



Effects of Used Engine Oil as an Admixture in Concrete Durability

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Authors' contributions

This work was carried out in collaboration between all authors. Authors NS and MFN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript and managed literature searches. Authors SB, NLMK and SNS managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Excellent flowability is one of the important characteristics of concrete for easier handling and placing and it facilitates the removal of undesirable air voids by introducing superplasticizer (SP). But due to environmental issue related to the waste during SP production, alternatives being initiate to incorporate used engine oil (UEO) that has the same function as SP. It was reported that UEO resulted in improving some concrete properties therefore can lead to counter problems of higher SP cost and UEO disposal. The principal aim of this research mainly to identify the effectiveness of UEO in durability improvement of concrete. Investigation of porosity, chloride penetration and high elevated temperature exposure was conducted. From the result obtained, UEO decrease the concrete porosity and comparable with SP. The result of chloride penetration showed that incorporation of 0.5% of UEO did not cause any adverse effect as compared to the control mix, which meant that UEO could improve the concrete durability. Elevated temperature exposure test was conducted and the percentage strength loss of concrete with UEO was almost similar to the mix with SP. It can be stated that UEO performed very good in durability improvement and comparable with SP.

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1. INTRODUCTION

Recently, the interest on utilization of greener technology is on the rise. A lot of wastes are being utilized to replace the commercially available materials. While the previous researchers have discussed the powerful superplasticizer function, however the alternative admixture to replace it is something new to be explored. With the increase usage of concrete, new type of admixtures that are cost effective may have many economic and technical impacts on the Malaysian construction industry as well as worldwide concrete usage. This research was carried out extensively along with the increasing concern about environmental issues from superplasticizer (SP) production and used engine oil (UEO) disposal.

SP is functioning in providing excellent workability to the concrete. However, production of SP is commonly associated with the water pollution. Liquid and solid waste produced due to the manufacturing process discharged into public sewerage network was found violating the environmental regulations. The chemicals used during the manufacturing processes are also hazardous and have severe impact on the environment [1].

In the meantime, the number of vehicles is increasing all over the world therefore this leads to the increase production of UEO. According to the Annual Report of the Road Transport Department of Malaysia, the number of registered road vehicles had increased from more than 6.8 million in 1995 to more than 12.2 million in March 2003 [2]. It is estimated 380 million gallons of UEO are recycled each year [3]. It was reported that worldwide 45% of UEO is being collected while remaining 55% is thrown away the end used in the environment [4]. Besides that, 40% of the total re-used oil is improperly disposed.

The potential of UEO as concrete admixture were found by Mindess and Young [5]. They were reported that the leakage of oil into the cement in older grinding units result in concrete with greater resistance to freezing and thawing. This implies that adding UEO 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 another technique of disposing the oil waste. It was also discussed by Chin [6] that UEO has similar SP properties because of the SO_3 content.

Oil is a common and highly visible form of pollution. Oil and water are immiscible and even a small spillage can cause significant pollution. Studies have shown that 5 litres of it can cover a small lake [7].

Bilal et al. [8] have studied the effects of UEO on fresh and hardened properties and also structural performance of concrete and it gave the positive effects comparable with the available commercially air entraining agent. UEO also suggested by Aravind and Das [9] to be used in highway construction but requires well organized oil collection system. The further research is noteworthy to produce the good quality and performance of concrete.

The study of the effect of UEO on properties of concrete has been carried out by Bilal et al. [10]. Mixes was contained with 0.075, 0.15 and 0.30% of UEO by weight of cement. Result shows that UEO acted as a chemical plasticizer improving the fluidity and almost double slump of the concrete mix and supported by Chin et al. [9]. Beddu et al. [11] stated that UEO did not adversely affect the strength development process of concrete with silica fume, 28 days strength was achieved as 76MPa with 4% UEO. It was also stated that UEO act positively towards the concrete performance. Concrete mixes containing high percentage of fly ash (40% and 50%) followed the same trend [12].

The research of UEO effects in concrete were then publish by Kamal et al. in 2014 [13] that stated the inclusion of 0.5% UEO gave the highest compressive strength and comparable with SP. Assaad [14] concluded that an optimum UEO dosage of 0.3% of cement mass was found, beyond which detrimental effects on initial slump, setting time, and compressive strength can be encountered.

The research of UEO also being explored by some researcher. Salmia et al. [15,16] concluded that used cooking oil can contribute to the improvement of slump, mechanical properties and microstructure with the optimum dosage of 1.5 of cement content.

The main objective of this research is to identify the effects of used engine oil with respect to durability, important consideration in the design and construction of new structures and also when assessing the condition of existing structures.

2. RESEARCH METHODOLOGY

2.1 Design Mix

In order to achieve reliable results, practicing of strict measures of quality control is the most important criterion for the experimental investigation as part of any research program. Therefore, the spurious results and false trend can be avoided by applying the prevailing code of standards and specifications for the selection of concrete making materials and mix proportions. The mix proportions of concrete for casting of specimens are presented in Table 1. Eleven mixes were cast with water binder ratios (w/b) of 0.55. Water and admixture were measured in percentage by weight proportion of cement used.

2.2 Materials

The Ordinary Portland Cement (OPC) Type 1 was used in this research, that complied to the requirements of BS 12 (1996) [18] and MS 522 (1989) [17]. OPC Type 1 was preferred because the observation on concrete properties can be done in normal hydration process. OPC was supplied by Tasek Corporation Sdn. Bhd., located in Ipoh, Perak.

Superplasticizers (SP) are used in fresh concrete to enhance its workability and allow to reduce the water content, so the high strength concrete

could be produced. In this study, SP call Sikamen-N1 supplied by SIKAKimia, Malaysia was used. This SP is Sulfonated Naphtalene Formaldehyd (SNF) condensate type.

Used engine oil (UEO) was collected from service-stations around Tronoh and Seri Iskandar, Perak. It was collected randomly at the service-stations that have no proper disposal. Samples of UEO and superplasticizer were analyzed using X-ray fluorescence (XRF) technique to determine their chemical composition in percent, which is given in Table 2.

2.3 Method of Experiments

2.3.1 Porosity test

The porosity of concrete was carried out by coring three 50 mm diameter from concrete planks. Total porosity was determined by vacuum saturation method developed by RILEM CP 113 [19] and the porosity calculated as:

$$P = (W_s - W_d) / (W_s - W_w) \times 100 \quad (1)$$

Where

- P = total porosity in percentage
- W_s = mass of saturated samples measured in the air, g
- W_d = mass of oven dried samples measured in the air, g
- W_w = mass of saturated samples measured in the water, g

2.3.2 Chloride penetration test

Rapid migration test according to AASHTO T277 [20] was carried out to determine the depth of chloride penetration into the mortar cube. The

Table 1. OPC Concrete mix proportion

Mix	OPC (kg/m ³)	CA (kg/m ³)	FA (kg/m ³)	w/c	UEO (%)	SP (%)
C	325	1137.5	757.3	0.55	-	-
CU-0.15	325	1137.5	757.3	0.62	0.15	-
CS-0.15	325	1137.5	757.3	0.55	-	0.15
CU-0.3	325	1137.5	757.3	0.55	0.3	-
CS-0.3	325	1137.5	757.3	0.55	-	0.3
CU-0.5	325	1137.5	757.3	0.62	0.5	-
CS-0.5	325	1137.5	757.3	0.55	-	0.5
CU-0.8	325	1137.5	757.3	0.55	0.8	-
CS-0.8	325	1137.5	757.3	0.55	-	0.8
CU-1	325	1137.5	757.3	0.55	1	-
CS-1	325	1137.5	757.3	0.55	-	1

C: concrete; U: UEO; S: SP; Numbers: UEO/SP percentage

mortar then put into 3.6% salt solution. Depth of chloride penetration was measured at 7, 14, 28 and 42 days. The mortar cube was then cut into two and silver nitrate (AgNO) solution sprayed to visualize (purple color on the mortar's surface) the depth of chloride penetration into mortar specimens for each type of mortar. The average depth of penetration were recorded and compared to each type of sample. The penetration rate measured in mm/day. The mixes containing 0.5% chemical admixtures (UEO and SP) in OPC concrete were chosen since it gave the optimum performance.

Table 2. Chemical composition of superplasticizer and used engine oil

Chemical composition	Superplasticizer (%)	Used engine oil (%)
SiO ₂	-	-
Fe ₂ O ₃	-	0.43
CaO	-	15.9
SO ₃	99.9	37.0
P2O5	-	8.95
ZnO	-	17.7
Cl ⁻	-	15.9

2.3.3 High elevated temperature exposure test

Elevated temperature test of concrete is important to evaluate the effect of high temperature exposure especially during fire. Hence, a series of fire endurance temperature tests on various types of concrete were conducted to measure their fire endurance temperatures and then compared to control mix. This method of testing was adopted from Mundhada et al. [21] that that concluded quality of concrete suffers slightly & strength too comes down, therefore the method is appropriate.

The mixes containing 0.5% chemical admixtures (UEO and SP) in OPC concrete was chosen since it gave the optimum performance. Concrete cubes of 100 mm size were cast, for testing at age 28 days, 3 cubes were tested at every testing. After de-moulding, the specimens were then dried at 110°C to remove the water and moisture from the specimens. Then, all of the specimens were simultaneously placed inside a furnace at the Material Laboratory of Universiti Teknologi PETRONAS. The temperature of the furnace was increase up to 500°C. After the temperature reached 500°C, the furnace was turned off for the specimens to cool off for a day.

Then, the specimens were tested for compressive strength at the Concrete Laboratory of Universiti Teknologi PETRONAS. The average value of compressive strength for each type of concrete were recorded and compared to each other and with the normal concrete. From the results, the residual compressive strength and the actual strength were compared and presented as percentage strength lost due to exposure to extreme fire and heat.

3. RESULTS AND DISCUSSION

3.1 Effect of UEO and SP on the Concrete Workability

Fig. 1 shows the effects of SP and UEO on slump value of OPC concrete. In this series of mixes, all ingredients were kept constant except the dosage of SP and UEO, which was varied from 0 to 1% by weight of cement content.

As shown in the figure, slump value increased from 20 mm to 48 mm when dosage of SP was increase by 0.15%. A steady increase in the slump value was observed when the SP dosage was increased to 0.3% and 0.5%, which was measured as 60 mm and 80 mm. There was a sudden jump in the slump value to 200 mm when the SP dosage was increased to 0.8%. However at 1% SP dosage, the rate of increment was lower and it reached to 220 mm.

It can be observed that when dosage of 0.15%, 0.3% and 0.5% were used, the slump value of UEO mixes were quite close to that of SP mixes. For example with 0.15% dosage of UEO mix showed a slump value of 42 mm as compared to the corresponding SP mix that showed a slump value of 45mm. However, the gap widened when a dosage of 0.8% and 1% UEO were added. At 0.8% dosage, UEO mix resulted in 150 mm slump as compared to 200 mm slump value of the SP mix. Similarly, when 1% dosage of UEO was added the slump value of 170 mm was measured, whereas with 1% SP dosage the slump of 220 mm was observed.

To study the effects of UEO on 100% OPC concrete, it can be concluded that up to dosage of 0.5%, the slump value obtained was similar to that obtained with SNF superplasticizer. Beyond 0.5% dosage of UEO, it still acted as plasticizer in concrete, however its effectiveness was inferior to that of SP.

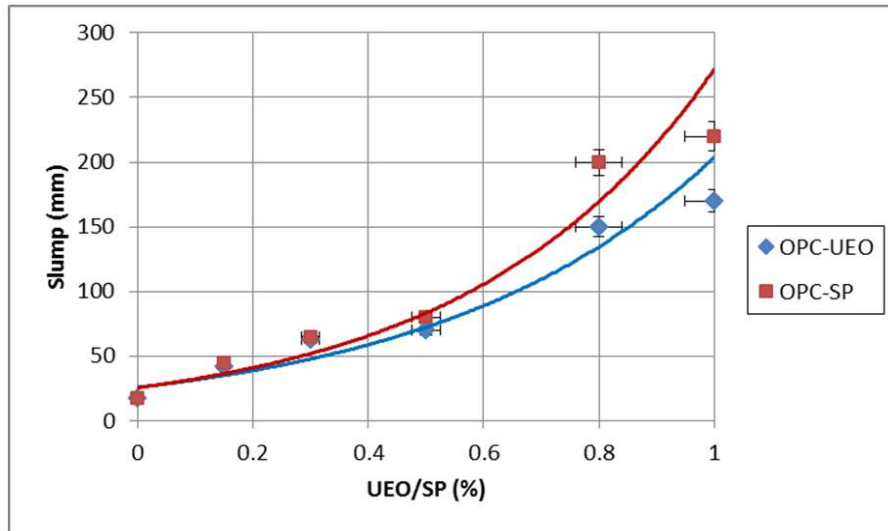


Fig. 1. Effect of SP and UEO dosage on workability of OPC concrete

The trend of workability improvement of OPC concrete containing SP and UEO did not show much significant difference since the differences in the value of exponential equation are very small. It can be stated that UEO can possibly act as water reducer and lubricant that improve concrete workability. The result obtained shows that UEO acted as chemical plasticizer by improving the fluidity of fresh concrete mix. Thus, there are similarities between UEO and SP in improving the fluidity of fresh concrete.

3.2 Effect of UEO and SP on the Concrete Compressive Strength

Fig. 2 present the effect of different dosage of SP and UEO on 28 days compressive strength. It can be witnessed that the early increment of the dosage of SP and/or UEO reduced 28 days compressive strength as compared to the OPC control mix. A dosage of 0.15% and 0.3% of UEO showed about 3% higher strength than the corresponding similar dosage of SP concrete, however at 0.5% and 0.8% dosage of UEO concrete showed about 8% lower strength than the SP concrete whereas at 1% the gap has widen to 15% difference. The reason could be influence of heavy metal contents especially ZnO and P_2O_5 in the UEO became active when the dosage is increased to a certain value, however, up to a dosage of 1% of UEO there is not very significant reduction in compressive strength. With 1% dosage of UEO, 28 days strength was obtained as 29.5 MPa, which was about the same as desired target strength. The presence of

high amount of Zn probably decrease the setting time of concrete therefore lower the compressive strength of concrete compared to control mix [22]. High dosage of P_2O_5 also affected the concrete hydration process. It slower the rate of hardening thus slow the rate of strength development [23].

3.3 Effect of UEO and SP on the Total Porosity of Concrete

Fig. 3 shows the total porosity of OPC concrete containing different dosages of UEO in comparison with the control mix. Concrete with 0.15% and 0.3% UEO showed lower porosity at all ages, whereas concrete with 0.5% and 0.8% dosage showed almost the same porosity result at the age of 28 days and beyond. At the age of 28 days, 0.15% UEO concrete showed a porosity result of 7.6% which was lower than the porosity of 0.15% SP concrete that showed a result of 8.0% with 0.3% dosage of UEO, the porosity results at ages were obtained similar to that of 0.3% SP concrete results.

Fig. 4 shows the total porosity of concrete containing different dosages of SP, which compared with the total porosity of control mix. For control mix, total porosity at age of 3 and 7 days was obtained as 11.6% and 11.0% respectively, which was substantially reduced at the age of 28 days that was obtained as 8.4%. Beyond 28 days the porosity was reduced up to 8%, which was not an appreciable reduction in porosity.

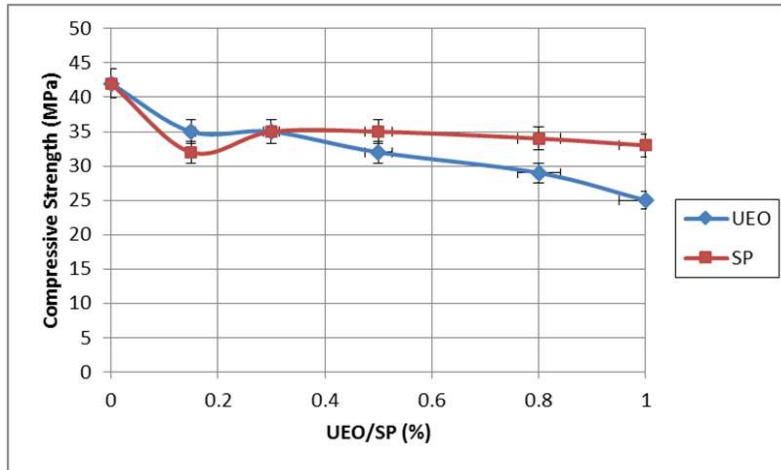


Fig. 2. Compressive strength at 28 days of OPC concrete at various dosages of UEO and SP

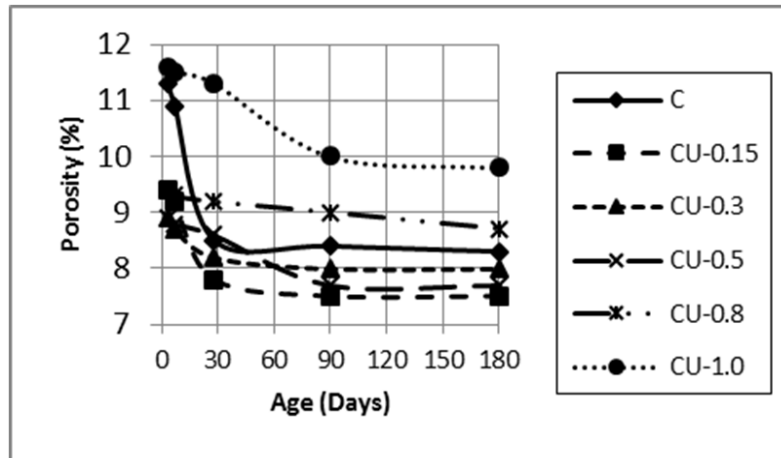


Fig. 3. Total porosity of concrete containing various dosages of UEO

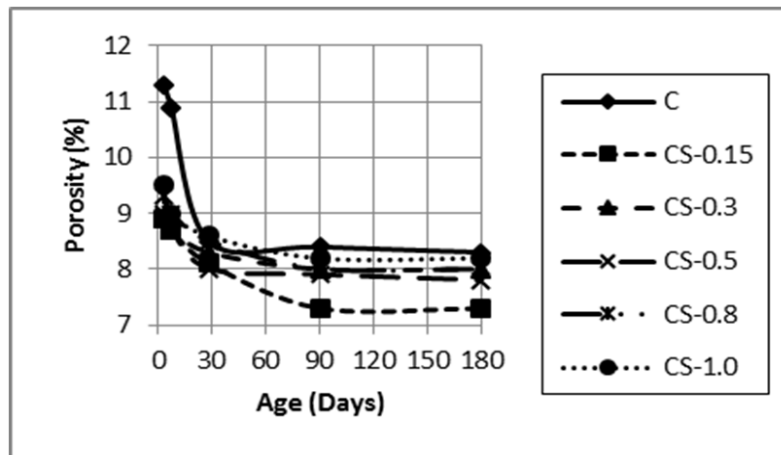


Fig. 4. Total porosity of concrete containing various dosages of SP

At the ages of 3, 7, and 28 days, porosity of concrete with 0.15%, 0.3% and 0.5% SP was almost similar. At 3 days it was about 8.5%, which was reduced to 8.4% at 7 days, whereas at 28 days it was obtained between 7.95% and 8%. Similarly as obtained in the control mix, porosity of concrete with different SP dosage did not reduced much after 28 days. In general, porosity of SP mixes was obtained lower than the control mixes, it was due to the SP caused the flocculation effects that reduced the cement absorbed water with the solid particles, so the size of pores would be of smaller sizes than the control mix.

Fig. 5 shows the 28 days porosity results with different dosages of SP and UEO. The figure is plotted to determine the optimum dosage that resulted in lower porosity value, as can be observed a dosage of 0.15% and 0.3% are found as the optimum dosage that resulted in lower porosity.

It can be stated that, the incorporation of UEO contributed towards the reduction of porosity and comparable with SP. It can be explained that the capillary porosity formed from residual spaces occupied by original mix water increases with high water/cement ratio within Portland cement paste. Adding superplasticizer or used engine oil could increase the free water in the mix therefore caused very high workability, increased capillary porosity, lower strength and potential decrease in

durability of the concrete. For this experiment, at 0.55 w/c, the incorporation of superplasticizer or used engine oil beyond 0.3% could increase the total porosity of concrete. Besides that, used engine oil contains heavy metal and high air content that also contribute to the higher porosity.

The correlation between porosity and compressive strength of OPC concrete containing superplasticizer defined as:

$$P_c = 1.78(SP)^2 - 1.37(SP) + 8.42$$

$$R^2 = 0.90$$

Where

P_c = porosity of concrete in%

SP = Superplasticizer

while the correlation between porosity and compressive strength of OPC concrete containing UEO follows this equation:

$$P_c = 5.7692(UEO)^2 - 3.1008(UEO) + 8.4291$$

$$R^2 = 0.948$$

Where

P_c = porosity of concrete in%

UEO = Used engine oil

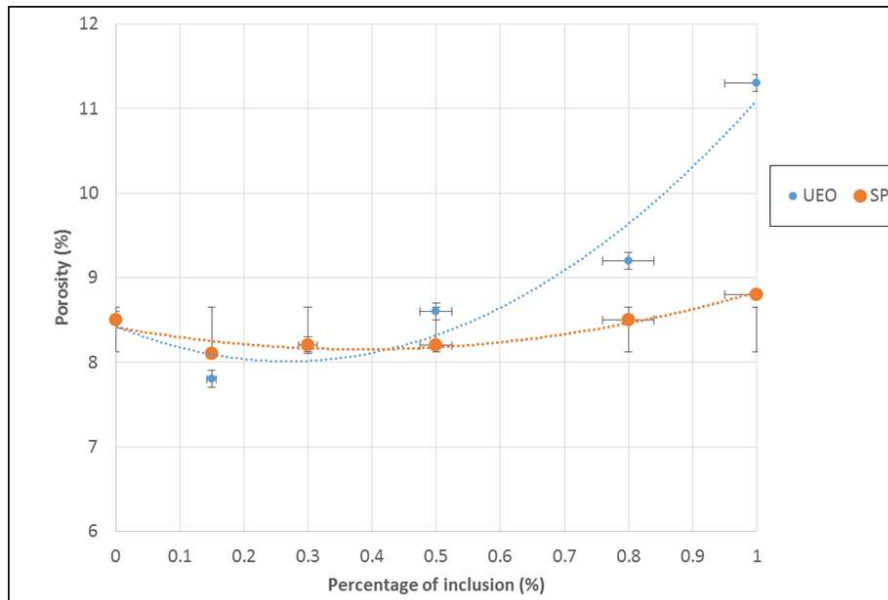


Fig. 5. 28 days total porosity of concrete containing various dosage UEO and SP

3.4 Effects of UEO on Chloride Migration in Concrete

Fig. 4 illustrated the chloride penetration of mortar. Control mortar gives the highest penetration. Mortar with UEO and SP gives higher penetration than OPC control mortar. At the age of 42 days, chloride penetration of UEO and SP mortar was 4% higher than OPC control mortar respectively which does not give very significant difference.

The chloride penetration result showed that 0.5% used engine oil did not give very high air entraining potential to concrete and the result were found similar to SP concrete at the same dosage. It can be stated that SO₃ function in workability improvement and also contributed towards the proper concrete matrices therefore decrease chloride penetration rate in concrete.

3.5 Effects of Concrete Containing UEO on Elevated Temperature Exposure

Compressive strength of OPC control mix, OPC with SP and OPC with UEO before exposed to the heat are 42, 35 and 32 MPa respectively while the compressive strength after exposed heat are 39, 31 and 29 MPa.

The percentage of strength loss after burned is 8%, 11% and 10% respectively as illustrated in Fig. 7. The compressive strength of OPC was slightly higher as compared to OPC with SP and OPC with UEO for both before and after exposed to fire and heat. It is also noted that the percentage of strength loss after burn at 500°C for the concrete with chemical admixture which are SP and UEO is slightly higher than the ordinary concrete. Thus, it shows that the performance of UEO in terms of compressive strength is comparable with SP.

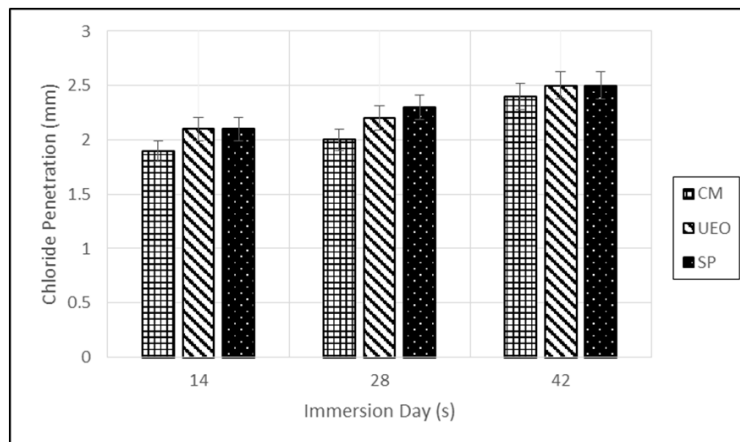


Fig. 6. Chloride penetration of OPC mortar cube

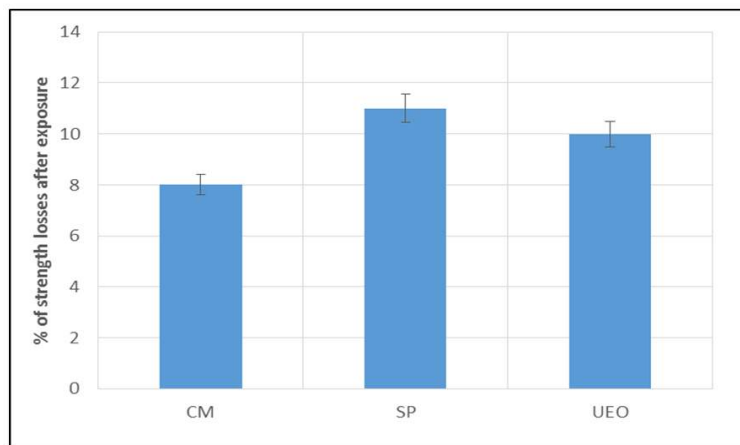


Fig. 7. Strength losses of OPC concrete after burn at 500°C

4. CONCLUSION

The following conclusions could be made from the studies:

1. UEO can act as a chemical plasticizer similar to superplasticizer to improve workability, air content and strength of OPC concrete. The slump value of OPC concrete containing UEO and superplasticizer was 3.9 times and 4.4 times as OPC control mix.
2. Incorporation of UEO and SP similarly decrease the compressive strength about 10% and 12% respectively. It may be due to the optimum or enough water content for hydration process in concrete. As a comparison between UEO and SP, the incorporation below 1% dosage gives almost similar strength. Therefore, it can be concluded that UEO has potential to improve concrete strength as water-reducing admixture same as SP.
3. UEO contributed to lower the porosity for all types of concrete and was comparable with SP. Therefore, during investigating the effects of used engine oil on porosity of concrete, up to 1% dosage did not cause any adverse effect as compared to the control mix, which means used engine oil can improve the durability.
4. The result of chloride penetration showed that incorporation of 0.5% of UEO did not cause any adverse effect as compared to the control mix, which meant that UEO could improve the durability. Therefore, when mortar samples were immersed in sodium chloride solution, used engine oil and superplasticizer caused 3% lower penetration as compared to control mix.
5. In order to determine the effects of used engine oil on fire resistivity of concrete, cubes were placed in oven at 500°C for one whole day. Results showed a reduction in strength of about 11% or below, which is supposed to be very minimal, hence, UEO did not add combustibility to concrete.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sohair I. Abou-Elala, Hesham Abdel Halem, Enas Abou-Taled, Hanem S. Ibrahim. Application of cleaner production technology in chemical industry: A near zero emission. *Journal of Cleaner Production*. 2007;1852-1858.
2. Ministry of Transport. "MOT2006". Available:<http://www.mot.gov.my/BM/stat/darat.htm>
3. Environmental Protection Agency, United States; 2013.
4. El-Fadel M, Khoury R. Strategies for vehicles waste-oil management: A case study. *Resources, Conservation and Recycling*. 2001;33(2):75-91.
5. Mindess S, Young J. *Concrete*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc; 1981.
6. Chin CS. Performance of used engine oil in fresh and hardened states of normal and blended cement concretes. MSc Dissertation, Universiti Teknologi PETRONAS, Malaysia; 2007.
7. Prof. Bamiro OA. (National Expert) and Prof. Osibanjo O. Pilot Study of Used Oils in Nigeria; 2004.
8. Bilal S. Hamad, Ahmad A. Rteil, Muttassem El-Fadel. Effect of used engine oil on properties of fresh and hardened concrete. Elsevier Science Ltd, *Construction and Building Materials*. 2003;311-318.
9. Aravind K, Animesh Das. Pavement design with central plant hot-mix recycled asphalt mixes. *Construction and Building Materials*. 2007;21:928-936.
10. Chin SC, Shafiq N, Nuruddin MF. Structural performance of reinforced concrete beams containing used engine oil. In: *International Conference on Sustainable Building and Infrastructure (ICSBI 2010)*, 15-17 June 2010, Kuala Lumpur Convention Centre; 2010.
11. Beddu S, Nuruddin MF, Shafiq N. Effects of used engine oil as chemical admixtures on the properties of high strength concrete. *International Conference on Construction and Building Technology*. Kuala Lumpur, 2008;16:185-190.
12. Nasir Shafiq, Muhd Fadhil Nuruddin, Salmia Beddu. Properties of concrete containing used engine oil. *International Journal of Sustainable Construction Engineering and Technology*. 2011;2(1).

13. Kamal M, Liyana N, Beddu S, Nurudinn MF, Shafiq N, Muda ZC. Microwave Incinerated Rice Husk Ash (MIRHA) and Used Engine Oil (UEO): Towards sustainable concrete production. In Applied Mechanics and Materials. 2014;567:434-439.
14. Assaad JJ. Disposing used engine oils in concrete—Optimum dosage and compatibility with water reducers. Construction and Building Materials. 2013; 44:734-742.
15. Salmia B, Zakaria Che Muda, Md. Ashrafal Alam, Sidek LM, Hidayah B. Used cooking oil as a green chemical admixture in concrete. 4th International Conference on Energy and Environment 2013 (ICEE 2013). IOP Conf. Series: Earth and Environmental Science. 2013;16:012077. DOI: 10.1088/1755-1315/16/1/012077
16. Beddu S, Talib SHA, Kamal NLM, Zakaria CM, Yap KW, Khidzir ABM. The performance of concrete containing used cooking oil. Proc. of the Third Intl. Conf. on Advances in Civil and Structural Engineering - CSE 2015 Copyright © Institute of Research Engineers and Doctors, USA. All rights reserved. ISBN: 978-1-63248-057-6 DOI: 10.15224/ 978-1-63248-057-6-101
17. MS 522: Part 4: 1989. Specification for Portland cement (Ordinary and rapid-hardening); 1989.
18. BS 12:1996: Specification for Portland cement. British Standard Institute, London; 1996.
19. RILEM, CP113 1984. Absorption of water by immersion under vacuum, Materials and Structures. Research and Testing. No. 101. 1984;393-394.
20. AASHTO T 277-86. Rapid determination of the chloride permeability of concrete, American Association of States Highway and Transportation Officials, Standard Specifications-Part II Tests, Washington, DC; 1990.
21. Mundhada, Ashok R, Arun D. Pofale. Effect of high temperature on compressive strength of concrete.
22. Murat M, Sorrentino F. Effect of large additions of Cd, Pb, Cr, Zn, to cement raw meal on the composition and the properties of clinker and cement. Cement and Concrete Research. 1996;26(3):377-383.
23. Tashiro C. The effects of several heavy metal oxides on the hydration and the microstructure of hardened mortar of C3S. in: 7th International. Congress Paris, Septima. 1980;2:37–42.

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