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Analysis of Fresh and Hardened Properties of M35 Concrete Mix using Burned Engine Oil as an Admixture

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Abstract

Since construction industry has always tried to utilize various waste materials in it so that they get re-utilized and the problem of their disposal will not become a great issue. Also from the past few decades, processed or unprocessed industrial wastes are used as raw materials in cement manufacturing, components of concrete binder, aggregates or a portion of aggregate or as ingredients of manufactured aggregates. Finding substitutes and utilizing waste products is in a huge trend in construction industry so that the problem of availability of conventional building materials is reduced. During technological advancements in last few years, attempts are made to utilize by-products of industries by dispose-off them wisely and also to reuse them. Already, many books on concrete technology describes that leakage of oil on cement and concrete surfaces in old grinding units resulted in formation of concrete that possess more resistance to freezing and thawing. This effect is considered as similar by adding an air- air-entraining admixture to the concrete thereby increasing its resistance against freeze-thaw cycles and hence enhancing its durability. However, this theory is not supported by sufficient experimental data hence this present study was conducted to investigate the effects caused by using burned engine oil on fresh and hardened properties of concrete. The performance of concrete in M35 control mix and in 6 other mixes containing burned engine oil and air-entraining admixture is then studied out.
Keywords: Admixture, Air-content, BEO (Burned Engine Oil), Compressive Strength, Flexural Strength, Slump, Waste Material

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I. Introduction

Wastes or by-products of various industrial, agricultural and other processes are required to get disposed-off wisely. Lubricants that are generally produced by refinery of crude oil have a very wide range of applications. During their service period, a part or sometimes all the lubricant is consumed. The remaining part is then considered as a waste as it becomes contaminated and contains unwanted substances like metal particles, carbon, lead, dirt etc. This waste if illegally disposed-off, can pollute groundwater. According to various studies, 1 litre of waste/burned lubricant is able to pollute 950,000 litres of drinking water. Besides polluting water, it also pollutes land if disposed on land without any prominent treatment. In context to this, burned lubricant produces an adverse impact on environment. A major part of waste lubricant is generated by the vehicles when their periodic maintenance/servicing is done and thus automobile industry is considered as a huge source that contributes towards the production and generation of waste lubricant. Although, all over the world various norms and rules are guiding towards the safe and legal disposal of burned engine oil however, the reality is only 45% of waste oil is getting disposed according to the norms. Remaining 55% is illegally discarded which then pollutes land, rivers, seas and produces a negative impact on environment. Aim of the present research is to find out the way for managing the generation of burned engine oil through automobiles by utilizing this waste in concrete mixes. In this way we can maintain economy in our operations firstly by reducing the cost of materials required in concrete mixes and secondly, by eliminating out the cost incurred in treatment and disposal of burned engine oil.

II. Research Significance

This paper deals with the experimental study to investigate the fresh and hardened properties of concrete using burned engine oil as a chemical admixture in it. Results of this research will be helpful in determining whether we can use burned engine oil as a chemical admixture in concrete or not. This study emerged out as a new technique where burned lubricant is utilized in concrete. This experimental study will also help us in understanding the behavior of concrete when burned lubricant and traditional chemical admixture are used in it.

III. EXPERIMENTAL PROGRAMME

A. Material Proportion:

A detailed experimental programme was prepared to determine the fresh concrete properties by examining its slump and air content and hardened concrete properties by examining compressive strength at the age of 3, 7, 28 days and flexural strength at the age of 28 days. A control mix was prepared containing no admixture and 6 other concrete mixes were prepared containing an amount of 0.20%, 0.40% and 0.60% BEO (Burned Engine Oil) and commercially available air-entraining admixture respectively. Ordinary Portland cement, OPC43 Bangur Cement was used that complied with the standards given in IS-8112:1989. Sand was used as fine aggregates and aggregates of size 10mm and 20mm were used as coarse aggregates that were in accordance to the requirement of IS-383:1970. Burned Engine Oil was collected from TVS service center, Phoolbagh, Gwalior and commercially available air-entraining admixture Duraspred, supplied by Dura Build Care, New Delhi were used in this investigation. By weight mix proportion of 1: 1.4: 2.498 was used for proportioning of cement, sand and coarse aggregates and concrete of grade M35 was prepared. Content of water, waste engine oil and admixture were measured in percentage by weight of cement used. Details of all the 7 concrete mixes are listed in following table.

Table – 1
Details of concrete mix proportion

Mix Type	*OPC Kg/m^3*	*Sand Kg/m^3*	*Coarse Aggregates Kg/m^3*	*Water %*	*BEO %*	*AER %*
Control	*445*	*625*	*1112*	*0.43*	*-*	*-*
0.20% BEO	*445*	*625*	*1112*	*0.43*	*0.20*	*-*
0.40% BEO	*445*	*625*	*1112*	*0.43*	*0.40*	*-*
0.60% BEO	*445*	*625*	*1112*	*0.43*	*0.60*	*-*
0.20% AER	*445*	*625*	*1112*	*0.43*	*-*	*0.20*
0.40% AER	*445*	*625*	*1112*	*0.43*	*-*	*0.40*
0.60% AER	*445*	*625*	*1112*	*0.43*	*-*	*0.60*

B. Material Preparation:

All the dry ingredients, cement, sand and coarse aggregates were initially mixed in the mixer in their dry state. Mixing process was performed in the laboratory of MITS, Gwalior using a 100lit capacity of concrete mixer. Admixtures, AER and BEO were diluted in water before adding them to the dry mix. When dry mixing was done, water containing admixtures was added to the dry ingredients and allowed to mix again for 2 minutes so that a homogeneous concrete-mix is obtained. Now, concrete was taken out of the mixer and tested for determining fresh properties like slump and air-content. Slump value of all the mixes were measured in accordance with the American Society for Testing and Materials (ASTM C-143) and air content was measured in accordance with the American Society for Testing and Materials (ASTM C-231).

After testing fresh concrete properties, concrete cubes were casted in standard steel moulds of dimensions 150mm x 150mm x 150mm. Concrete was poured in the cube-moulds in 2 layers of about same thickness and compaction was done by applying vibrations to the moulds by placing them on a vibrating table according to the specifications given in Indian Standards (IS-2514). Similarly concrete beams were also casted using steel moulds of dimensions 500mm x 100mm x 100mm and the same layering and compaction process was adopted. After casting all the cubes and beams specimens, they were left for 24hr for drying and then striped-out and transferred to the water tank for curing till the desired age of 3,7 and 28 days.

C. Test Setup:

Freshly mixed concrete was tested for the measurement of slump values and air content. These tests were done in accordance to the standards of American Society for Testing and Materials, ASTM C-143 and ASTM C-231 respectively. In hardened state, concrete cubes were tested for finding the compressive strength of concrete using a compression testing machine of maximum capacity of 2000 kN at the age of 3, 7 and 28 days. This test was performed in accordance to the specifications given in Indian standards (IS-516:1959) and concrete beams were tested for flexural strength at the age of 28 days in accordance to the specifications given in Indian standards (IS-516:1959)

IV. RESULTS AND DISCUSSIONS

Properties that were tested during the fresh state and hardened state of concrete and their experimental results obtained during testing are discussed below

A. Fresh Concrete Properties:

1) Slump Value:

Slump value signifies the fluidity and consistency of concrete. It is the measurement of workability of concrete. Higher value of slump shows concrete of higher workability and lower value of slump shows low workable concrete. Slump values for different concrete mixes are shown in Table-2.

Table – 2
Slump values of different concrete mixes

Mix Type	*1st reading (mm)*	*2nd reading (mm)*	*3rd reading (mm)*	*Average value (mm)*
Control	*70*	*71*	*69*	*70*
0.20% BEO	*75*	*77*	*76*	*76*
0.40% BEO	*84*	*82*	*83*	*83*
0.60% BEO	*91*	*90*	*89*	*90*
0.20% AER	*86*	*83*	*83*	*84*
0.40% AER	*97*	*93*	*95*	*95*
0.60% AER	*110*	*112*	*102*	*108*

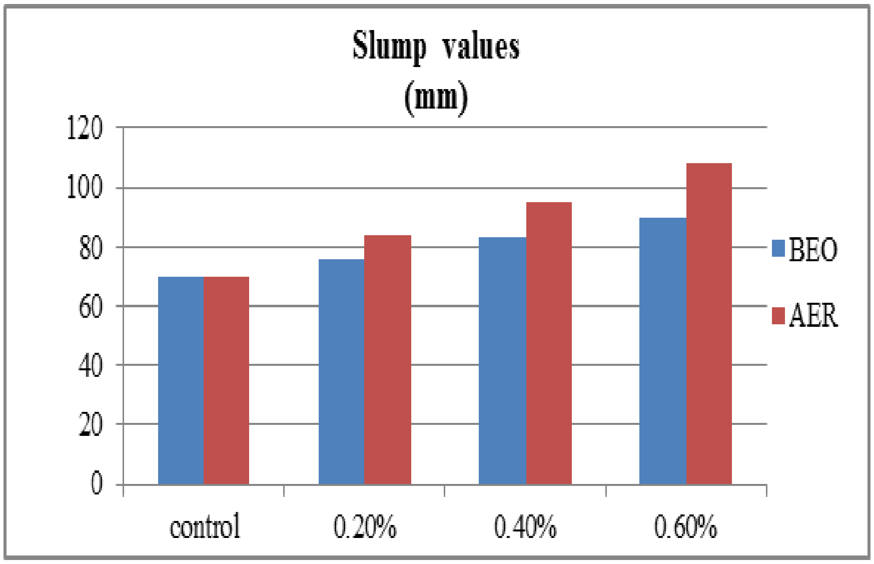

Fig. 1: Variation in slump of different concrete mixes

The results in given table shows that usage of BEO improved the slump values of mix as compared to the slump of control mix. The mix when tested with the addition of same concentration of AER, it also improved the slump values of concrete. Range of enhancement of slump value with the addition of BEO is 8.5% to 28.5% as compared to the slump value of control mix. These test results are shown in Figure-1.

2) Air-Content:

Air-content can be explained as the measurement of amount of entrained air in fresh concrete mix. This entrained air is effective in providing resistance to concrete against freezing and thawing cycles and hence maintaining its durability. Although compressive strength gets lowered by introducing air in concrete, it is desired to impart air in concrete for providing resistance to freeze-thaw cycles and increasing the durability of concrete. It is established that for every 1% increment in entrained air, compressive strength of concrete gets lowered by 5%. Air content of different mixes is shown in Table-3.

Table – 3
Air content of concrete mixes

Mix Type	*Air content (%)*
Control	*2.0*
0.20% BEO	*2.8*
0.40% BEO	*3.5*
0.60% BEO	*4.5*
0.20% AER	*3.4*
0.40% AER	*4.4*
0.60% AER	*6.1*

The results show that BEO improved the air content of the mix as compared to the entrained air in control mix. Range of improvement in values of entrained air with the addition of BEO is 40% to 125% as compared to air in control mix and the range of improvement in values of entrained air with the addition of AER comes out to be in range of 70% to 205%. These test results are also shown in Figure-2

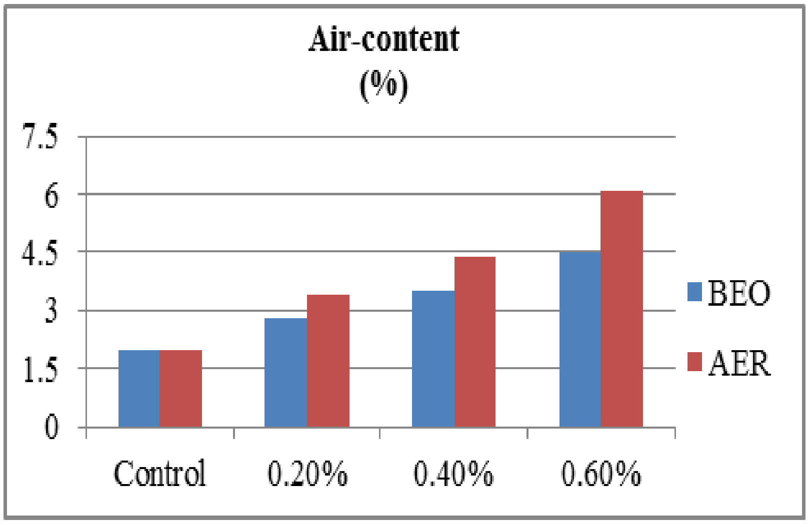

Fig. 2: Variation in air-content of concrete mixes

A. Hardened Concrete Properties:

1) Compressive Strength:

Compressive strength is the measurement of the capacity of a material to carry loads that tends to reduce its size. In this study, compressive strength for concrete mix of grade M-35 was measured at the age of 3, 7 and 28 days. The readings for compressive load of different mixes are given in Table-4.

Table – 4
Compressive strength of M35 Grade concrete (N/mm^2)

Mix Type	*3-days*	*7-days*	*28-days*
Control	*18*	*29.77*	*43.11*
0.20% BEO	*17.33*	*28.88*	*42.22*
0.40% BEO	*16.88*	*28*	*40.88*
0.60% BEO	*16.22*	*27.11*	*39.55*
0.20% AER	*16.88*	*28*	*40*
0.40% AER	*16*	*26.67*	*37.7*
0.60% AER	*14.88*	*24.88*	*34.66*

The results shows that range of deterioration of compressive strength of concrete at the age of 28-days using BEO was in control i.e. from 2.0% to 8.2% while this range was high enough when commercially available AER was used. It varied from 7.2% to 20%. Hence, it can be concluded that reduction in compressive strength using commercially available AER is about three times to that of reduction in strength by using BEO in concrete mix.

Variation in compressive strength at all the ages of 3, 7 and 28-days is depicted in Figure-3 and comparison of 28-days characteristic strength of concrete mix is shown in Figure-4.

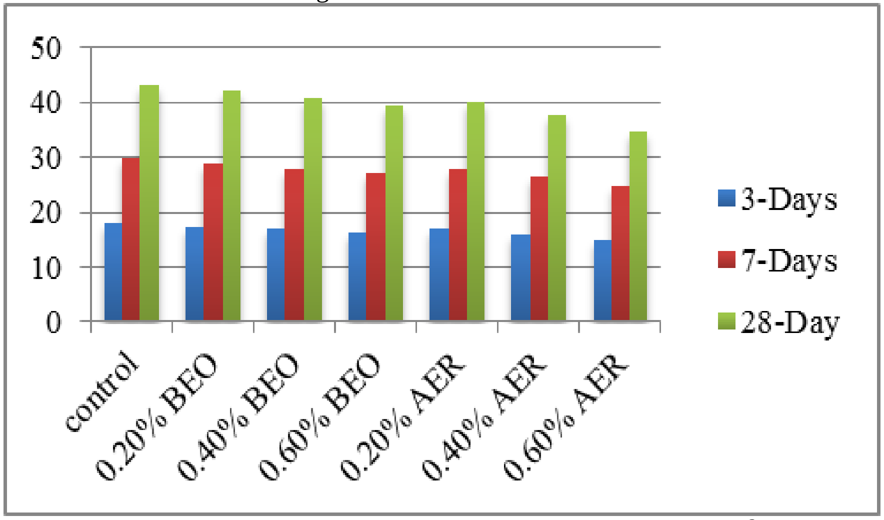

Fig. 3: Variation in compressive strength at different ages (N/mm^2)

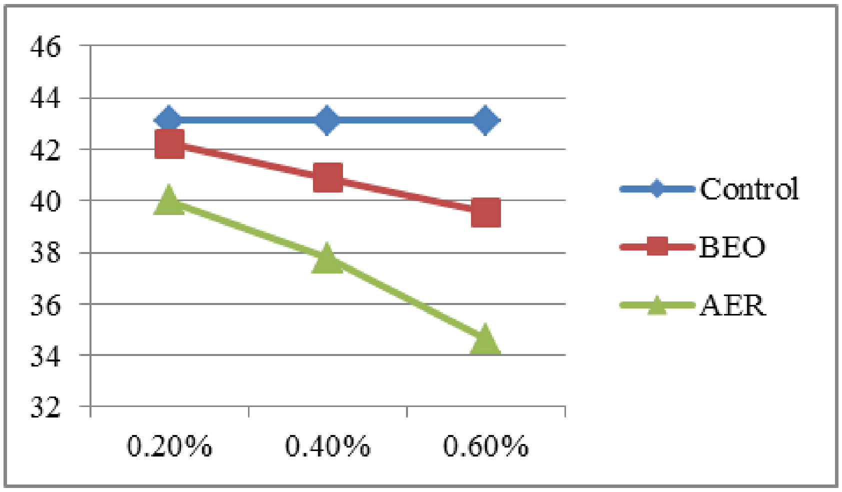

Fig. 4: Variation in 28-days compressive strength (N/mm^2) Flexural strength

Flexural strength can be described as a measure of an un-reinforced concrete beam or slab to resist its failure against bending. It is defined as the measurement of tensile strength of concrete. Concrete is considered to have negligible flexural strength and hence for making it safe against bending, reinforcement is done in concrete by providing steel bars in it. In this research study, flexural strength was measured by casting concrete beams of size 500mm x 100mm x 100mm at the age of 28-days. The readings are depicted in Table-5.

Table – 5
Flexural strength for different concrete mixes

Mix Type	*Flexural Strength (N/mm^2)*
Control	*4.50*
0.20% BEO	*4.40*
0.40% BEO	*4.20*
0.60% BEO	*4.10*
0.20% AER	*4.10*
0.40% AER	*3.90*
0.60% AER	*3.60*

Results shows that range of decrement of flexural strength using commercially available AER was high as compare to that of concrete mixes using BEO. Percentage flexural strength loss in case of AER was about 9-20% while it was nearly 2-9% in case of BEO. This relation is also depicted in Figure-5.

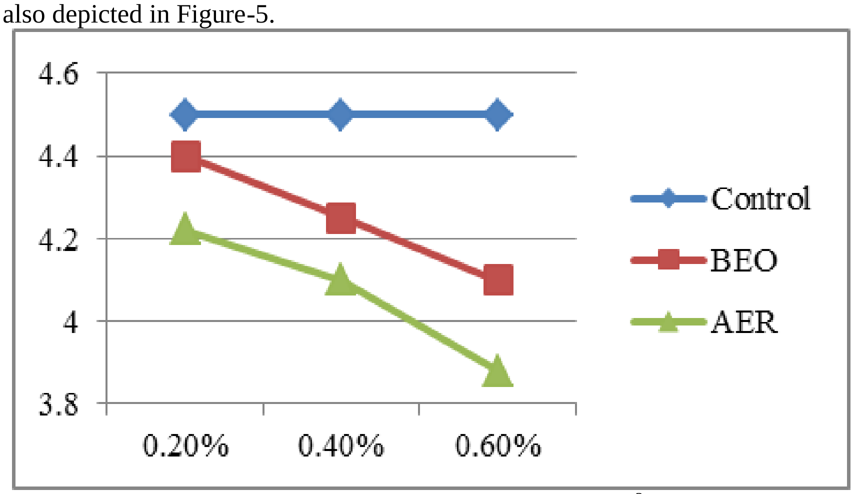

Fig. 5: Variation in flexural strength (N/mm^2)

V. Cost Analysis

A. Cost analysis for 1 m^3 of concrete,

Volume of concrete = 1 m^3
Cement = 445 kg
Water = 192 kg
Fine aggregate = 625 kg

Coarse aggregate = 1112 kg
Air-content needed (assume) = 4.5%
For 4.5% air content, dosage of BEO required = 0.60% by weight of cement
And, dosage of AER required = 0.41% by weight of cement
Quantity of admixture (BEO) required for given data = 2.67 kg or 2.67 lit
Quantity of admixture (AER) required for given data = 1.83 kg or 1.83 lit
Rate of BEO = Rs 35/lit (including freight charges)
Rate of AER = Rs 75/lit (including freight charges)
Total cost incurred in procurement of BEO = 2.67 x 35 = Rs 93/- (approx.)
Total cost incurred in procurement of AER = 1.83 x 75 = Rs 137/- (approx.)
Difference in cost using BEO and AER as an admixture in concrete for 1m^3 of concrete = Rs 44/-

VI. CONCLUSION

Based on the results and discussions the following conclusions are made

1) Dosage of BEO in concrete mix acted as a plasticizer.
2) Dosage of BEO in concrete mix acted as an air-entraining agent.
3) Role of BEO found to be act as a plasticizer in concrete which improved the workability of concrete by increasing the slump of concrete mix. This enhancement goes on increasing with the increasing concentration of BEO.
4) Enhancement in air content of fresh concrete was noticed with the introduction of BEO in the concrete mix. The results were positive and increased with its concentration. BEO increased the air content within the range of 40-125%.
5) The results on compressive strength using BEO shows that it maintained the strength of the mix with the negligible loss of about 2-8% in its strength while the same concentration of commercial air-entraining admixture resulted in approximately 7-20% loss of strength at the age of 28-days. Thus, BEO based concrete mix resulted in yielding a higher compressive strength as compared to using commercial air-entraining admixture.
6) Use of BEO in the concrete mix resulted in the loss of about 2-9% in the value of flexural strength while the use of commercial air-entraining admixture resulted in just double the loss which is approximately 9-20% loss in flexural strength of the concrete mix.
7) BEO proves out to be a very cost efficient air-entraining admixture resulting in about 32% savings in cost of admixture.

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