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USING EVA FOAM WASTE AS THE CONSTITUENT OF LIGHT WEIGHT CONCRETE MIXTURE FOR CONSTRUCTION APPLICATION

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ABSTRACT
This work aimed to study the effects of proportional additions of EVA waste as constituent of lightweight concrete and to evaluate its efficiency to produce a concrete with high strength and lightweight. Experimental study was carried out by preparing different test samples using various proportions (10%, 25%, 40%, 55%, and 70%) of EVA waste in the mix and a blank sample of concrete of grade M25. Samples and Blank were cured in tanks for 7 days and 28 days. Resulted samples were then tested for compressive strength of concrete and slump value. Finally the results were compared with the normal conventional concrete. Results showed that using10% EVA gave the best performance. Accordingly it was concluded that there is an indirect relationships between the amount of the EVA in the mix and the weight of the product. Same relation was notices against compressive strength.

KEYWORDS: EVA, Industrial waste, Fine aggregate (F.A), Coarse aggregate (C.A), Concrete

INTRODUCTION
EVA is a co-polymer made from two different monomers: 1.Ethylene monomer. 2. Vinyl acetate monomer.

In a foam state, EVA has properties like rubber, making it useful where cushioning is important such as in midsoles, sock liners, and unit soles in footwear. In EVA, the relative amount of vinyl acetate to ethylene influences polymer properties. Higher vinyl acetate content tends to make the polymer softer and more rubbery, while lower vinyl acetate content tends to make the polymer harder and more crystalline, Figure1.illustrates the molecular formula of EVA [1][2].

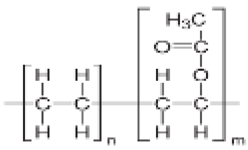

Figure 1 EVA molecular formula

EVA foams provide ideal mechanical and physical properties for many structural materials. Because of their low densities, foams have a very large properties-to-weight ratio which make them an ideal choice for several industrial applications such as thermal and sound insulators and lightweight materials for the automotive industry and construction.

The annually consumptions for EVA waste all over the world has been growing phenomenally, According to CBI China Presented by Stephen Moore (2012) concluded the total consumption of EVA in the world from 2011-2016 shoes as one of the EVA products ,there are 17 billion pairs of shoes are produced worldwide every year, and this creates an enormous amount of post-consumer (end-of-life) shoe waste that is currently being disposed of in land fill sites around the world [1]. Total EVA demand grows by an estimated 645.7KT over an annual growth rate of 3.5% ,summarizes in table (1) [3][4][5].

Table 1 presented EVA Capacity by Region /Country

	North America	South and Ceneter America	Western Europe	Central and Eastern Europe	Japan	China	Asia - Pacific	India	Middle East	Africa	Total
2011											
Consumption	1084	100	480	51	190	722	304	85	275	129	3,419
Calculated Production	1234	80	699	17	243	276	842	2	65	0	3419
2016											
Consumption	1121	122	527	72	222	921	402	99	412	168	4065
Calculated Production	1292	86	726	7	270	657	788	5	255	0	4065

In footwear industry, during the manufacture of products, unavoidableEVA wastes are generated This huge quantities from EVA waste include different techniques for recycling as the chemical modification depolymerization done by done by ZENG De-Wen(2004) [6] and mechanical recycling and thermal processing. Although all of these techniques can be effective for recycling industrial EVA waste by reduce the accumulation and get a virgin EVA but have disadvantages one of them increase the cost of machines and incinerations, reactors and the energy consumption, the short of cycle time for EVA waste, it require time and effort . This work is based on the engineering recycle technique as example study Paulo Roberto (2010), had shown the recycled lightweight concrete made from footwear industry waste and construction demolition waste [7]. But In this work had been used only EVA waste in this technique EVA waste used as partial replacement of coarse aggregate in light weight concrete applications to decrease the weight, reduction of the consumption of energy and decrease the use of natural materials, reduction the total cost of the construction.

MATERIALS AND METHODS

Experimental study

In order to achieve the stated objectives , this study was carried out in few stage .on the initial stage ,all the material and equipments needed must be gathered or check for availability. Then the concrete mixes according to the predefined proportions. Concrete samples were tested through concrete tests such as cube test. Finally the results obtained were analyzed to draw out conclusion.

High performance concrete was designed by using British curing method. Trail control mixes (S_1) for 7 and 28 days with replacement of coarse aggregate by industrial EVA waste in concrete with different dosages$S_2$10%, S_3 25%, $S_4$40%, S_5 55% and $S_6$70%.

The results of laboratory experiments were analyzed and discussed to investigate the effect of EVA waste on workability of fresh concrete and compressive strength of hardened concrete.

Materials Used

EVA foam waste (EVA aggregates): For the present study, EVA waste were obtained by collected from local footwear industry (shahata industry) like runner shoes as shown in figure 2 and then EVA waste were cut into pieces of different length between (2mm-15mm) by using cutter machine as shown in figure 3. water Absorption.1.03%. the specific gravity of EVA waste 0.5 Absorption test: BS 1881: Part 122 [8]

Fig 2 industrial EVA waste (runners shoes) in local Footwear industry before cutting

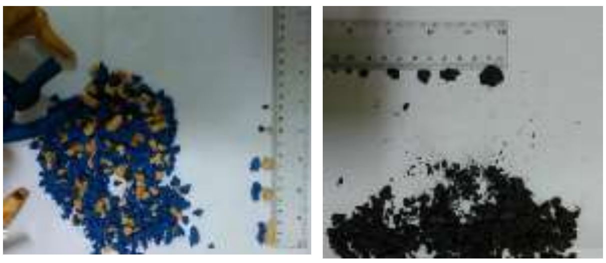

Fig 3. Fractions of EVA aggregatefrom(2mm-15mm) after cutting

Cement: The cement used was Ordinary Portland cement (45Grade) conforming to IS: 12269–1987 ,the specific gravity of cement 3.15 [9]
Fine Aggregate: The sand used for experimental program was locally The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm. The fine aggregates were tested as per Indian Standard Specification IS: 383-1970. the specific gravity was found to be 2.6, water Absorption.0.8%.
Coarse Aggregate: The natural broken stone (coarse aggregate) used for the study was of 5-15mm size maximum. It is conforming to IS: 383-1970. specific gravity was found to be 2.65, water Absorption.0.7%. It was retrieved from a local coarse. The shape and quality of aggregate was uniform throughout the project work[9].

Mix Design:
Mix design is done as per IS: 10262: 1982. In order to study the mechanical properties of EVA waste concrete, nine mix proportions were made. The percentage replacements of aggregates by industrial EVA waste were 10%, 25%, 40%,55%and 70%. This was done to determine the proportion that would give the most favorable result. The 0% replacement was to serve as control for other sample which is finally used for the comparison. The mix proportions studied for the EVA waste concrete are totally 6 proportions as shown in Table 1.
Mix Design Method
British method of mix design was used for mix design for concrete cubes test .concrete specimens with various percentages of EVA waste were prepared .the details of various mix proportions for different replacement levels of Aggregate by EVA waste at 7 and 28 days[10][11].
The aggregate dry density used was 2470 kg/m^3,and the maximum aggregate size use in all mixes was 15mm .using standard cubes moulds (100*100*100)mm, 6 cubes representing each ratio, were casted and tested at age 7 and 28 days.

Fig. 4 Samples for different proportions of concrete with EVA

Fig. 5 Machine of compressive Test

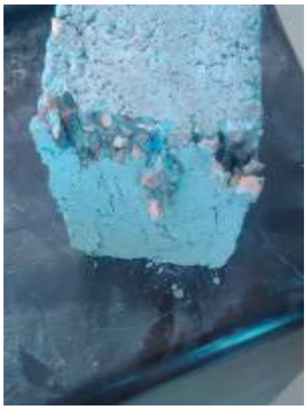

Fig. 6 Sample of concrete mix with industrial EVA

Components of mix materials

Table 2 Quantities of materials for all mix (According to the1988British method)[0000]

	Quantities					
Samples	**EVA%**	**EVA Agg,*Kg***	**Coarse agg,*Kg***	**Fine agg,*Kg***	**Water,**	**Cement ,**
S_1	0	0	11.26	6.34	1.80	3.60
S_2	10	0.225	11.035	6.34	1.81	3.61
S_3	25	0.630	10.63	6.34	1.82	3.64
S_4	40	0.910	11.35	6.34	1.83	3.66
S_5	55	1.24	10.02	6.34	1.84	3.67
S_6	70	1.58	9.68	6.34	1.85	3.69

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RESULTS AND DISCUSSION

The results of fresh and hardened concrete tests conducted by adding different ratios of Industrial EVA waste, examples of this result of the compressive strength are shown in table 3 and depicted graphically in Figures 7to 10. Compressive strength of lightweight concrete(concrete mixtures) is determined on the 7, and 28 days for each sample S1, S_2, S_3, S_4, S_5 and S_6. There were three samples for each test and the results would be taken as the average of these three.[8]

Table 3 Compressive Strength for all samples at 7 and 28 days

Mixes	Compressive strength N/mm^2	
	7days	28days
Concrete mix with zero EVA	27	27
Concrete mix with 10% EVA	15	20.5
Concrete mix with 25% EVA	12.15	10.3
Concrete mix with 40% EVA	7	5.84
Concrete mix with 55% EVA	4.6	5.02
Concrete mix with 70% EVA	2.93	2.68

The effect of, age of mix concrete e and propositions of EVA waste on compressive strength can be observed in above table , the value of compressive strength when add 10 from EVA waste after 28day give us good strength compare with blank sample and when add 70% from EVA waste gave low value.

Table 6: Results of slump test for concrete mixtures for samples S_1, S_2, S_3, S_4, S_5 and S_6 at 7 and 28 days age ASTM C143-90 [11]

Mixes		Slump
1	Concrete mix with zero EVA	10
2	Concrete mix with 10% EVA	8
3	Concrete mix with 25% EVA	5
4	Concrete mix with 40% EVA	0
5	Concrete mix with 55% EVA	0
6	Concrete mix with 70% EVA	0

Table 4 Results of average density at 7 and 28 days

Mixes		Average Density Kg/m^3	
		7days	28days
1	Concrete mix with zero EVA,S_1	2520	2540
2	Concrete mix with 10% EVA,S_2	2450	2490
3	Concrete mix with 25% EVA,S_3	2220	2410
4	Concrete mix with 40% EVA,S_4	2100	2120
5	Concrete mix with 55% EVA,S_5	2030	2090
6	Concrete mix with 70% EVA,S_6	1910	1940

In table4 observe the values of average density for different propositions from EVA waste, The lowest density values belong to concrete with the highest replacement level of EVA. The mixtures 70% EVA, can be classified as lightweight concrete

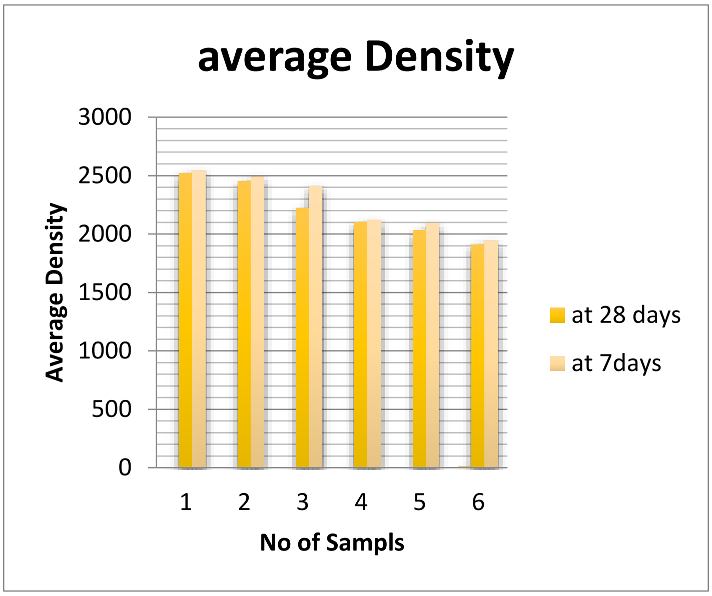

Fig.7 Relation between %of EVA and Average Density of concrete at ages of 7 and 28 days

Table 5 Average weights for concrete mixtures for samples at 7 and 28 days age:

Mixes		Average Weight *kg*	
		7days	**28days**
1	**Concrete mix with zero EVA**	2.52	2.54
2	**Concrete mix with 10% EVA**	2.45	2.49
3	**Concrete mix with 25% EVA**	2.22	2.41
4	**Concrete mix with 40% EVA**	2.1	2.12
5	**Concrete mix with 55% EVA**	2.03	2.09
6	**Concrete mix with 70% EVA**	1.91	1.94

This table explain the effect of add different proposition from EVA waste on the average weight and the result which have been observed and gave low weight when add 70% from EVA waste.

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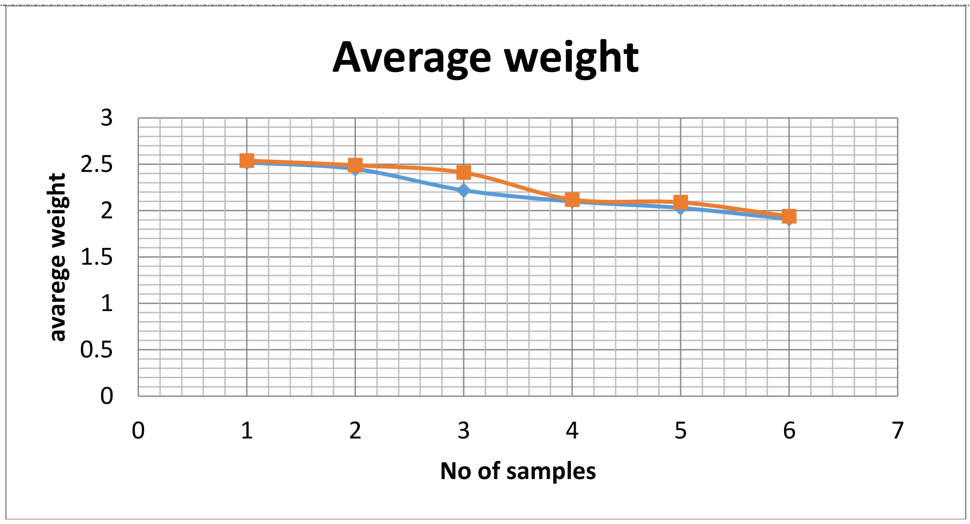

Fig.8 Relation between % of EVA and Average Weight of concrete at ages of 7 and 28 days

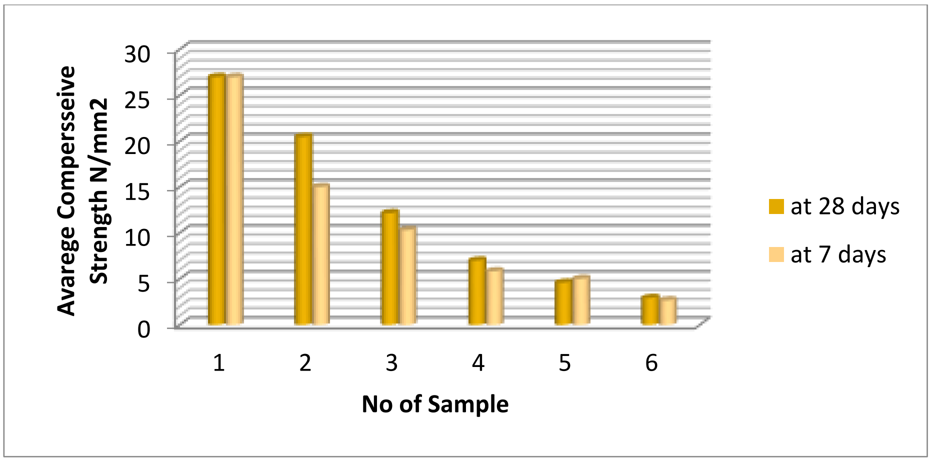

Fig.9 Relation between %of EVA and Average C of concrete at ages of 7 and 28 days

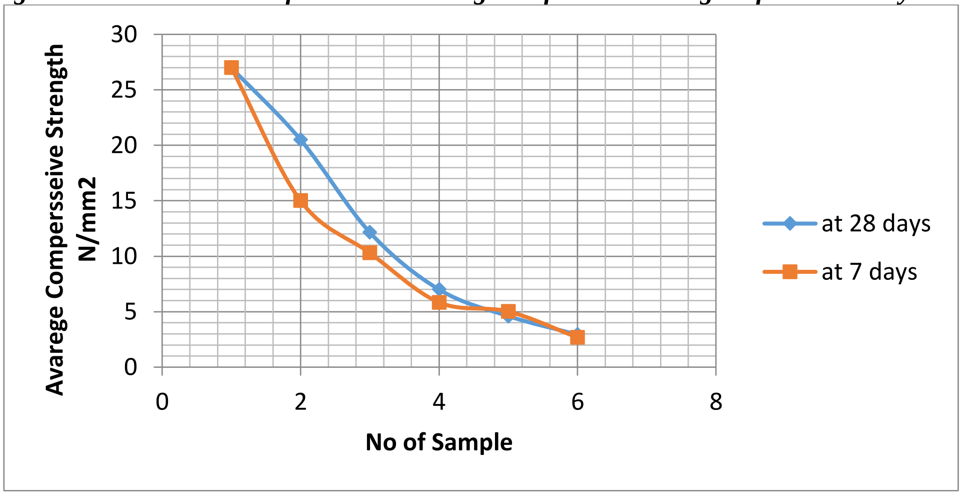

Fig.10 Relation between %of EVA and Average compressive of concrete at ages of 7 and 28 days

The results obtained from the different tests are summarized as following:

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1. Compressive strength of concrete at the age of 7 and 28 days decreased with increasing amounts of EVA waste Fig. 9&10.
2. The density of concrete decreased with increasing amounts of EVA wasteFig 7.
3. The weight of concrete decreased with increasing amounts of EVA wasteFig 8.
4. Increased value of slump with increased amounts of EVA waste as table 6.

CONCLUSION

In this study the EVA waste was used as additive to investigate its effect on fresh and hardened concrete through the measure of workability for fresh concrete and compressive strength for fresh and hardened concrete in 7 & 28 days. Based on the results it can be concluded that:

- For fresh concrete the value of slump decreased with increased amounts of EVA waste
- For hard concrete the value of average compressive strength concrete decreased with increased amounts of EVA waste for 7days and 37.5 M pa& 40.2 M pa for 28 days respectively.

RECOMMENDATIONS

Based on the result of the study performed in this research, twotypes of the following recommendations are made:

Used of industrial EVA waste as replacement of aggregate is better for non loads structure members for examples light weight blocks ,tiles and interlock

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