LIGHT WEIGHT CONCRETE USING EPS

Jaydeep Singh
M.Tech Student, Department of Structure Engineering, Faculty of Technology, Uttarakhand Technical University, Dehradun
Sangeeta Dhyani
Head, Department of Structure Engineering, Faculty of Technology, Uttarakhand Technical University, Dehradun.

ABSTRACT

We developed a new structural light weight concrete by completely replacing coarse aggregate in concrete by expanded polystyrene (EPS) beads. Expanded polystyrene (EPS) is a lightweight material that has been used in engineering applications since at least the 1950s. Expanded polystyrene waste in a granular form is used as light weight aggregate to produce light weight non-structural concrete with the unit weight varying from 950 kg/m³ to 1350kg/m³. This paper reports the results of an experimental investigation into the engineering properties, such as compressive strength, modulus of elasticity, drying shrinkage and creep, of polystyrene aggregate concrete varying in density.

Keywords: EPS beads, concrete, compression Strength, Replacement.

I. INTRODUCTION

Expanded polystyrene is a stable, low density Foam and consists of discrete air voids in a polymer matrix. The polystyrene beads can be easily incorporated into mortar or concrete to produce lightweight concrete with a wide range of density. Applications of polystyrene concrete were they include curtain walls, cladding panels, tilt-up panels and composite flooring systems. Polystyrene concrete was used to produce load-bearing concrete blocks, sub-base material for a pavement, as the material of construction for floating marine structures. It was suggested that an overlaying layer of polystyrene concrete could provide protection to structures against impact loading. In the past, the use of polystyrene beads in concrete produced segregation due to extreme lightness and hydrophobic nature of the untreated Beads .Expanded polystyrene (EPS) was a kind of stable foam with low density, consisting of discrete air voids in a polymer matrix. The polystyrene beads can easily be incorporated into mortar or concrete to produce lightweight Concrete, with a wide range of densities especially, it can be used within the protective layer of a structure for impact resistance due to its good energy absorbing characteristics.
Polystyrene concrete is made from a mixture of cement, natural aggregates and polystyrene beads in the form of expanded polystyrene (EPS) aggregates.

II. HISTORY OF LIGHT WEIGHT CONCRETE

Light weight concretes have been used in construction since before the days of the Roman Empire. The earliest types of lightweight concrete were made by using Grecian and Italians pumice as the lightweight aggregate. Ordinary hydrated burned lime was used as the cementations material in the mix. These early lightweight concretes, by reason of the obviously weak materials, fell far short in structural performance of what we expect and achieve today. They were, however, amazingly durable, and existing examples of these early lightweight concretes are still to be found in various early structures of the Mediterranean area. The primary use of light weight concrete is to reduce the dead load of the concrete structure, which then allows the structural designer to reduce the size of the column, footing and other load bearing elements.

TYPES OF LIGHT WEIGHT AGGREGATES:

Light weight aggregate are broadly classified into two types:
1 Natural light weight aggregate
Pumice, diatomite, volcanic cinders etc.
2 Artificial light weight aggregate
Perlit, clay, sintered fly ash, expended shale, etc. expended polystyrene (EPS) is a type of artificial light weight aggregate with the density of only 10-30 kg/m^3.

LIGHT WEIGHT CONCRETE USING EPS

Lightweight concretes (LWCs) can be used in various construction fields. It can be used for repairing wooden floors of old buildings, carrying walls of low thermal conduction, bridge decks, floating quay, etc. For the first applications, the lightest possible material is used, i.e., usually it has a specific gravity of 0.5, the strength being of less importance.
But for some structural applications, a compressive strength higher than 40MPa is sometimes necessary, which leads the designer to optimize a material with a specific gravity close to 1.8. In such a case, lightweight aggregates, such as expanded glass or clay, take part in the resistance of the composite. The possibilities offered by new cement-based materials suggest that it is possible to improve the compressive strength versus the specific gravity, or to reach equivalent strength for lower specific gravity.
The aim of this report is to achieve a mix design for Lightweight EPS Concrete with density lesser than 1800kg/m³ and enough high compressive strength so that it can be used in construction purpose.

III. SCOPE OF THE STUDY

An attempt is made to examine the it is lighter than the conventional concrete with a dry density of 300 kg/m3 up to 1840 kg/m3.The main specialties of lightweight concrete are its low density and thermal conductivity. The experimental investigation mechanical properties of concrete made with expanded polystyrene beads (EPB) as a partial replacement of coarse & fine aggregate in proportions of 0%, 10%, 20%, 30%, 40% and 50% in the water cement ratio of 0.50 was studied with silica fume as a partial replacement of cement.

IV. MATERIALS

Cement - SHREE Ordinary Portland cement of 53 grade conforming to ISI standards has been used.
Fly ash - 10% Cement replaced by fly ash in mass (Kg/m3).
Coarse aggregate – Natural coarse aggregate passing through 20mm sieve and retained on 10mm sieve.
Expanded Polystyrene Beads (EPB) - The sizes of EPB beads are 8-10 mm
Mechanical properties of EPS beads:
Specific gravity = 0.013
Bulk density =6.88 kg per cub.mtr
Particle size = 8-10 mm dia.
Compressive strength = 0.089MPa
Water absorption = 3.5 % by volume

V. RESULTS & DISCUSSIONS

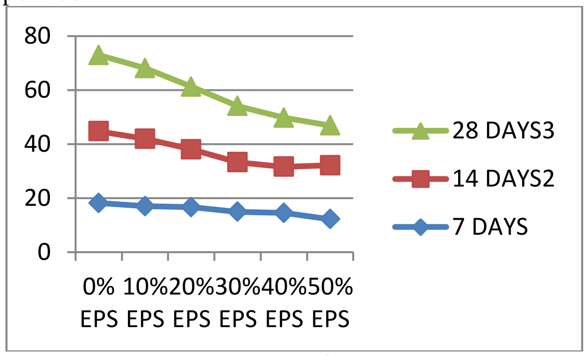
Concrete Mix Proportions:
The results of the various tests conducted on grade of concrete M20 considering partial replacement of Natural aggregate by (EPS) are in the range of 10% to 50% and are presented in the following tables.
Slump:
In general, it was observed that workability of a concrete mix increased on addition of polystyrene. Workability of mixes was observed to increase with increase in percentage replacement of aggregates with polystyrene (as a partial replacement of aggregate) i.e. higher the polystyrene replacement, higher was the workability. Bleeding was observed with the increase in water/cement ratio.

S. No	Mix designation	Slump value (mm)
1.	M_{20} control mix(0%EPS)	35
2.	M_{20} (10%EPS+10%FA)	40
3.	M_{20} (20%EPS+10%FA)	45
4.	M_{20} (30%EPS+10%FA)	60
5.	M_{20} (40%EPS+10%FA)	72
6.	M_{20} (50%EPS+10%FA)	85

Table-1: variation in slump with EPS (%)
Compressive strength:
The compression test on the plain cubes was conducted on 3000 KN digital compression testing machines. The rate of load being applied at 0.5KN/sec. Cube compressive strength of reference Artificial light weight Aggregate (for 5 different % replacements) for M20 grade of concrete is given **Table-2.**

S. No.	Mix designation	Average compressive strength (CUBES) (N/mm2)		
		7 days	14 days	28 days
1.	M_{20} control mix(0%EPS)	18.20	26.56	28.20
2.	M_{20} (10%EPS+10%FA)	17.00	24.96	26.12
3.	M_{20} (20%EPS+10%FA)	16.65	21.40	23.20
4.	M_{20} (30%EPS+10%FA)	14.95	18.30	20.85
5.	M_{20} (40%EPS+10%FA)	14.50	17.12	18.14
6.	M_{20} (50%EPS+10%FA)	12.20	19.97	14.67

Table-2: Compressive strength Results for different age periods



Graph-1: Variation of compressive strength

From the above results, It can be seen that the compressive strength (at 28days) of EPS concrete yields compressive strength of reference concrete, For Natural aggregate replacement levels up to 30% for M20 grade concrete .However the cylinder and compressive strength for all the grades of concrete considered in the study.
Split tensile strength test on cylinders:
The cylindrical specimen was kept horizontally between the compressive plates on the testing machine. The load was applied uniformly to the cylinder fails, the loads related to ultimate load are recorded. A test was conducted for cylinders with different EPB aggregate additions. The split tensile strength was calculated by the standard formula.
Split tensile strength = **2P/ΠDL**

Where P = ultimate load D = Diameter of the cylinder in mm L = cylinder Length in mm. Making use of the lab data flexural strength has been calculated using the formula.

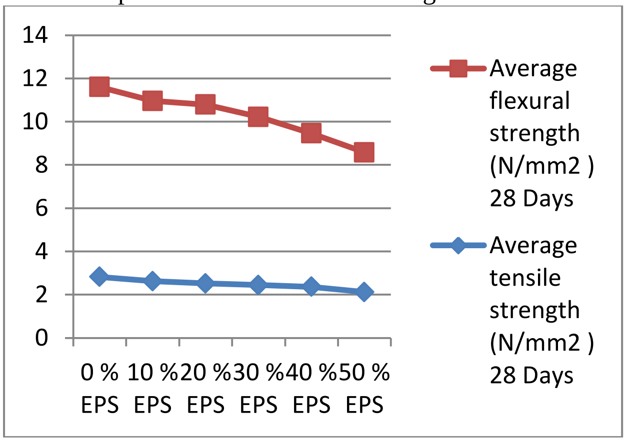
f=M/Z in N/mm2

Where, M= Bending moment

Z=I/y= Section modulus

S. No	Mix designation	Average tensile strength (N/mm^2) 28 Days	Average flexural strength (N/mm^2) 28 Days
1.	M_{20} control mix(0%EPS)	2.82	8.78
2.	M_{20} (10%EPS+10%FA)	2.62	8.34
3.	M_{20} (20%EPS+10%FA)	2.52	8.27
4.	M_{20} (30%EPS+10%FA)	2.44	7.78
5.	M_{20} (40%EPS+10%FA)	2.36	7.10
6.	M_{20} (50%EPS+10%FA)	2.12	6.46

Table-3: Split tensile and flexural strengths



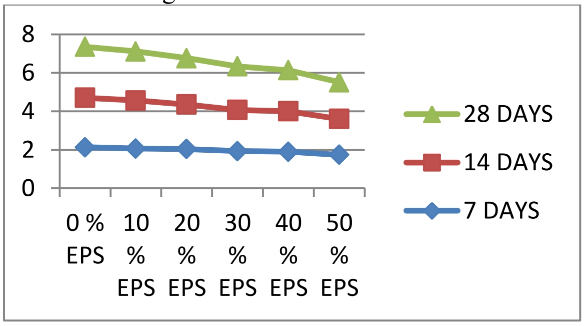
Graph-2: Variation of tensile and flexural strength.

From the study, it may be concluded that the split strength and flexural strength have been observed to decrease continuously with the increase in % age of EPS Aggregate i.e., from 0 to 50% replacement of course and fine aggregate by EPS Aggregate.

An attempt was made to find out the modulus of elasticity for the various EPB concrete mixes studied and the results were tabulated in Table-4.

S. No.	Mix designation	Young's modulus E=5000√ fck In $*10^4$ N/mm		
		7 days	14 days	28 days
1.	M_{20} control mix(0%EPS)	2.13	2.57	2.65
2.	M_{20} (10%EPS+10%FA)	2.06	2.50	2.55
3.	M_{20} (20%EPS+10%FA)	2.04	2.31	2.41
4.	M_{20} (30%EPS+10%FA)	1.93	2.14	2.26
5.	M_{20} (40%EPS+10%FA)	1.90	2.10	2.13
6.	M_{20} (50%EPS+10%FA)	1.74	1.86	1.91

Table-4: Young's modulus Results based on E=5000√ fck



Graph-3: Variation of Young's modulus

EPS concrete density:

It may be observed that with the addition of EPS Aggregate the density of the specimens decrease continuously up to 50% replacement of Granite by EPS Aggregate. The density decreases with the increase of the age are presented in Table-4.

Structural light weight concrete of density of 1812 kg/m3 and the corresponding strengths of about 20.85MPa are successfully developed.

S. No.	Mix designation	Density (Kg/m3) for day curing period		
		7 days	14 days	28 days
1.	M_{20} control mix(0%EPS)	2474	2453	2428
2.	M_{20} (10%EPS+10%FA)	2310	2292	2284
3.	M_{20} (20%EPS+10%FA)	2115	2096	2081
4.	M_{20} (30%EPS+10%FA)	1878	1840	1812
5.	M_{20} (40%EPS+10%FA)	1710	1693	1653
6.	M_{20} (50%EPS+10%FA)	1550	1522	1502

Table-5: Density of EPS based concrete at the age of 7, 14 and 28 days

VI. CONCLUSIONS

- Structured light weight concrete of density of 1812 kg /m3 and the corresponding strengths of about 20.85MPa is successfully developed. The concretes are fabricated via substituting partially coarse and fine aggregates with EPS beads
- Optimum level of replacement of aggregate by EPS beads is found to be 30% to obtain better compressive strength, split tensile strength and flexural strength.
- The compressive strength generally increases with age at curing, but it decreases densities and strength when EPS beads increased accordingly
- The spilt tensile strength decreases when EPS beads replaced content decreased accordingly
- The flexure strength decreases when EPS beads replaced content decreased accordingly.

REFERENCES

[1] R. Sri Ravindrarajah & A. J., Tuck "Properties of Hardened Concrete Containing Treated Expanded Polystyrene Beads", School of Civil Engineering, University of Technology, Sydney, New South Wales, Australia.

[2] RamazanDemirboga&,AbdulkadirKan."Thermal conductivity and shrinkage properties of modified waste polystyrene aggregate concretes" Construction and Building Materials 35 ,2012,35, 730 – 734.

[3] D. S. Babu, G. K. Babu, and W. Tiong-Huan, "Properties of lightweight expanded polystyrene aggregate concretes containing fly ash," Cement and Concrete Research, vol. 35, no.6, pp. 1218–1223, 2005.

[4] Durability of Building Materials and Components. (1999) Edited by M.A. Lacasse And D.J. Vanier. Institute for Research in Construction, Ottawa ON, K1A 0R6,Canada , pp. 505-514.National Research Council Canada 1999

[5] Jay bankim shah, sagar patel U.G. Student, Civil Department, Shankersinh Vaghela Bapu Institute of Technology, Unava,Gandhingar-382650.Research Article Impact Factor: 4.226 ISSN: 2319-507X Jay Bankim Shah, IJPRET, 2015; Volume 3 (10): 43-48 IJPRET

[6] IS 383:1970 "Specifications for coarse and fine aggregates from natural sources for concrete", Bureau of Indian Standards, New Delhi.

[7] S.H. Perry, P.H. Bischoff, K. Yumura, "Mix details and material behaviour of polystyrene aggregate concrete", Magazine of Concrete Research 43, 1991.

[8] IS: 10262: 1982, "Recommended guidelines for concrete mix design" Bureau of Indian Standards, New Delhi

[9] IS 456: 2000 – „Code of practice for plain and reinforced concrete" , Bureau of Indian Standards, New Delhi.

[10] IS 2386:1963 "Methods of tests for aggregates for concrete", Bureau of Indian Standards, New Delhi

[11] ACI Committee 2112-98 Standard practice for selecting proportions for structural light weight concrete. Detroit, American Concrete Institute.

[12] Miled K. Roy R. L. Sab K. and Boulay C. "Compressive behavior of an idealized EPS lightweight concrete: size effects and failure mode", Mechanics of materials, vol. 36, no. 11, pp. 1031–1046, 2004.