CELLULAR LIGHTWEIGHT CONCRETE BY USING EPS

[1] A Karthik, [2] M Bhanu Prakash, [3] A Dinesh Venkat Sai Krishna, [4] B Rakesh

[1] Associate Professor, Dept. of Civil Engineering, Aurora's Technological and Research Institute, Parvathapur, Telangana, India
[2,3,4] B. Tech, Dept. of Civil Engineering, Aurora's Technological and Research Institute, Parvathapur, Telangana, India

Abstract

Cellular Lightweight Concrete (CLC) has been known since ancient times. Cellular light weight concrete is popular because of its light weight which reduces self-weight of the structure. It was made using natural aggregates of volcanic origin such as pumice, scoria, etc. Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as Low density and lessened the dead weight.

In this project we are replacing the Fine aggregate with the expanded polystyrene beads. The EPS is to reduce the structural weight of the material for precast and prefabrication construction with enhanced thermal/acoustic insulation. In this paper, parametric experimental study for producing CLC using expanded polystyrene beads is presented. The performance of cellular lightweight concrete in term of density and compressive strength are investigated.

Key words: Cellular lightweight concrete (CLC), Expanded polystyrene beads (EPS), Density, Compressive strength.

1.0 INTRODUCTION

Concrete is the most important construction material. Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate that is bonded together by cement and water. In recent years there has been an increasing worldwide demand for the construction of buildings, roads, and airfields which has mitigated the raw material in concrete like aggregate. In some ruler areas, the huge quantities of aggregate that have already been used means that local materials are no longer available and the deficit has to be made up by importing materials from another place. Therefore, a new direction toward Cellular Lightweight Concrete in building and civil engineering construction is used.

The construction industry stands at a crossroads where innovation and sustainability are paramount. As global urbanization continues to surge, the demand for construction materials that offer improved performance, energy efficiency, and environmental friendliness has become increase ingle urgent. Among the myriad of materials, cellular lightweight concrete (CLC) has emerged as a promising solution to address these demands, particularly when incorporating expanded polystyrene (EPS) beads.

Expanded polystyrene (EPS) concrete is a form of concrete known for its light weight made from cement and EPS (Expanded Polystyrene). It is a popular material for use in environmentally "green" homes. It has been used as road bedding, in soil or geo-stabilization projects, as sub-grading for railroad track age.

Lightweight concrete is a type of concrete that is made by replacing some or all of the normal-weight aggregate (usually sand and gravel) with lightweight materials. These lightweight aggregates can include materials like expanded clay, shale, or slate, as well as synthetic materials like expanded perlite or polystyrene beads. The purpose of using lightweight aggregates is to reduce the density of the concrete, making it significantly lighter than traditional concrete.

Lightweight concrete offers several advantages, including improved insulation properties, reduced dead load on structures, and better fire resistance. It is commonly used in construction for applications where weight is a critical factor, such as in high-rise buildings, bridges, and precast concrete products.

Statement of the Problem:

To decrease the structural weight of the building we need to use the lightweight concrete, to produce the Lightweight concrete we use lightweight materials in the concrete. In this project we are going to produce the cellular lightweight concrete by using the EPS, the EPS is replaced with the fine aggregate. The Size of the EPS used is 4mm.

The Project Objectives:

- To Produce the Cellular Lightweight Concrete by Using EPS
- To study the properties of 5%, 10% and 15% replacement of Fine Aggregate with Expanded Polystyrene (EPS)
- To analyze the properties of the concrete in terms of Density, Compression Strength, and Tensile Strength.
- To compare the Cellular Lightweight Concrete with the Conventional Concrete.

2.0 LITERATURE REVIEW

Abhijit Mandlik, Tarun Sarthak Sood, Shekhar Karade:

Expanded polystyrene (EPS) geofoam is a lightweight material that has been used in engineering applications since at least the 1950s. Its density is about a hundredth of that of soil. It has good thermal insulation properties with stiffness and compression strength comparable to medium clay. It is utilized in reducing settlement below embankments, sound and vibration damping, reducing lateral pressure on sub-structures, reducing stresses on rigid buried conduits and related applications. Expanded polystyrene waste in a granular form is used as lightweight aggregate to produce lightweight structural concrete with the unit weight varying from 1200 to 2000 kg/m³. The polystyrene aggregate concrete was produced by partially replacing coarse aggregate in the reference (normal weight) concrete mixtures with equal volume of the chemically coated crushed polystyrene granules. 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. The main objectives of this study are the cement contents for the concrete mixtures used were 410 and 540kg/m³.

Manish Awana, Chandan Kumar:

Cellular Light weight Concrete (CLWC) has been known since ancient times. It was made using natural aggregates of volcanic origin such as pumice, scoria, etc. Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as inability and lessened the dead weight. The usage of Cellular Light-weight Concrete (CLC) blocks gives a prospective solution to building construction industry along with environmental preservation. In this paper, parametric experimental study for producing CLW C using fly ash is presented. The performance of cellular lightweight concrete in term of density and compressive strength are investigated. From the result, it can be seen that compressive strength for cellular light weight concrete is low for lower density mixture. The increments of void throughout the sample caused by the foam in the mixture lowers the density. As a result, compressive strength will also decrease with the increments in void. As strength increases its density also increases. The test result shows that the compressive strength of replacement mixture with 1% of foam is higher than of 1.4% foam. Compressive strength of mixture with 1.2% foam is slightly higher than that of 1.4% foam. In this experimental study, two grades of cement such as 53 and 43 grade cement are used. Compressive strength of 53 grade cement is slightly higher than 43 grade cement.

Sagar W. Dhengare, Ajay L. Dandge, H. R. Nikhade:

Cellular Light weight Concrete (CLWC) is not a new invention in concrete world. It has been known since ancient times. It was made using natural aggregates of volcanic origin such as pumice, scoria, etc. The Greeks and the Romans used pumice in building construction. Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as inability and lessened the dead weight. The usage of Cellular Light-weight Concrete (CLC) blocks gives a prospective solution to building construction industry along with environmental preservation. It can be concluded that the lightweight concrete has a desirable strength to be an alternative construction material for the industrialized building system. This study has shown that the use of fly ash in foamed concrete, either can greatly improve its properties. The properties of cellular lightweight concrete its advantages, disadvantages and applications were studied thoroughly.

CH. Vinay Kumar, E. Arun, B. Bhaskar:

The rise in demand for construction materials, alternative materials are becoming increasingly important for long-term growth. The primary goal of this study is to determine the attributes of lightweight concrete incorporating Expanded Polystyrene (EPS) beads, such as compressive and tensile strengths. Its qualities are compared to those of ordinary concrete, which does not contain EPS beads. Coarse aggregates are partially replaced with EPS beads. The findings revealed that the number of polystyrene beads used in concrete had an impact on the qualities of hardened concrete. In this experiment, half of the coarse aggregate is substituted with EPS (Expanded Polystyrene) beads in M15 grade concrete with a W/C ratio of 0.50 and 0.40. Concrete structure that is light weight, functional, and environmentally beneficial. The low density and low heat conductivity sound insulating properties of light weight concrete are its key advantages. Conventional concrete has a density of 2200 to 2600 kg/m^3. Because of its high self-weight, it will be an uneconomical structural material to some extent. Light concrete has a density ranging from 300 to 1850 kg/m^3. Light concrete has a strength range of 1 to 20 MPa. The weight of light weight concrete is 50-75 percent less than that of regular concrete.

3.0 MATERIALS AND METHODS

Lightweight Concrete:

Poly concrete is made by mixing the lightweight aggregate (expanded polystyrene beads) with cement, sand, and water in a conventional mixer. Its density can be adjusted within close limits to anywhere in the range of 500-2000 kg/m3, so that it can be used for insulating screeds and rendering, non-bearing, and load-bearing components. Within the normal density range of non-structural lightweight concrete the uniformly dispersed expanded polystyrene beads occupy much of the volume between 600 kg/m3 and 800 kg/m3, where compressed aggregate occupies 60-80%, nearly all the remaining space being filled by the mortar. Since the mortar determines the mechanical properties of the material it generally has high cement content. The consistency of fresh poly concrete is not adequately measured using test generally employed for normal concrete e.g. various forms of slump tests. The compacting factor test can be applied as a measure of consistency and workability, but the values obtained need to be interpreted differently from the values of normal concrete. The difference arises from the high proportion of the very regular aggregate, which gives a mix that is lean and not very cohesive, but offers little resistance to flow.

Materials used:

Cement: The cement used was Ordinary Portland cement of 53 grade.

Fine Aggregate: Fine Aggregate used for the project work was River sand should be taken as per the ASTM standard. It should be clean, strong and hard and free of organic impurity. Specific gravity of fine aggregate was 2.74. It confirming to grading zone II with Particles in between 4.75 mm and 150 μm.

Expanded Polystyrene (EPS): Expanded Polystyrene (EPS) used in the project was in the form of ‘EPS Beads’ which is spherical in shape with size varying in between 4 mm to 6 mm in diameter. It is made up of pre-extended Polystyrene globules. It offers a non-hydroscopic and does not readily absorb moisture from the atmosphere.

Coarse Aggregate: Crushed aggregates of less than 12.5mm size produced from local crushing plants were used. The aggregate exclusively passing through 12.5mm sieve size and retained on 10mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity, and bulk density in accordance with IS: 2386 1963. The individual aggregates were mixed to induce the required combined grading.

Mix Proportion of the Cellular Lightweight Concrete:

The Mix Proportion for conventional concrete M30 grade arrived as per IS 10262-2009. This Mix proportion of conventional concrete was taken as reference to the Floating Concrete by making partial replacement of Fine aggregate by EPS Beads.

- The Specific gravity of cement: 3
- The Specific Gravity of fine aggregate: 2.46
- Bulk Density of EPS Beads: 18 kg/m3

For the Floating Concrete we are replacing 5,10 & 15% Fine aggregate by EPS Beads (To Finalize the percentage replacement for Fine Aggregate we test density of the various cube by Varying percentage replacement)

Table: Mix Proportion of the Concrete

Water	Cement	Fine Aggregate	Coarse Aggregate
191.58 Kg/m^3	510.88 Kg/m^3	486.58 Kg/m^3	924.71 Kg/m^3
0.375	**1**	**0.95**	**1.81**

Procedure:

Batching and mixing:

Weigh batching was practiced with the help of electronic weight balance. Batching was done as per the mix proportion. The mix was prepared manually. First, all three dry materials cement, sand and coarse aggregate mixed dry through, then properly mix these three ingredients by adding water after that mix all by adding EPS beads make a uniform mixture.

Placing and compacting:

Moulds are cleaned and oiled to prevent the formation of bonds between concrete and moulds. The fresh concrete filled into the moulds in three layers with hand compaction at least of 25 blows after adding each successive layer. The entrapped air in concrete is removed by a table vibrator. In the case of concrete with EPS beads vibration makes the segregation. Vibrations are given as no segregation occurred and EPS beads do not float on concrete, so give more preference to the hand compaction method for concrete containing EPS beads. After the compaction had been completed, the excess mortar was removed from the mould with the help of a trowel and the surface was levelled.

Fig: Placing and Compaction of Concrete in moulds

Demoulding and curing:

After placing fresh concrete in moulds, it was allowed to set for 24 hours. Concrete samples were demoulded and it was marked with some permanent identification marks. Concrete samples were now kept in a curing tank for a required period of 7 days, 14 days and 28 days, after that period, concrete samples were removed from the curing tank to conduct tests on hardened concrete.

Fig: Lightweight Concrete Blocks

Fig: Curing of Concrete Cubes, Cylinders & Blocks

4.0 TEST RESULTS AND ANALYSIS

Slump test:

In general, 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 coarse aggregate with polystyrene (as a partial replacement of aggregate) i.e., higher the polystyrene replacement, higher was the workability.

Fig: Slump Cone Test on Fresh Concrete

Table: Slump Cone test Values

S. No	% of Replacement	Slump Value
1	0%	11.2
2	5%	5.6
3	10%	5.4
4	15%	5.4

Compaction factor test:

The Compaction factor test is another method used to find out the workability of fresh concrete. It is more accurate than the slump test from the values obtained it is clear that the workability of concrete increases with the percentage of polystyrene increases.

Fig: Compaction Factor Test on the Fresh Concrete

Table: Compaction Factor Value

S. No	Grade of Concrete	Compaction Factor
1	M30	0.95

Compression Strength Test Results:

The compression test was conducted according to IS 516-1959. This test helps us in determining the compressive strength of the concrete cubes. The obtained value of compressivestrength can then be used to assess whether the given batch of that concrete cube will meet therequired compressive strength requirements or not. For the compression test, the specimen's cubes of 15 cm x 15 cm x 15 cm were prepared by using crumb rubber concrete as explained earlier. These specimens were tested under universal testing machine after 7 days and 28 daysof curing. Load was applied gradually at the rate of 140kg/cm2 per minute till the specimens failed. Load at the failure was divided by area of specimen and this gave us the compressive strength of concrete for the given sample.

- **7 Days Compression Strength:**

Table: 7 Days Compressive strength of Cube

S. No	EPS %	Peak Stress (KN/m^2)			Avg Stress (KN/m^2)
		Cube 1	Cube 2	Cube 3	
1	**0%**	17.33	23.55	23.11	21.33
2	**5%**	0.44	0.44	-	0.44
3	**10%**	0.44	0.44	-	0.44
4	**15%**	0.44	0.44	-	0.44

- **28 Days Compression Strength:**

Table: 28 Days Compressive strength of Cube

S. No	EPS %	Peak Stress (KN/m^2)			Avg Stress (KN/m^2)
		Cube 1	Cube 2	Cube 3	
1	**0%**	28	21.3	44.4	31.23

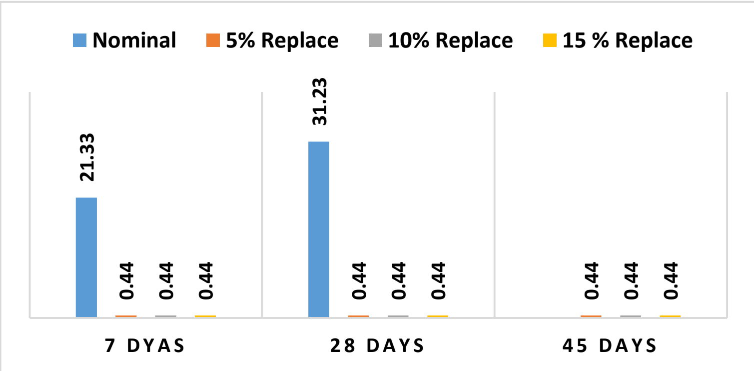
2	**5%**	0.44	0.44	-	0.44
3	**10%**	0.44	0.44	-	0.44
4	**15%**	0.44	0.44	-	0.44

- **45 Days Compression Strength:**

Table: 45 Days Compressive strength of Cube

S. No	EPS %	Peak Stress (KN/m^2)		Avg Stress (KN/m^2)
		Cube 1	Cube 2	
1	**5%**	0.44	0.44	0.44
2	**10%**	0.44	0.44	0.44
3	**15%**	0.44	0.44	0.44

Fig: Compression Strength test



Graph: Compression Strength of the concrete

Split Tensile Strength Test Results:

The split tensile strength at which failure occurs is the tensile strength of concrete. In this Investigation the test is carried out on cylinder by splitting along its middle plane parallel to the edges by applying the compressive load to opposite edges as per IS: 516-1959.

- **7 Days Split Tensile Strength:**

Table: 7 Days Split Tensile Strength of Cylinder

S. No	EPS %	Split Tensile Strength (N/mm^2)
1	0%	4.1

2	5%	0.14
3	10%	0.14
4	15%	0.14

- **28 Days Split tensile Strength:**

Table: 28 Days Split tensile Strength of Cylinder

S. No	EPS %	Split Tensile Strength (N/mm^2)
1	0%	3.53
2	5%	0.14
3	10%	0.14
4	15%	0.14

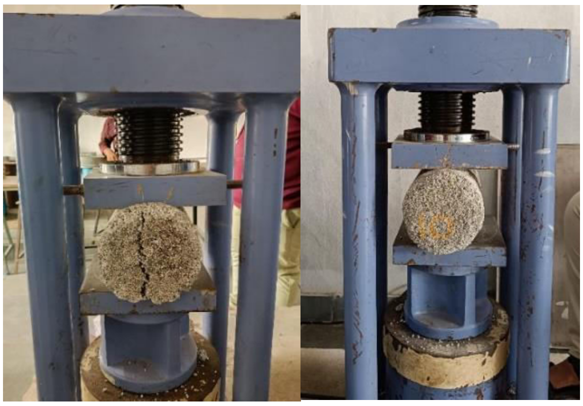
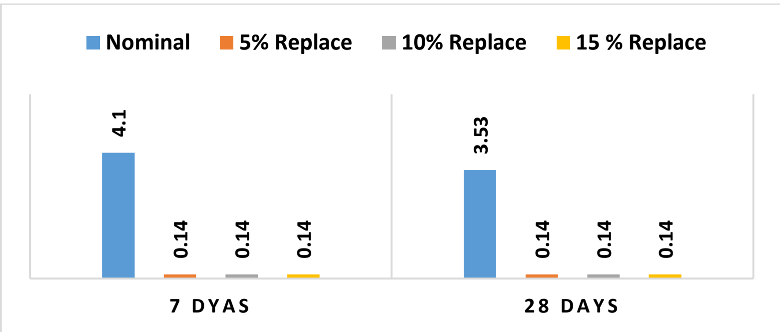


Fig: Split Tensile Strength Test



Graph: Graph of Split Tensile Strength of the Concrete

Density Test Results:

Table: Density of the Cube

S. No	EPS %	Density of Cube (Kg/m^3)					
		Cube 1	Cube 2	Cube 3	Cube 4	Cube 5	Cube 6
1	**0%**	2435	2376	2382	2441	2394	2441

2	**5%**	1398	1238	817	1232	1258	1305
3	**10%**	687	693	734	580	678	698
4	**15%**	628	634	651	569	593	615

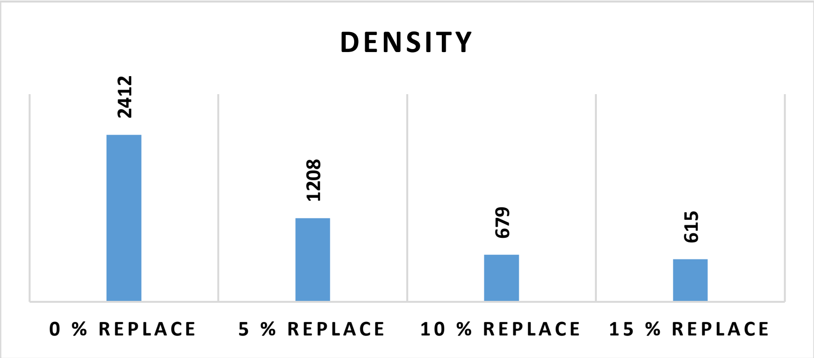
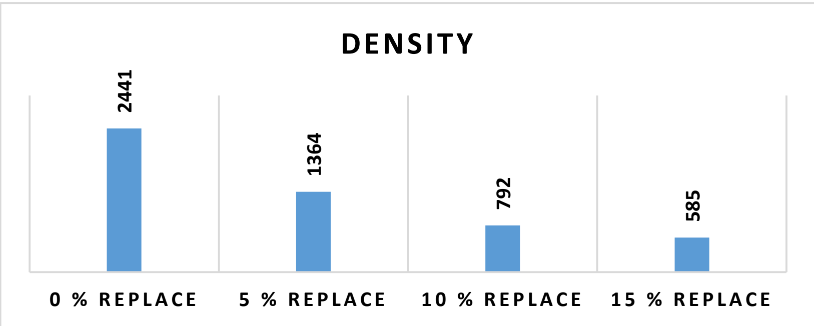


Fig: Density of the Cubes

Table: Density of the Cylinders

S. No	EPS %	Density of Cylinder	
		Cylinder 1	**Cylinder 2**
1	0%	2437	2445
2	5%	1388	1340
3	10%	690	894
4	15%	622	547



Graph: Density of the Cylinder

CONCLUSION

- The Compressive strength of the CLC is less than the Conventional Concrete, because of the EPS present in the Concrete. The EPS present in the concrete makes the concrete lightweight and decreases the compressive strength of the concrete. With the Increase in the EPS content in the concrete the Density of the Concrete decreases and the Compression strength also decreases.
- Replacing fine aggregate with Expanded Polystyrene (EPS) in cellular Lightweight concrete (CLC) offers several advantages, including improved thermal insulation, reduced dead load, and enhanced workability. This innovative approach results in lightweight concrete with lower density and improved insulation properties compared to conventional concrete.

- The Cellular lightweight Concrete (CLC) made of EPS can't be used in place of conventional concrete, because it doesn't have the compressive strength of conventional concrete, but it can be used where there is no external heavy load falling on it like, Pavement backfill, antifreeze Subgrade, thermal insulation roof, floor sound insulation and marine structure. With the help of EPS concrete, we can make lightweight bricks, and Footpath blocks etc.
- The compressive strength of EPS increases with a reduction in replacement levels of the Expanded Polystyrene Beads. Lightweight concrete using partial replacement of Fine Aggregates with Expanded Polystyrene Beads can be used for parking lots, Rooftops, Floorings, Insulation Walls, etc.
- We can make the concrete blocks using EPS Concrete, and can be used in footpaths and parking lots, etc., with an increase in the amount of EPS in concrete blocks, the cost reduces but also the compressive strength and tensile strength decreases gradually.

REFERENCES

1. Abhijit Mandlik, Tarun Sarthak Sood, Shekhar Karade, "Lightweight Concrete Using EPS". International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438
2. Thomas Tamut, Rajendra Prabhu, Katta Venkataramana, "Partial Replacement of Coarse Aggregates by Expanded Polystyrene Beads in Concrete", IJRET: International Journal of Research in Engineering and Technology ISSN: 2319-1163 | ISSN: 2321-7308
3. Manish Awana, Chandan Kumar, "Cellular Lightweight Concrete" International conference on Emerging Trends in Engineering, Technology, Science and Management, IIMT College of Engineering, Greater Noida, India. (ICETETSM-17) 12th April 2017, ISBN:976-93-86171-38.
4. Sagar W. Dhengare. Ajay L. Dandge, H.R. Nikhade, Department of Civil Engineering, YCCE, Nagpur, India "Cellular Lightweight Concrete" Journal of Advance Research in Mechanical and Civll Engineering (ISSN:2208-2379)
5. CH Vinay Kumar, E.Arun, B.Bhaskar, "Light Weight Concrete using EPS (Expanded Polystyrene) Beads", International Journal of Research Publication and Reviews (ISSN:2582-7421)
6. P.S. Bhandri, Dr. K.M.Tajne, "Cellular Lightweight Concrete Using Fly Ash" International Journal of Innovative Research in Science, Engineering and Technology, (ISSN:2319-8753), ISO 3297:2007 Certified Organization, Vol.3 Issue 11, November 2014
7. Bing Chen, Juanyu Liu, "Properties of Lightweight Expanded Polystyrene Concrete Reinforced with Steel Fiber" Department of Civil Engineering, Shanghai Jiaotong University, Shanghai, Cement and Concrete Research 34 (2004) 1259-1263
8. Nikhil S.Chavan, Govind H.Dake, Vaibhav B. Chavan Dr. P.S.Bhalage, "Making of Floating Concrete by Using Expanded Polystyrene Beads as Replacement of Aggregates", International Research Journal of Engineering and Technology (IRJET), Volume:07 Issue:08, Aug 2020, e-ISSN:2395-0056, p-ISSN:2395-0072.