International Journal of Engineering Research and Science & Technology

ISSN : 2319-5991
Vol. 5, No. 3
August 2016

www.ijerst.com

Email: editorijerst@gmail.com or editor@ijerst.com

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 5, No. 3, August 2016

Research Paper

EFFECTIVE REPLACEMENT OF FINE AGGREGATES BY EXPANDED POLYSTYRENE BEADS IN CONCRETE

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With the increase in demand for construction materials there is a strong need to utilize alternative materials for sustainable development. The main objective of this investigation is to study the properties, such as compressive strength and tensile strengths of light weight concrete containing Expanded Polystyrene (EPS) beads. Its properties are compared with those of the normal concrete, i.e., without EPS beads. EPS beads are used as partial replacement to fine aggregates. The results showed that the amount of polystyrene beads incorporated in concrete influences the properties of hardened concrete. Since the compressive strength less than a certain percentage depending on the amount of replacement. At 28 days, it was found that compressive strength of 5%, 15%, 20%, EPS based concretes compared to control concrete were 41%, 38 %, 25%, respectively.

Keywords: Expanded Polystyrene beads (EPS), Workability, Compressive strength

INTRODUCTION

Increase in the developmental activities world over, the demand for construction materials is increasing exponentially. This trend will have certainly greater impact on the economic system of any country an attempt is made to address the possibility of utilizing Expanded Polystyrene (EPS), a packing material in the form of beads in concrete, which otherwise is posing a threat to waste disposal as well as for waste management.

This material is a cause of concern to environmentalists. In this study, it is attempted to partially replace coarse aggregates by means of EPS beads. A general discussion on EPS its production and its application along with environmental concerns are being discussed. EPS is a lightweight cellular plastics material consisting of fine spherical shaped particles which are comprised of about 98% air and 2% polystyrene. It has a closed cell structure and cannot absorb water. It has a good sound and

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thermal insulation characteristics as well as impact resistance. Polystyrene foam is a non-biodegradable material. It is a waste material from packaging industry. It creates disposal problem. Utilizing crushed polystyrene granules in concrete is a valuable waste disposal method.

There are many advantages to be gained from the use of lightweight concrete. These include lighter loads duringconstruction, reduced self-weight in structures, and increased thermal resistance. Lightweight concrete is generally accepted as concrete having a density of about 1800 kg/m^3 or less. The present investigation was taken up, keeping two targets in view, disposal of the polystyrene waste from the point of view of environment and for the replacement of aggregate from the point of view of construction industry. The present study aims at utilization and the suitability of polystyrene beads as fine aggregate. A comparative study on strength parameters is also done against conventional concrete to study the behavior of the polystyrene aggregate. For this 5%, 15%, 20%, and replacement of fine aggregate by expanded polystyrene beads is attempted in this work.

Tamut, Prabhu (2014) studied engineering properties of polystyrene (PS) partially replacing natural coarse aggregate with equal volume of the chemically coated polystyrene at the levels of 30, 50 and 70%.

Mandlik (2013) investigated the behavior of lightweight expanded polystyrene concrete containing silica fume.

The Saradhi Babu *et al*.(Momtazi, 2010) study covers the use of expanded polystyrene (EPS) beads as lightweight aggregate, both in concrete and mortar.

The Miled investigation confirmed the presence of a particle size effect on the EPS concrete compressive strength.

Most research on EPS concretes as mentioned above has shown a decrease in the durability performance and the engineering properties of concrete with increasing the amount of polystyrene aggregate in mixtures and an increase in strength with smaller EPS bead size concrete.

The studies on EPS concretes reviewed have also shown that mixtures produced using ordinary vibration method will lead to a large number of particles floating upward and serious concrete segregation, resulting in EPS lightweight concrete with reducing its various performances due to the ultra-light EPS particles and being quite weak. A great deal of research has used super plasticizers and fly ash to increase the workability of the concrete.

MATERIALS AND METHODS

The ingredients of concrete were Expanded Polystyrene beads in the form of spheres. It is used locally known styrene polycarbonate granules one of the materials available to a great extent in terms of human waste used in the packaging of goods Food and household appliances has been getting these granules in a manner smashed pieces. Properties of expanded polystyrene beads Specific Gravity (0.011), Bulk density (6.86 kg/m^3). Portland cement was used in all the usual trial mixes for this search. Use Ordinary Portland cement manufactured in Iraq with trade mark of (Tassloga) has been used throughout this investigation Table 3 and 4. coarse aggregate brought from (Al-Soddor source as a fine aggregate after it have been sieved by sieve size (4.75 mm) according sieve analysis in Table 1 and 2 with density 2300 kg/m^3,drinking water

processed by the liquefaction plant.

MIX PROPORTIONS

Adopting w/c = 0.47, the proportion of concrete mix is, 1:1.8:2.56

This concrete mix proportion is taken as the reference or control mix in the present study. The mix proportion for EPS beads based concrete is obtained by partially replacing sand with different dosages of polystyrene beads volumetrically. The quantities of materials for various mixes are obtained by partial replacement (by volume) of sand by EPS beads. Cubes of 150 mm size for compressive strength evaluation and the specimens were cured in water for 7 day and 28 days then tested. For every mix, 6 cubes of 150 mm size (for compression tests: 3 numbers each for 7 days and 28 days. 3 levels of replacement of sand were considered (5, 15, 20 %).

Table 1: Gradation of Fine Aggregate

Sieve Size (mm)	Passing %	Standard passing % of zone (2)
4.75	93	90-100
2.7	83.4	75-100
1.18	69	55-90
0.6	47.31	35-59
0.3	15.405	8-30
0.15	0.707	0-10

Table 2: Gradation of Coarse Aggregate

Sieve size (mm)	Passing %	Limit of Iraq SpecificationNo.45-1984
12.5	100	100
9.5	88	100-85
4.75	10	25-0
2.36	2.5	5-0

MIXING

The steel molds of 150 x 150 x 150 mm were oiled properlybefore filling mortar. The mortar was filled into the molds in three layers with hand compaction after adding each successive layer.

After filling the molds completely with the mortar, a needle vibrate was used to remove air voids from the mortar. It is to be kept in mind that needle vibrator is used just for few seconds to avoid segregation and floating of EPS balls to surface. After the compaction has been

Table 3: Physical Properties of Cement

Physical properties	Test results	Standard Specifications IQS 5/1984
Specific surface area (Blaine method), m^2/kg	495	≥230
Setting time (Vicate apparatus),		
Initial setting, h:min		
Final setting, h:min	2:55	≥00:45
	4:35	≤10:00
Compressive strength, MPa		
3 days	33.5	≥15
7days	38.6	≥23
Soundness (Autoclave) method, %	0.3	≤0.8

Table 4: Chemical Composition of Cement		
Oxides composition	**Content %**	**StandardSpecifications IQS 5/1984**
CaO	63.06	-
SiO_2	22.	-
Al_2O_3	6.25	-
Fe_2O_3	3.13	-
MgO	2.95	<5
SO_3	3.03	<2.8
L.O.I.	3.33	<4
Insoluble residue	1.21	<1.5
Lime Saturation Factor L.S.F	0.88	0.66-1.02
Mineralogical Composition (Bogue's equations)		
C_3S	47.04	-
C_2S	28.11	-
C_3A	10.98	-
C_4AF	6.98	-

Table 5: Concrete Mix				
Cement (kg)	**Sand(kg)**	**Aggregate(kg)**	**EPS(kg)**	**Water(litter)**
7.56	13.86	19.582	0.004	3.5955
7.56	13.86	19.582	0.007	3.5955
7.56	13.86	19.582	0.0119	3.5955

Table 6: Results Compression Test in 7 Days Curing			
EPS%	**Weight (Kg)**	**Compressive Strength (MPa)**	**Density (Kg/m^3)**
5%	7.260	11.871	2.15
	7.205	12.144	2.13
	7.120	10.105	2.11
15%	7.645	12.766	2.26
	7.695	13.445	2.28
	7.640	12.05	2.26
20%	7.575	5.868	2.24
	7.865	6.670	2.33
	7.537	6.455	2.23

Table 7: Results Compression Test in 28 Days Curing			
EPS%	**Weight (Kg)**	**Compressive Strength (MPa)**	**Density (Kg/m^3)**
5%	7.790	15.454	2.308
	7.655	16.887	2.268
	7.660	17.291	2.269
15%	7.695	12.731	2.280
	7.100	9.330	2.103
	7.600	13.38	2.252
20%	7.140	8.467	2.116
	7.210	7.855	2.136
	7.239	8.000	2.145

Figure 1: Cubes Mixing

completed, the excess mortar was removed from the moulds with the help of trowel and the surface was levelled. After a setting time of 24 h, concrete samples were demoulded and were taken for curing.

CURING

After 24 hours, we put the cubes in a tank of water to let the concrete become forcing and strength for 7 and 28 days.

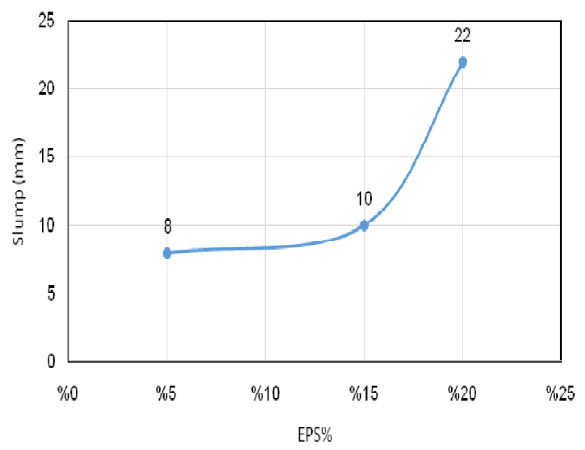
TESTS ON EPS BASED CONCRETES

Workability

The slump test is the most well-known and widely used test method to characterize the workability of fresh concrete. it was observed that workability of a concrete mix increased on addition of polystyrene. Workability of the mixes was observed to increase with increase in percentage replacement of fine aggregate with polystyrene (as a partial replacement of aggregate) the slump was 8mm, 10 mm and 22 mm.

Figure 2: Slump Test

Figure 3: Slump Test Curve



Compressive Strength

Strength of concrete is the most important, although other characteristics may also be critical and cannot be neglected. Strength is an important indicator of quality because strength is directly related to the structure of hardened cement paste. Even though strength is not a direct measure of durability or dimensional stability, it has a strong relationship with the water to cement ratio of the concrete, which in turn influences durability, dimensional stability and other properties of concrete.

Figure 4: Compressive Strength Test

Figure 5: Broken Surfaces of Failed

RESULTS AND DISCUSSION

The results of compression test are shown in Figure 6 is seen that the compressive strength of all concrete mixes increased with the increase of age. It is observed that, the larger the amount of polystyrene beads in concrete, the lesser the compressive strength. As expected, the normal weight concrete has more compressive strength at all ages compared to lightweight concrete. At 28 days, it was found that compressive strength of 5%, 15%, 20%, EPS based concretes compared to control concrete were 41%, 38 %, 25%, respectively.

Figure 6: Compressive Strength Variation with ESP% in 7 Days and 28 Days

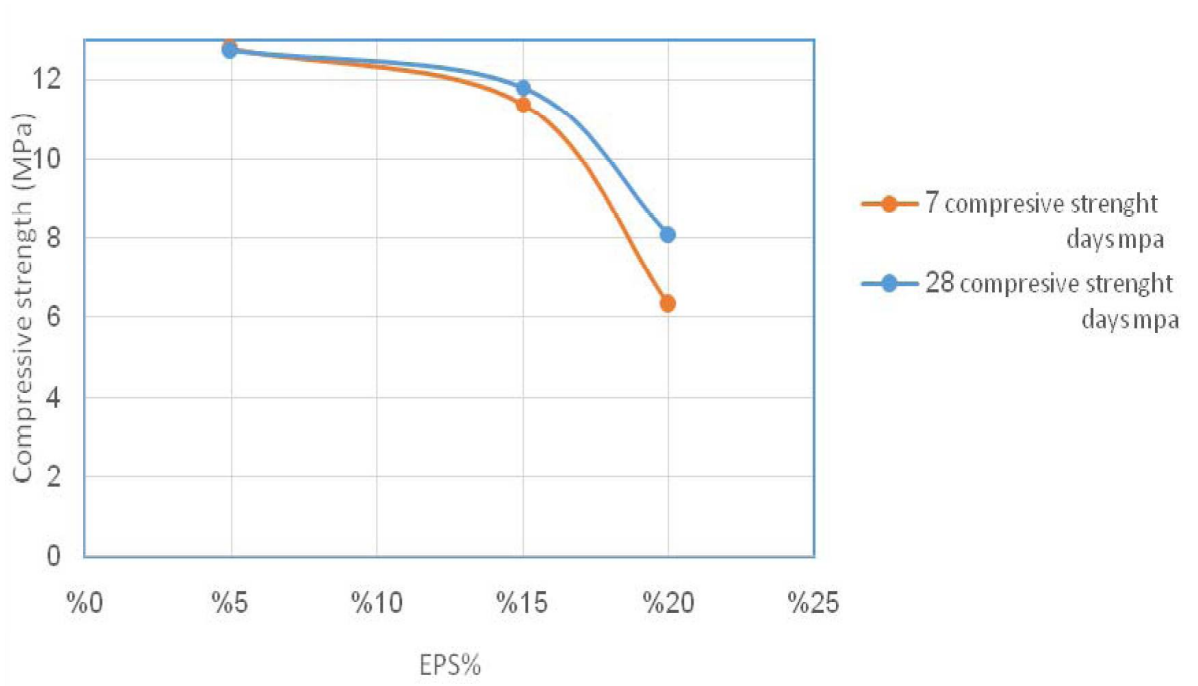


Figure 7: Compressive Strength Normal and Polystyrene

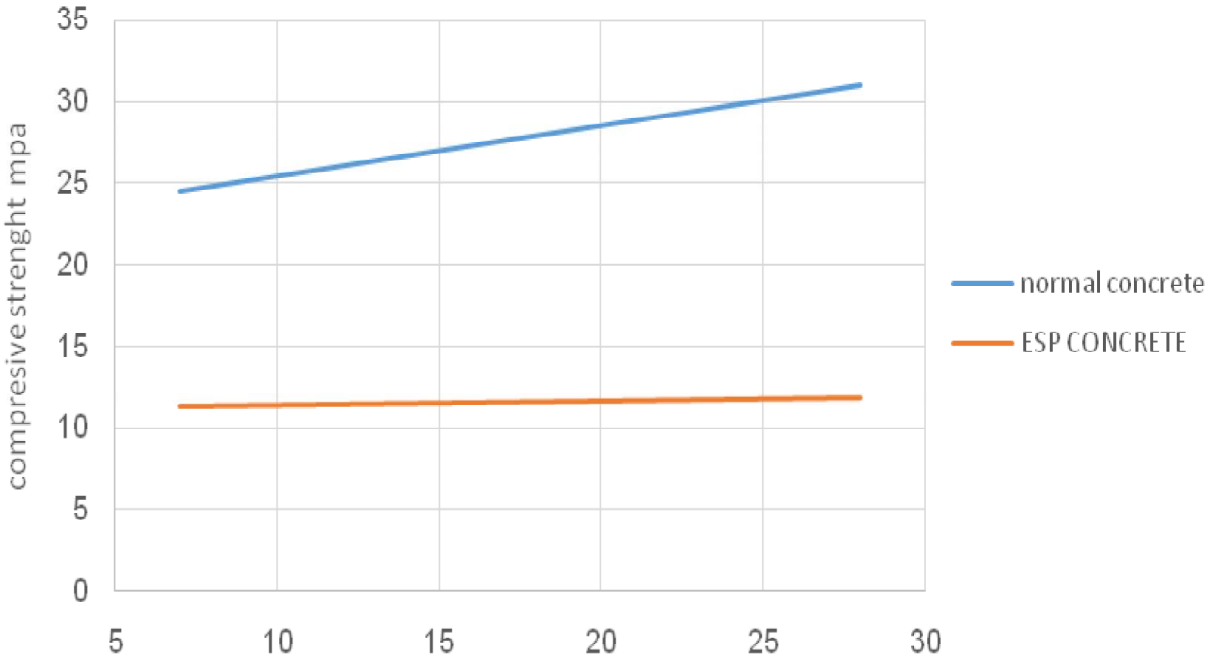
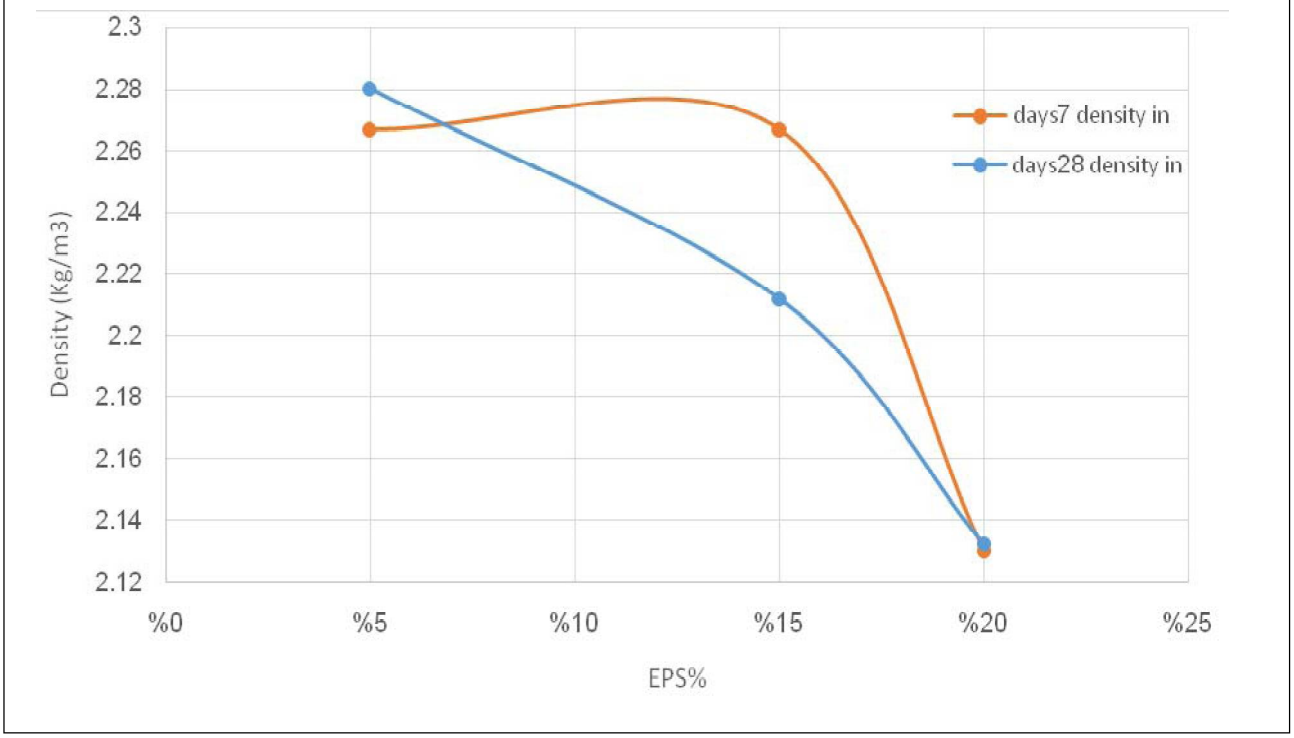


Figure 8: Density Variation with ESP% in 28 Days



As shown in Figure 6 for 7 days and 28 days curing of the relation between compressive strength and (EPS%), we see that the compressive strength of concrete reduce as the (EPS %) replacement increase in the mixture.

In the Figure 8 above that show the relation between density of concrete and the percentage of replacement of (EPS) by the weight of fine aggregate , we see that the density of concrete reduce with the increasing of (EPS%). EPS based concrete mixes, in general, decrease with an increase in polystyrene beads content. This can be attributed to

a. Increase in polystyrene volume, increases the voids as compared to the control mix.

b. Smooth surface of the polystyrene; hence the polystyrene beads tend to bond loosely with the cement paste. It is seen that the polystyrene particles could be easily plucked and removed from the rupture surfaces of the cubes after compression tests. Due to this poor bond characteristic, failure takes place through the cement paste- polystyrene interface at much lower stress levels.

c. Low specific gravity of the polystyrene due to which there is a reduction in overall density of the concrete Density affects the compressive strength.

CONCLUSION

Increase in the EPS content in concrete mixes reduces the compressive strength of concrete.

Increase in the EPS content in concrete mixes reduces the density of concrete.

Workability increases with increase in EPS beads content.

The replacement by using EPS has shown a positive application as an alternate material in

building nonstructural members, and it also serves as a solution for EPS disposal.

Obtained results suggest that expanded polystyrene concrete has scope for nonstructural applications, like wall panels, partition walls, etc.

REFERENCES

1. ACI 213R, American Concrete Institute "Guide for structural lightweight aggregate concrete" , Farmington Hills, MI.
2. Kohling K (1960), "The manufacture of light weight concrete using pre-expanded styropore particles as aggregates", *betorstein – zeitung,* Vol. 26, pp. 208 -212.
3. Mandlik Tarun Sarthak Sood, and others (2013), "Lightweight Concrete Using EPS", ISSN (Online): 2319-7064.
4. Maura G (1978), "Light weight concrete made with expanded substituted polystyrene", IL Cemento (Rome), Vol. 75, part 1, 1978, pp. 21-29.
5. Momtazi and others (2010), "Durability of Lightweight Concrete Containing EPS In Salty Exposure Conditions".
6. Parton G M and Shendy-EL- Barbary M E (1982), "Poly styrene –bead concrete properties and mix design", *Journal Of Cement Composite And Light weight Concrete*, Vol. 4, No. 3, pp.153-161.
7. Tamut Prabhu and others (2014), "Partial replacement of coarse aggregate by expanded polystyrene deads in concrete", Vol. 3, No. 2.

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