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PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH EXPANDED POLYSTYRENE

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Abstract - Expanded polystyrene beads (EPS) is a lightweight material that has been used in construction applications since at least the 1950s. Its density is about a hundredth of that soil. It has good fire insulation properties with stiffness and compression strength comparable to medium clay. It is utilized in embankments sound to reduce the settlements and vibration damping, it reduces the lateral pressure on sub-structures, reducing stresses on rigid buried conduits and related applications. Expanded polystyrene waste in a coarse grained form is used as lightweight aggregate to produce lightweight structural concrete. The polystyrene aggregate concrete was produced by partially replacing coarse aggregate in the reference of normal weight concrete mixtures with equal volume of the coated crushed polystyrene granules is done chemically. This paper reports the results of an experimental investigation into the engineering properties, such as compressive strength, modulus of elasticity, dry shrinkage and creep coefficient of polystyrene aggregate concrete varying in density.

Key Words: Concrete, Expanded polystyrene, Fire insulator.

1. INTRODUCTION

Expanded Polystyrene (EPS) concrete is a modern, active, safe and economic construction system for the construction of buildings. It can be used as both load bearing and non-load bearing elements. EPS (Expanded Polystyrene) are also known for the Dow Chemical Company's brand name, STYROFOAM, is an extremely lightweight product that is made of expanded polystyrene beads. It is originally discovered by Eduard Simon in 1838 in Germany by accident, EPS foam is more than 94% air and only about 6% plastic.

Small solid plastic particles of polystyrene are made from the single monomer styrene. Polystyrene is normally a solid thermal plastic at room temperature that can be melted at a high temperature and re-solidified for desired applications. The expanded polystyrene is about forty times the volume of the original polystyrene granule.



Fig.1 Expanded polystyrene concrete block

EPS after shotcrete has the following five factors,

- i. The outer layer of shotcrete.
- ii. Welded reinforcing mesh of high wire.
- iii. The core of expanded polystyrene sheet.
- iv. Diagonal wire (stainless or galvanized wire).
- v. The inner layer of shotcrete.

The welded mesh fabric connected shattering polystyrene with truss of steel wire, welded to the welded fabric at an angle. It gives a rigidity spacial structure, and simultaneously prevents polystyrene core shifting.

Individually welded internal strut wires or diagonals extend through the concrete block between each surface. The galvanized strut wires are welded continuously in the required spacing so they form, with the welded wire fabric, into a triangulated truss system which greatly increases the block strength.

EPS panel is a versatile structural element designed for floors, walls, partitions, roof and stairs etc. The typical EPS block is generally manufactured with dimensions of 1200 mm width, 3000 mm length and over all thickness range of 80-230 mm. The concrete block is finished at the site by using minimum 30 mm thick shotcreting of cement & fine aggregate in the ratio of 1:4 applied under pressure. The shotcreting coat barriers the EPS beads with centrally placed steel welded wire mesh.

Some of the advantages of the EPS concrete block systems are as follows:

- i. Reduce the cost of construction
- ii. Reduce Construction period
- iii. Reduce transport cost. Light weight panels: do not requires cranes and other heavy construction equipment. (A Standard panel of size (1.2×3) m without shotcrete weighs 20 kg).
- iv. For heavy construction equipment the installation is not required.
- v. Ensure high levels of thermal insulation, sound insulation, as well as sanitary and fire safety.
- v. EPS 3-D panels allow no additional cost to erect buildings in areas with moving soil, especially heaving, subsidence, frozen ground, and remote areas.
- vi. Strength and durability - used extruded polystyrene purposely indolent and does not absorb moisture, is durable and resistant to decay.

The natural coarse and fine aggregates, cement, and water are the main ingredients in normal weight concrete (NWC) production. The production processes of these natural materials are severely damaging the environment and are produced at relatively high cost (e.g., quarrying, processing, transportation). In addition, many countries have introduced taxes on virgin quarried materials. It is known that other types of materials including agricultural wastes, recycled materials, and industrial byproducts such as broken old concrete, desulfurized waste, slag, limestone powder, and silica fume (SF) can be used in concrete to replace naturally manufactured aggregates, cement, or other

construction applications are used for the replacement.

II. EXPERIMENT

2.1 Materials Used: Material used in the present study as follows were cement(OPC), expanded polystyrene, fine aggregate (river sand passing through 4.75mm), coarse aggregate (well graded), and Water.

2.1.1 Cement: Ordinary Portland Cement of super grade confirming to IS 12269:2013.

2.1.2 Expanded polystyrene: Locally available expanded polystyrene conforming to IS 4671 - 1984

2.1.3 Fine Aggregate: Locally available river sand confirming to Grading zone II of IS 383 – 1970.

2.1.4 Coarse Aggregate: Locally available quarry stone in good strength conforming to IS 383 - 1970.

2.1.5 Water: Portable water free from acidity and alkalinity.

III. LITERATURE REVIEW

3.1 Aman mulla, amole shelake, et al., 19 March 2016

When increase in demand for construction materials man has improved a lot in construction techniques of structures. In early ages structures were constructed with heavy materials, but in this modern era of construction old techniques are being costlier due to multistory buildings. So the use of lightweight materials is started. The expanded polystyrene beads are the material which replaces in the place of coarse aggregate. The main objective of this investigation is to find a concrete mix proportion which gives better results than the normal concrete, and to study the properties, such as density, compressive strength and splitting tensile strength of light weight expanded polystyrene concrete (EPS). Then its properties are compared with M20 grade of conventional concrete.

3.2 Ganesh Babu and Saradhli Babu, et al., 7 April 2015

Lightweight concrete can be produced by substituting the normal aggregate with lightweight aggregate is done partially or fully, depending upon the density and strength of the building to be constructed. The present study shows the use of expanded polystyrene (EPS) beads as a lightweight aggregate both in concretes and mortars which contains a silica fume as a complete cementitious material. The main objective of this project is to study the strength and the durability performance of concretes. These mixes were designed by using the efficiency of silica fume at different ratios. The resulting concretes were seen to have densities varying from 1600 to 2000 Kg/m³, with the corresponding strengths varying from 10 to 20 Mpa.

The rate of strength gain for these concretes is due to the increase in the percentage of silica fume which increases the 7-day strength. Further, the absorption values were seeming to be decreasing with increasing cementitious content. The performance of these concretes was observed to be very good, in terms of their chloride permeability and corrosion resistance, even at the minimal silica fume content level.

3.3 B. Singh, M. Gupta, Monika Chauhan and S.K Bhattacharyya, et al., MARCH 2012

EPS beads can be effectively used as part replacement of the normal aggregates in making light weight geopolymer concrete in different densities. The mix was cohesive with natural latex pre-wetted EPS beads. The floating and segregation of EPS can be minimized by using low slump of mix and fast setting of geopolymer with hardener. The compressive strength and tensile strength

decreased with the increase of EPS bead aggregate.

3.4 Abhijit Mandlik, Tarun Sarthak, et al., April 2011

When compared to normal concrete the use of lightweight concrete using EPS has good quality. It can be used in various construction fields like floor in wooden of old building, carrying walls of low thermal consumption, bridges, floating quay, etc. Hence it's been observed that the cost of EPS concrete is less compared to coarse aggregate in concrete. Increase in the EPS beads content to normal concrete. The tensile strength of concrete will be reduced by increasing the EPS beads.

IV.MIX DESIGN

4.1MIX PROPORTION

Cement	=	350 Kg/m ³
Water	=	197 Kg/m ³
Fine aggregate	=	829 kg
Coarse aggregate	=	1117 kg
EPS	=	0.23

4.2 MIX RATIO

Cement	:	fine aggregate	:	coarse aggregate	:	EPS
350 / 350	:	829 / 350	:	1117/35	:	0.23 / 350
1	:	2.36	:	3.1	:	6.571*10 ⁻⁴

V. TESTING ON MATERIALS

5.1 SPECIFIC GRAVITY TEST



Fig.2 Pycnometer Apparatus

5.1.1 SPECIFIC GRAVITY OF CEMENT

Table.1 Specific gravity of cement

Content	Weight in grams
Weight of empty pycnometer (W1)	664
Weight of pycnometer + cement (W2)	761
Weight of pycnometer + cement + water (W3)	1455
Weight of pycnometer + water (W4)	1389

Specific gravity of Cement (G)

$$= \frac{(W2-W1)}{(W2-W1)-(W3-W4)} = \frac{(761-664)}{(761-664)-(1455-1389)} = 3.11$$

5.1.2 SPECIFIC GRAVITY OF FINE AGGREGATE

Table.2 Specific gravity of Fine aggregate

Content	Weight in grams
Weight of pycnometer (W1)	680

Weight of pyconometer + fine aggregate (W2)	881
Weight of pyconometer + fine aggregate + water (W3)	1635
Weight of pyconometer +water (W4)	1511

$$\text{Specific gravity of Fine aggregate (G)} = \frac{(W2-W1)}{(W2-W1)-(W3-W4)} = \frac{(881-680)}{(881-680)-(1635-1511)} = 2.61$$

5.1.3 SPECIFIC GRAVITY OF COARSE AGGREGATE

Table.3 Specific gravity of Coarse aggregate

Content	Weight in grams
Weight of empty pyconometer (W1)	680
Weight of pyconometer + coarse aggregate (W2)	1039
Weight of pyconometer + coarse aggregate + water (W3)	1736
Weight of pyconometer +water (W4)	1510

$$\text{Specific gravity of Coarse aggregate (G)} = \frac{(W2-W1)}{(W2-W1)-(W3-W4)} = \frac{(1039-680)}{(1039-680)-(1736-1510)} = 2.70$$

5.2 SIEVE ANALYSIS TEST



Fig.3 Sieve Analysis

5.2.1 SIEVE ANALYSIS OF FINE AGGREGATE

Table.4 Sieve analysis of Fine aggregate

Weight of sample taken is 1000g

IS sieve size	Weight retained in grams			Cumulative weight retained W4	Cumulative % retained W5 = $\frac{W4 \times 100}{1000}$	% finer 100- W5
	Empty weight of sieve W1	Retained weight of sieve W2	Retained weight of sand W3			
4.75 mm	375	440	65	65	6.5	93.5
2.36 mm	344	414	70	135	13.5	86.5
1.18 mm	363	453	90	225	22.5	77.5
1 mm	348	448	100	325	32.5	67.5
600μ	301	321	20	345	34.5	65.5
300μ	300	600	300	645	64.5	35.5
150μ	307	582	275	920	92.0	8
pan	303	383	80	1000	100	0

Total cumulative % retained = 266

Fineness modulus = 266/100 = 2.66

5.2.2 SIEVE ANALYSIS OF COARSE AGGREGATE (20 mm)

Table.5 Sieve analysis of coarse aggregate

Weight of sample taken is 3000g

IS-Sieve (mm)	Wt. Retained (gm)	%age retained	%age passing	Cumulative % retained
80	0.00	0.00	100.00	0.00
40	12.5	0.41	99.59	0.41
20	63.0	2.1	97.9	2.51
10	2756	91.87	8.13	94.38
4.75	126.5	4.21	95.8	98.59
Pan	0	0	0	0

Total cumulative % retained = 195.89+500=695.89

Fineness modulus =695.89/100 =6.96

5.3 COMPRESSIVE STRENGTH OF CONVENTIONAL AND EPS CONCRETE

Size of the cube = 15cm*15cm*15cm

Area of the specimen (Calculated from the mean size of the specimen) = 225cm²

Expected maximum load = $f_{ck} \cdot \text{area} \cdot f.s$

Table.6 Compressive strengths of Conventional and EPS Concrete

M35 grade of concrete days	Compressive strength of Conventional Concrete	Compressive strength of EPS Concrete
7 Days	23	10.1
14 Days	27	13.2
28 Days	35	15.4

VI.CONCLUSION

The following conclusions were drawn from the study,

- 1) Hereby, we have observed that cost of EPS is less compared to that of normal coarse aggregate in concrete.
- 2) The compressive and tensile strength of concrete will be reduced by increasing the EPS beads in the concrete.
- 3) The EPS concrete show good workability by without adding any special bonding agent and also could easily be compacted and finished.
- 4) The EPS shows a positive replacement as an alternate material in the building construction and provides a solution for safe disposal.
- 5) The expanded polystyrene concrete shows a scope for nonstructural applications, like wall panels, partition walls, etc.
- 6) As the material is light in weight it imparts less weight to the structure and can be moulded in any shape, versatile in nature.
- 7) Expanded polystyrene as an efficient and effective thermal insulation material can play its part in reducing carbon dioxide emissions and make a very positive contribution to the alleviation of global warming.
- 8) The energy used in its manufacture (embodied energy) is recovered within six months by the energy saved in the buildings in which it is installed

9) At the end of its useful life it can be recycled or the thermal energy contained within can be recovered by incineration in suitably designed waste to energy plants to provide energy for district heating or the generation of electricity.

10) The construction using EPS technology is cost effective, high performance, less maintenance, recyclable, decreases the use of natural resources, rapid construction with less duration and leads to sustainable future.

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