude and they range from thin easily flowing spindle oils to tank cylinder oils (Ogbeide S. O., 2010).

Lubricants are generally produced from the base-stocks refined from the heavy fractions of crude oil or other hydrocarbons, to which various additives are blended. Lubricants are used for a wide range of applications, including: engine and transmission lubricants, hydraulic fluids, metal working fluids, insulating and process fluids and greases. During service in these applications, part or all of the lubricant may be consumed in the process. The balance tends to become contaminated with substances such as water, metal particles, rust, dirt, carbon and lead, and with other by-products of the combustion or the industrial process (El-Fadel M. and R. Khoury 2001).

It is estimated that less than 45% of the used-engine oil is being collected worldwide while the remaining 55% is thrown by the end user in the environment. The discharge of used oil can become a serious problem or a valuable resource depending upon how it is managed. Simply reflect on the fact that one oil change contains four quarts of foils, which when improperly disposed of sufficient to ruin one million gallons of fresh water, which in turn adversely impacting human life, fish and plant life (El-Fadel M. and R. Khoury 2001 , Ibrahim, T. H. and Al-Zubaidy, A. H. 2007).

Historically, reference books on concrete technology and cement chemistry indicated that the leakage of oil into the cement in older grinding units has led to a greater resistance to freezing and thawing, which led few researchers in two separate studies to adopt and utilize used-engine oil (UEO) in concrete mixes. They have added UEO to concrete mix ingredients aiming to obtain a similar effect to that reported from using air entraining admixture in concrete mixes (Samarin, A. 1999, Hamad et al 2003, Shafiq et al 2006). Hamad et al. 2003 have therefore investigated the effects of used engine oil on properties of fresh and hardened concrete. The main variables included the type and dosage of an air-entraining agent, mixing time, and the water/cement ratio of the concrete.

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 (El-Fadel M.and R. Khoury 2001). However, lack of experimental data to support this hypothesis led to designing a research program in Iraq at the University of Technology to evaluate the effect of used engine oil on concrete behavior.

Hamad et al (2003) study the effects of used engine oil on concrete properties and concrete behavior. 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. They found that UEO did not have significant effect on the structural behavior of reinforced concrete elements, where the ultimate load or load deflection diagrams have not been altered due to adding UEO to concrete mix ingredients.

Shafiq et al (2006) also investigated the effect of used-engine oil and new-engine oil on the properties of fresh and hardened concrete. Their results showed that the used-engine oil increased air content between 26 to 58%and the slump between 18 to 38% and with respect to the control mix containing no admixture. Used engine oil reasonably reduced the porosity and did not adversely affect the strength properties of concrete. They also found that the performance of concrete made with either UEO or new engine oil were more or less similar. This means that UEO behaved as a chemical plasticizer and air entraining admixtures in concrete as the fluidity and air content of concrete have been increased with adding UEO to concrete mix. However, this hypothesis has to be backed with an experimental proof**.**

Abdelaziz G. (2011) showed that utilizing of UEO in OPC mixes has reasonably altered its fresh

parameters, where, an increase in initial slump and air content, and a decrease in rate of slump loss and initial setting time were found. A slight reductions in the 28-day compressive, homogeneity, density and degree of hydration, and an increase in porosity and rate of water in flow into cover zone were noted when UEO was induced into OPC mixes. The results also indicated that the fresh and hardened characteristics of OPC concretes containing either UEO or air entraining admixture are comparable**.**

Nasir S. et al (2011) also study the properties of concrete containing used engine oil study. The results of their study showed that with the addition of used engine oil, concrete slump was increased by 18% to 38% and air content by 26% to 58% as compare to the slump of control concrete. Porosity and oxygen permeability of concrete containing used engine oil was also reduced and the compressive strength obtained was approximately same as that of the control mix**.**

2. RESEARCH SIGNIFICANCE

The main objective of the research was to investigate the effect of adding Iraqi used engine oil to concrete on the some properties of fresh and hardened concrete. The significance of the program was to check the hypothesis that adding used engine oil to the fresh concrete mix could be similar to adding an air entraining chemical admixture, thus enhancing some properties of fresh and hardened concrete while serving as a technique of disposing the Iraqi oil waste. the another objectives of this study are to clarify the effects of used-engine oil (UEO) on consistency and initial setting and to compare between the behaviors of concretes made with either used-engine oil or traditional chemical admixtures (namely air-entraining) during their fresh state. Also, it was important to compare the performance of concrete with used engine oil and concrete with new engine oil to assess the effect of the type of the oil on concrete.

3. EXPERIMENTAL INVESTIGATION

3.1. Materials and Mix Proportions

A detailed experimental program was prepared to determine the value of slump, Rate of slump loss, and Initial setting time of fresh concrete mixes and also to investigate the properties of hardened concrete such as compressive strength at the age of 7, 28, 60, and 90 days and splitting tensile strength at the age of 28 days. A control mix without any chemical admixture and 12 different concrete mixes containing an amount of 0.15, 0.2, 0.25, and 0.3% used engine, new engine oil and commercially available air entraining agent were prepared.

Ordinary Portland cement manufactured by AL-Mass cement factory was used throughout this research. It was stored in air-tight plastic containers to avoid the atmospheric conditions and to maintain constant quality. Table 1 and Table 2 show the chemical and physical properties of the cement used in this research. The used cement conforms to Iraqi specification No.5 / 1984.

Natural sand (Al-Ukhaider) was used with maximum size of 5mm. The gradation and sulfate content were tested. Table 3 shows that the grading and sulfate content are conforming to the Iraqi Standard No.45/1984 Zone 2.

Crushed gravel with MSA (5-19) mm, it was brought from AL Nabai region. Table 4 shows that the grading and sulfate content are conforming to the Iraqi standard No. 45/1984.

The used and new engine oil used in this research were PERFO XC. It is a monograde engine oil suitable for use in all turbo-charged or normally aspirated diesel engines. It is recommended for use in engines of trucks, fishing boats, construction machinery and stationary diesel engines. PERFO XC used and new engine oil was collected from Service Station in Baghdad. The commercial air-entraining admixture used was Sika- AEA-14, which meets the requirements of ASTM C-260 for air entraining admixtures. Sika® AEA-14 admixture is an aqueous solution of organic materials. The appearance of Sika- AEA-14 is dark brown liquid with approx. (1.01) specific gravity.

Table 1. Chemical composition and main compounds of the cement

Oxide composition	CaO	SiO_2	AlO_3	Fe_2O_3	MgO	SO3	L.O.I	I.R
Content (percent)	61.89	21.37	4.6	3.35	3.05	2.42	2.16	0.6
Main compounds	C_3S		C_2S		C_3A		C_4AF	
Content (percent)	46.88		26.17		6.53		10.18	

Table 2. Physical properties of the cement

Physical properties	Specific surface area (m^2/kg) (Blain)	Soundness (mm) (Autoclave)	Setting time Initial setting (hrs:min)	Setting time final setting (hrs:min)	Compressive strength (Mpa) 3days	Compressive strength (Mpa) 7days
Test results	321	0.5	1:55	2:24	23	29

Table 3. Grading and physical properties of fine aggregate

Sieve size (mm)	**Percentage passing**	**Limits of IQS. No. 45/1984/Zone 2**
10	100	100
4.75	95	90-100
2.36	77	75-100
1.18	55	55-90
0.6	39	35-59
0.3	15	8-30
0.15	0	0-10
Sulfate content	0.1	Max = 0.5%
Fine materials passing from sieve (75 μm)	4.2%	Max = 5%
Specific gravity	2.6	-
Fineness modulus	3.19	-

Table 4. Grading and physical properties of coarse aggregate

Sieve size (mm)	**Accumulated percentage passing**	**Limits of IQS. No. 45/1984**
37.5	100	100
20	99	95-100
14	/	/
10	30	30-60
5	0	0-5
Sulfate content	0.01	Max = 0.1%
Specific gravity	2.7	-
Dry rodded density	1635 kg/m^3	-

3.2. Mixing, casting and curing

The control mix (Mix1) had a proportion of 1 (cement): 2.3 (sand): 3.2 (coarse aggregate) and did not include admixture. Details of 13 concrete mixes are listed in Table 5.Dry ingredients; cement, sand and gravel were first mixed for 1 minute in the mixture prior to water addition. Admixtures such as use oil, new oil and commercial AER were diluted in water before it was added to the dry ingredients in the mixer. After addition of water to dry ingredients it was mixed for 3 minutes in order to achieve homogenous concrete. After homogeneous mixing of fresh concrete, it was tested for determination of slump and setting time.

The slump test, specified in the ASTM standard test method for slump of hydraulic cement concrete (ASTM C 143/143M), is essentially an indication of the workability of an individual batch of concrete.

Concrete cubes (100*100*100 mm) were used for compressive strength test according to the ASTM (C 39/C 39M – 03). The splitting tensile strength was carried out according to the (ASTM C496-04)**.** Cylinders of (100×200) mm were used. The internal faces were thoroughly oiled to avoid adhesion with the concrete after hardening. The casting was carried out in two layers and compaction by vibration machine to remove entrapped air as much as possible and to produce full compaction of the concrete with neither excessive segregation nor laitance.

Table 5. Details of concrete mix proportion

Group No.	Mix no.	Mix Type	Air Entraining Agent	Dosage (%)	Water/Cemt Ratio.	Slump
Group (1)	1	CM	None	0	0.46	125
Group (2) commercial admixture	2	0.15 AER	commercial	0.15	0.46	144
	3	0.2 AER	Commercial	0.2	0.46	165
	4	0.25 AER	Commercial	0.25	0.46	176
	5	0.3 AER	commercial	0.3	0.46	195
Group (3) with used oil	6	0.15 UEO	used engine oil	0.15	0.46	133
	7	0.2 UEO	used engine oil	0.2	0.46	150
	8	0.25 UEO	used engine oil	0.25	0.46	169
	9	0.3 UEO	used engine oil	0.3	0.46	185
Group (4) with new oil	10	0.15 NEO	new engine oil	0.15	0.46	148
	11	0.2 NEO	new engine oil	0.2	0.46	155
	13	0.25 NEO	new engine oil	0.25	0.46	178
	14	0.3 NEO	new engine oil	0.3	0.46	193

Note: CM- control Mix, UEO- Used Engine Oil, NEO New Engine Oil, AER- Air Entraining Admixture,

4. RESULTS AND DISCUSSION

Experimental results as obtained during testing on fresh and hardened concrete are discussed below: Results of tests of fresh and hardened concrete properties of all 13 mixes are listed in Table 5. Each test result of the hardened concrete properties is the average of three test values.

4.1. Fresh concrete properties

Slump value is the measure of fluidity and consistency of concrete; for control mix it was obtained as 125 mm .The slump as a measure of fluidity and consistency of concrete improved to a value ranging from 133 to 195 mm when an air-entraining agent was used. Effect of inducing used engine oil (UEO), new engine oil (UEO), and air entraining into OPC mixes, as an admixture, on their slump are illustrated in Table 5 and Fig. 1.

The improvement was independent of whether air entraining agent or the used/new engine oil was used. The improvement was also independent of the dosage of the air-entraining agent (0.15, 0.2, 0.25 or 0.30%). When used engine oil was added to concrete, the slump value of 0.15 used oil and 0.30 used oil concrete mixes was obtained as 133 mm and 185 mm respectively. Similarly the slump of 0.15 new oil and 0.3 new oil mixes was obtained as 148mm and 193mm respectively and 144mm slump was measured for 0.15 air entraining admixture and 195 mm for 0.30 air entraining admixture concrete mixes. The results showed that admixtures either (new or used engine oil) or air entraining admixture improved the slump value as compared with the slump value of the control mix.

Moreover, the effects of UEO, NEO, and traditional-chemical admixtures on the initial setting time of OPC mixes were also investigated, and the results are plotted in Fig. 2.

The results affirms that UEO has a significant effect on reducing the value of setting time, where the initial setting time of OPC mixes made with 0.15, 0.25 and 0. 30% UEO reach 95, 86 and 75 minutes, respectively, while the corresponding of that mix made without admixture reaches 120 minutes. So, it can be stated that utilizing of UEO in OPC concrete mixes can reasonably alter their consistency, compactability and rate of setting, as verified from the results established in Figs. 1 and 2.

Determining the rate of loss in fresh properties of concrete is imperative for concrete technologists and engineers on site in order to specify the suitable period between mixing and casting. So, the instant slump of OPC concrete containing different dosages of UEO(0.0, 0.15, 0.25 and 0. 30%) were studied at different elapsed periods from mixing (EP), 0, 40, 80, 120 and 240 minutes. The results of this investigation are shown in Fig. 3, where the % values of relative slump (instant slump/initial slump) were plotted against EP. As seen, % of relative slump dramatically decreases with increasing EP for all investigated mixes. Rate of decrease in the % of relative slump increased with increasing the dosage of UEO. In other words, inclusion of UEO into OPC mix can lead to increase its rate of slump loss (fluidity loss). These results agree with those reported in Fig. 2, where the setting time was noted to be decreased with increasing UEO content, thus leading to increase the rate of slump loss (fluidity loss).

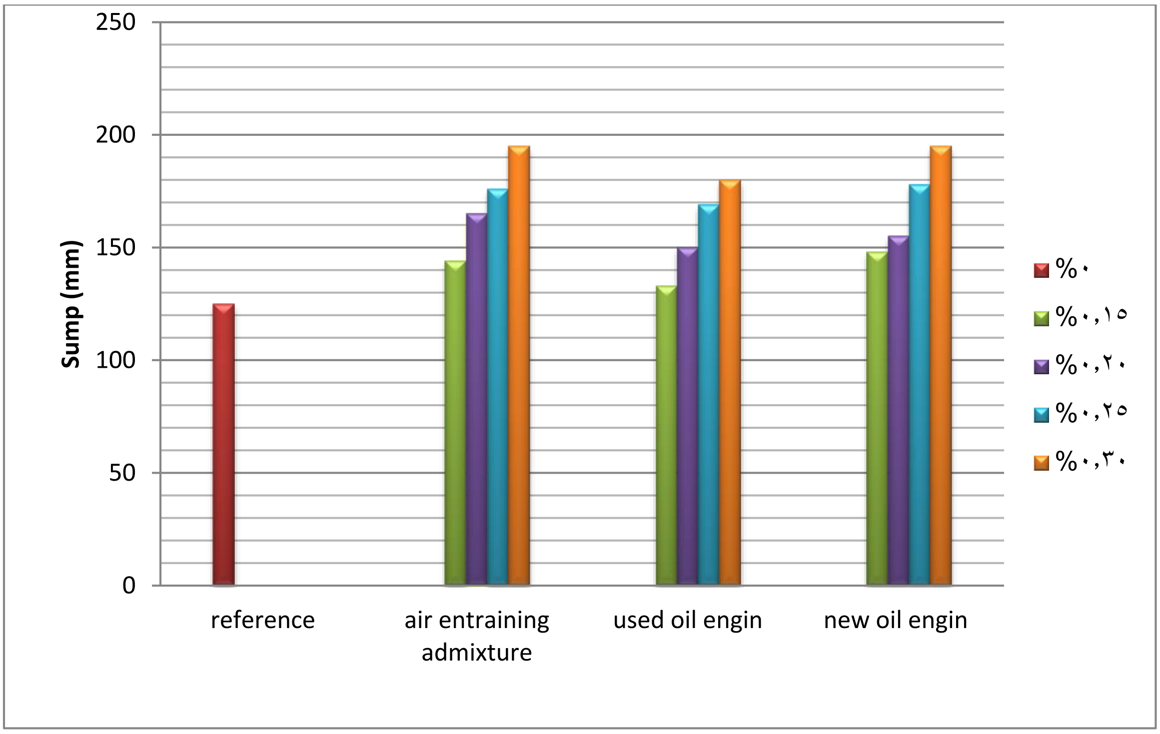

Fig. 1. Variation of slump (mm) of concrete mixes containing different admixtures

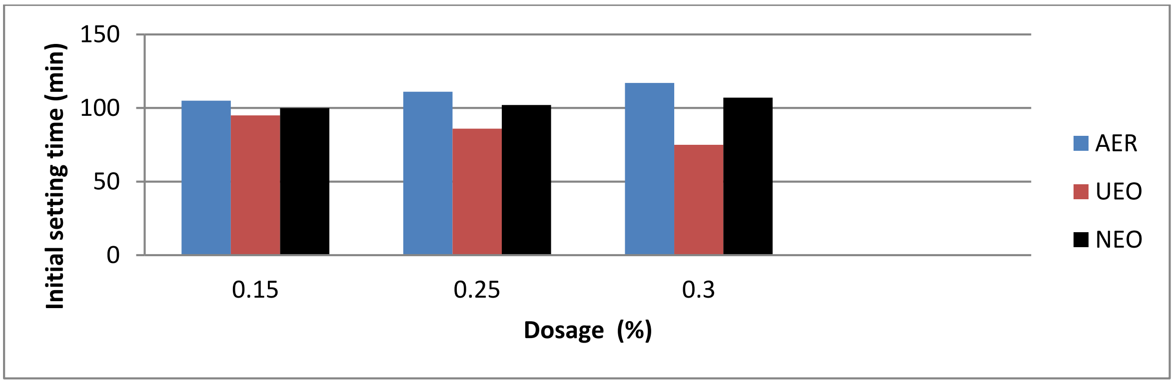

Fig. 2. Initial setting time of OPC mixes made with various admixtures

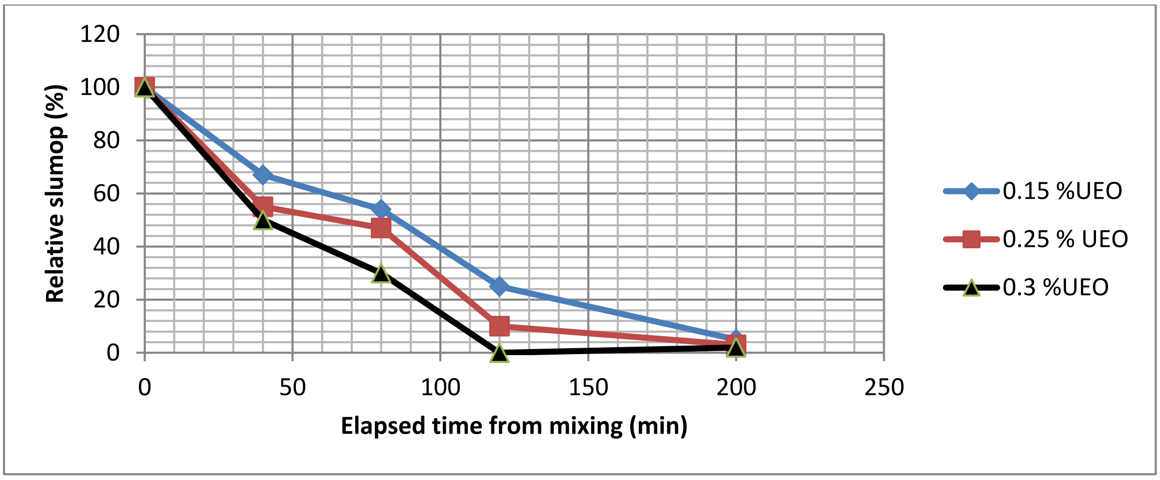

Fig. 3. Rate of slump loss of OPC concrete mixes made with different contents of UEO

4.2. Hardened Concrete Properties

4.2.1. Compressive strength

The concrete compressive strength was measured for each mix at four different ages: 7, 28, 60, and 90 days as shown in Table 6. Compressive strength at different ages of all concrete mixes are plotted in Figs. 4–7. When the dosage of the chemical air-entraining admixture was increased from 0.15 to 0.3 %, there was a decrease in the strength value. The compressive strength of concrete mixes containing 0.3% dosage of used engine oil and the new engine oil was obtained a slight lower than the compressive strength of the control mix at all the ages.

Table 6. Details of concrete mix proportion

Mix Type	Compressive Strength (MPa)			
	Age (days)			
	7	28	60	90
CM	15.1	19.1	22.2	23
0. 15 AER	8.9	15.2	17.5	17.6
0.2 AER	10.8	15.3	17.1	17.4
0.25 AER	10.7	16	17.1	17.1
0.3 AER	8.5	15	16.3	16.5
0. 15 UEO	10.9	15.8	17.9	18.1
0.2 UEO	12.8	16.9	19.6	21.8
0.25 UEO	11	17	21.1	22
0.3 UEO	11.9	18	21.5	22.4
0. 15 NEO	11.4	16.1	19.1	19.9
0.2 NEO	12.8	17.8	21.9	23.3
0.25 NEO	11.7	16.8	21	23.6
0.3 NEO	12.3	17.9	22	22.2

4.2.2. Splitting tensile strength

In general and regardless of the type of the air-entraining agent used, the splitting tensile strength measured only at the age of 28 days dropped slightly with respect to the splitting tensile strength of the control mix. The concrete splitting tensile strength was measured for each mix at 28 days when the dosage of the admixture was 0.3 %, as shown in Table 3. Splitting tensile strength is plotted in Fig. 8. The average values of the splitting tensile strength for different air-entraining agent were 2.1, 1.65, 1.98 and 1.8 MPa for concretes with no air entraining agent, with air entraining agent, with used engine oil, and with new oil, respectively. When the dosage of the chemical air-entraining admixture was 0.3 %, there was a decrease in the strength value. The splitting tensile strength of concrete mixes containing 0.3% dosage of used engine oil and the new engine oil was obtained a slight lower than the splitting tensile strength of the control mix at all the ages.

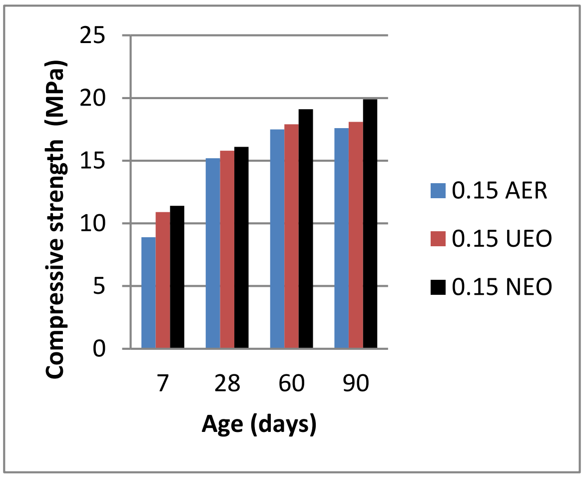

Fig. 4. Compressive strength of concrete mixes containing 0.15 dosage of different air entraining agent with time

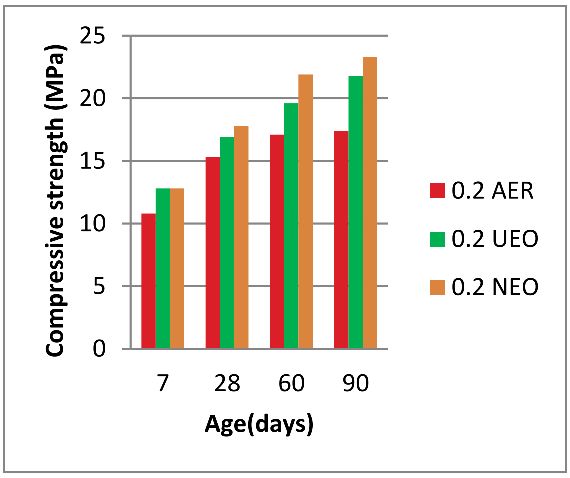

Fig. 5. Compressive strength of concrete mixes containing 0.2 dosage of different air entraining agent with time

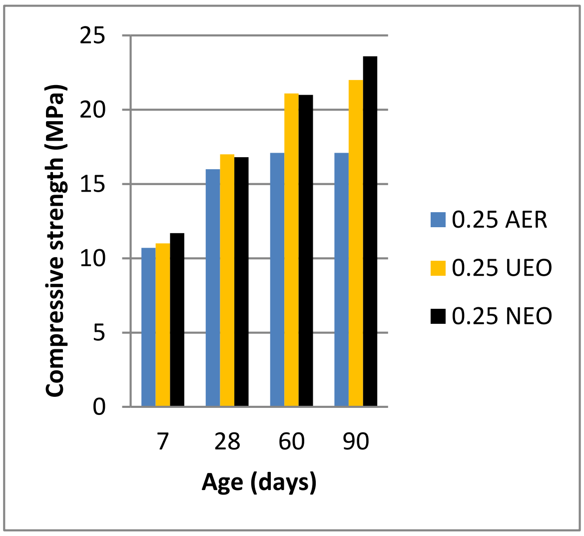

Fig. 6. Compressive strength of concrete mixes containing 0.25 dosage of different air entraining agent with time

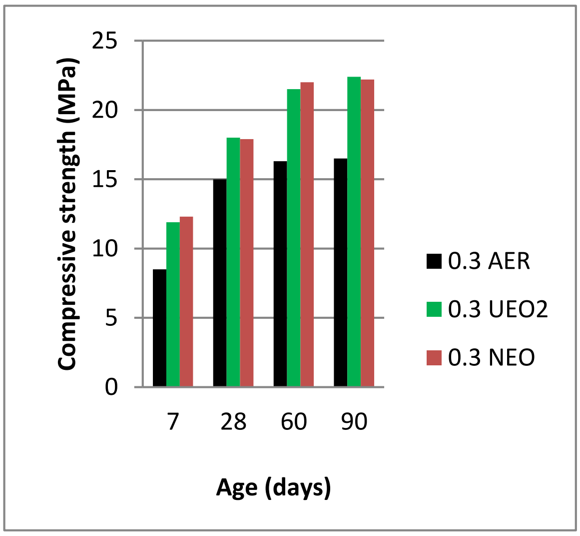

Fig. 7. Compressive strength of concrete mixes containing 0.3 dosage of different air entraining agent with time

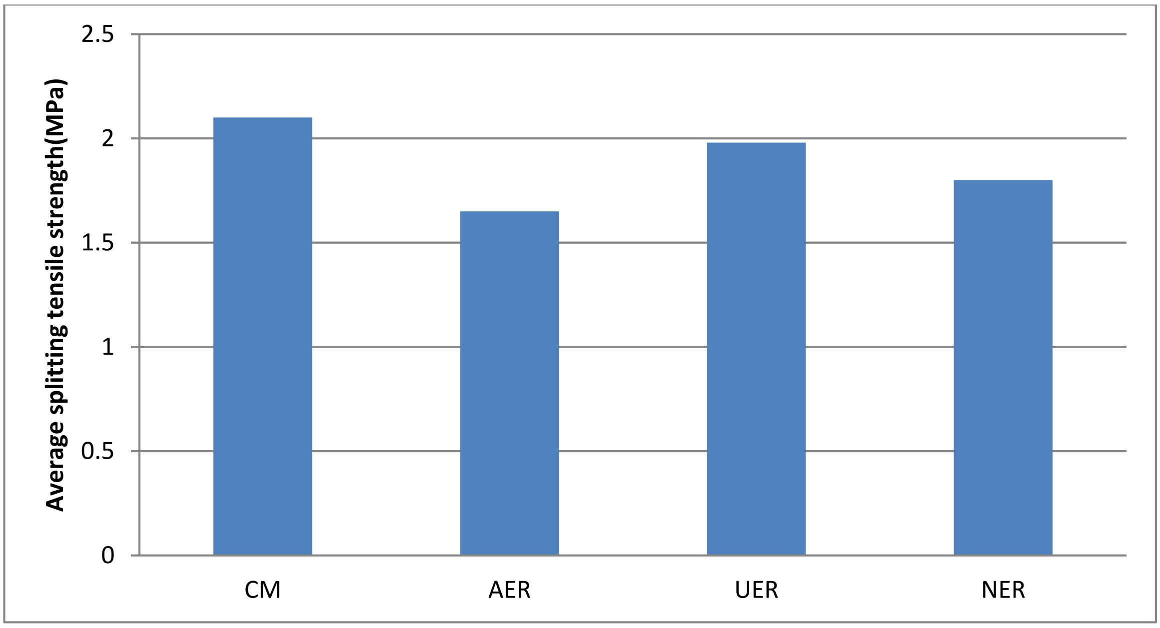

Fig. 8. Development of splitting tensile strength with time

5. CONCLUSIONS

Based on the results and discussion, the following conclusions were made:

- Used engine oil acted as a chemical plasticizer improving the fluidity and the slump of the concrete mix.
- Utilization of used-engine oil (UEO) resulted in a significant alteration in the performance of OPC concrete during its fresh state. UEO decreases the initial setting time and increases the consistency and rate of fluidity loss of OPC concrete. These effects increase with increasing the dosage of UEO in OPC mixes. Therefore, UEO behaved as a chemical admixture and its impacts would provide the dual action of both plasticizer and air-entraining admixtures
- Used engine oil maintained the concrete compressive strength whereas the chemical air-entraining admixture caused a decrease in compressive strength at all ages.
- Effects of engine oil on the concrete compressive strength were negative with respect to the control/reference mixes. However, engine oil concrete has a higher compressive strength than the corresponding concrete mixes containing dosage of air entraining agent.
- Effects of engine oil on the concrete splitting tensile strength were negative with respect to the control/reference mixes. However, engine oil concrete has a higher splitting tensile strength than the corresponding concrete mixes containing dosage of air entraining agent.

6. REFERENCES

1. Abdelaziz G.,2011, "Utilization of Used-Engine Oil in Concrete as a Chemical Admixture" Benha University, Egypt,

2. ASTM C 39/C 39M–03, 2003, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens", Vol.04.02.

3. ASTM C143/143M, 2003, "Standard Test Method for Slump of Hydraulic-Cement Concrete", Vol.04.02.

4. ASTM C496-04, 2004, "Standard Test Method for Splitting Tensile Strength for Cylindrical Concrete Specimens", American Society for Testing and Materials.

5. **Chinchalkar S.,** 1996, “An Upper Bound for the Number of Reachable Position", ICCA Journal 19 181-183.

6. **El-Fadel M. and R. Khoury**, 2001,"Strategies for Vehicle waste-Oil management": a case study; Resources, Conservation and Recycling, Volume 33, Issue 2, Pages 75-91**.**

7. Hamad, B. S., Rteil, , A. A. and El-Fadel, M. (2003), "Effect of Used Engine Oil on the Properties of Fresh and Hardened Concrete", Construction and Building Materials, Vol. 17, pp. 311-318**.**

8. Ibrahim, T. H. and Al-Zubaidy, A. H., (2007), “Assessment of Using Unleaded Fuel in Harsh Environment of the United Arab Emirates", Journal of Environmental Management, Vol.85, pp. 171-178

9. Nasir S., Muhd F. Nuruddin and Salmia B., June, 2011, "Properties of Concrete Containing Used Engine Oil", International Journal of Sustainable Construction Engineering & Technology Vol 2, Issue 1,

10. Ogbeide S. O., (2010) , "An Investigation To The Recycling Of Spent Engine Oil" , Journal of Engineering Science and Technology

11. Samarin, A. (1999), "Wastes in Concrete: Converting Liabilities into Assets", Proceedings of the International Seminar on Exploring Wastes in Concrete, Edited by Dhir, R., and Jappy T., Scotland, pp. 1-21.

12. Shafiq, N., Nuruddin, M.F. and Kamaruddin, I. (2006), "Effectiveness of Used Engine Oil on Improvement of Properties of Fresh and Hardened Concrete" Proceedings of the 6th Asia-Pacific Structural Engineering and Construction Conference (APSEC 2006), Kuala Lumpur, Malaysia, 5-6 Sept. , pp. 159-166.

13. Tendring District Council. 2011. Waste Cooking Oil.

14. المواصفة القياسية العراقية رقم (5) لسنة 1984"الاسمنت البورتلاندي"، الجهاز المركزي لتقييس والسيطرة النوعية

15. المواصفة القياسية العراقية رقم (45) لسنة -1984" ركام المصادر الطبيعية المستعمل في الخرسانة والبناء"، الجهاز المركزي للتقييس والسيطرة النوعية.