Assessment of Lightweight Concrete Using Expanded Polystyrene Beads

Ram kumar P, Anjan B. K, Arjun V

Abstract: ***Normal concrete has a density of 24-25 kN/m^3 which increases the self-weight of the structure and also makes it uneconomical. In order to reduce the weight of the structure lightweight concrete is used. One of the methods to produce lightweight concrete is to use Expanded Polystyrene beads as a partial substitute to fine aggregate. The main objective of this investigation is to obtain lightweight concrete and also to determine the optimum dosage of Expanded Polystyrene Beads. In the present work the Expanded Polystyrene beads are added at 10% interval (by total volume of fine aggregate) and their properties such as density and compressive strength are studied. From the results obtained it is observed that an optimum of 40% of Expanded Polystyrene beads can be replaced by volume of fine aggregate which gives a strength of 21 N/mm^2 for M20 grade concrete along with the density of 19 kN/m^3. It can be used for plain concrete structure, where M20 concrete is preferred.***

Index Terms: ***Density, Expanded Polystyrene Beads, Lightweight, Optimum dosage.***

I. INTRODUCTION

Concrete is a major material used in the construction field, from the foundation of buildings to the structures of bridges, dams etc., because of its various properties such as versatility, availability, durability, economic efficiency and ease with which it can be manufactured in site. Several construction techniques without incorporating concrete have been developed but concrete still continues to be the most important building material for infrastructure [1]. According to the present state of the art, concrete is not the combination of mere four component system, that is, cement, water, coarse aggregate and fine aggregate. It can be a combination of even more number of ingredients for example, judicious combination of ingredients from as many as ten materials. In the recent past, apart from the four ingredients mentioned above fly ash, ground granulated blast furnace slag, silica fume, rice husk ash, metakaolin, super plasticizer are six more ingredients which are generally used in concrete produced in practice as the situation demands [2]. Lightweight concrete reduces the cost of formwork also increases productivity, giving better thermal insulation than normal concrete. The density of lightweight concrete is between 300 and 1850 kg/m^3 [3].

The normal concrete because of its high density leads to increase in dead load of the section which in return leads to consumption of more reinforcement and it finally makes the section uneconomical. The high density of normal concrete will cause heavy weight in structural elements that leads to act more load on structure. In normal concrete the aggregate consumption will also be more which causes problems such as scarcity of aggregates, effects on environment, wastage of materials and time. Use of normal concrete will further lead to problems such as increased haulage and handling costs, rate of construction will be increased, increased dead load of structure etc., The properties such as fire resistance, insulation against heat and sound of normal concrete are not good [4]. Transportation and handling of normal concrete is also difficult. Poor nailing and sawing properties, mixers and pumps may exhibit greater rates of wear when working with this type of material.

Concrete weight is lightened by three succeeding methods, the introduction of air as air bubbles of rather coarse size (1-3 mm diameter) in the concrete, this is called "Aerated Concrete" or air can be introduced using air entraining agents and such concrete is called "Air-Entrained Concrete", Omitting the fine aggregate in concrete called "No Fine Concrete" [5], The use of lightweight aggregate as a substitute to normal aggregate [6]. In the subsequent method an attempt has been made to reduce the weight of concrete by using a material '**Expanded Polystyrene (EPS) beads**' as a partial replacement to fine aggregates. The specific gravity of fine aggregate is 2.6 but the specific gravity of EPS beads is 0.046 which very much lesser when compared to fine aggregate. These EPS beads create cellular voids inside concrete which reduces the weight of concrete to a greater extent. Further these voids are occupied by EPS beads itself so that there is no much effect on the strength and permeability factors. Therefore authors have been studied to find the optimum dosage of EPS beads and for understanding the mechanical properties of lightweight concrete using EPS beads.

II. MATERIALS AND METHODOLOGY

A. General

The present study deals with the strength characteristics of cement matrix using Expanded Polystyrene beads (EPS beads). In this study, an attempt has been made to check the feasibility of using EPS beads as a replacement of fine aggregate and to check the strength characteristics.

B. Materials

The materials used and methodology adopted in this research work is as per the "Bureau of Indian Standard" (BIS). The materials used are;

Coarse aggregate : 20mm downsize
Fine aggregate : M - sand double washed

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Ram kumar P, Department of Civil Engineering, Vidyavardhaka College of Engineering, Mysuru, India.
Anjan B K, Assistant Professor, Department of Civil Engineering, Vidyavardhaka College of Engineering, Mysuru, India.
Arjun V, Assistant Professor, Department of Civil Engineering, Vidyavardhaka College of Engineering, Mysuru, India.

Cement : Zuari OPC - 43 Grade
Water : Vidyavardhaka College of Engineering, Concrete lab tap
EPS beads : Expanded Polystyrene beads (EPS), Prajwal insulation packaging, Hebbal industrial area, Mysuru

C. Tests on Coarse Aggregate

Test on Grading zone, Water absorption, Specific gravity, Fineness modulus, Abrasion value, Impact value, and Crushing value was according to IS 383: 1970 and IS 2386: 1963.

D. Tests on Fine Aggregate

Test on Grading zone, Water absorption, Specific gravity, Fineness modulus, Abrasion value, Impact value, and Crushing value was carried according to IS 383: 1970 and IS 2386: 1963.

E. Tests on Cement

Tests on Normal consistency, Initial setting time, Final setting time and Specific gravity was carried according to IS 4031:1988.

F. Test on Water

Test on pH, Alkalinity, Hardness, Chlorides and Total Solids was carried according to IS 456:2000.

G. Test on Expanded Polystyrene Beads

Test on Water absorption and Specific gravity was carried out and listed in the table 3.1.

H. Mix Design

M20 mix of proportion 1:1.5:3 is designed as per IS 10262:1982 and W/C of the mix is adopted as 0.5 from the results obtained from the trial mix. The quantity estimation for various proportion of EPS.

I. Test on Concrete

Workability Test is done on Fresh concrete as per IS1199: 1959 and compression test on Hardened Concrete is done as per IS 9013: 1978.

J. Methodology

- Cement, M – Sand and Coarse aggregate are volume batched according to the mix proportion obtained from mix design and mixed thoroughly to obtain a homogenous mix by means of hand mixing
- Water is added as per the W/C ratio of 0.5 considered in mix design
- It is mixed for a homogenous consistency
- EPS beads are measured for the desired proportion in a container
- The EPS beads create cellular voids inside concrete and occupy these voids space itself so that there is no much effect on strength. But there is reduction in overall weight of concrete
- Concrete cubes are cast with the aid of table vibrator with neat finishing
- After 24 hours, the cubes are demoulded and placed in water curing tank
- Cubes are tested for compression strength for 7, 14 and 28 days of curing periods

III. RESULTS AND DISCUSSION

A. Test Result for EPS beads

The test result obtained on the characteristic of EPS beads are tabulated in Table 3.1.

Table 3.1 : Test Results of EPS beads

PROPERTIES	RESULT
Size	2mm-3mm
Specific Gravity	0.044
Water Absorption	Nil

B. Test Data for Concrete

To ascertain the structural strength of the concrete cubes, casted using EPS beads in concrete and Compressive strength test was conducted at the end of 7, 14 and 28 days curing period using compressive testing machine (Aimil- 2014), capacity 2000 kN. The results obtained are tabulated in Table 3.2.

Table 3.2: Compressive Strength Result for Different Proportion of EPS beads

Sl No.	% of EPS	COMPRESSIVE STRENGHT(MPa)		
		7 DAYS	14DAYS	28DAYS
1	10	17.98	18.75	24.56
2	20	17.01	17.95	23.83
3	30	16.89	17.01	22.71
4	40	15.45	16.89	21.43
5	50	14.68	15.38	19.85

The Mechanical strength of the Concrete Cubes with different EPS beads results obtained are indicated in Figure 3.1. We can observe that strength of Concrete gradually decreased with increase in Percentage of EPS beads.

Graphs of Compressive Strength for Curing periods of 7 days, 14 days and 28 days for 10%, 20%, 30%, 40%, and 50% EPS beads are shown in Figure 3.2.

Also, Figure 3.3 indicates the Compressive Strength of 7 days, 14 for varying proportions of EPS beads.

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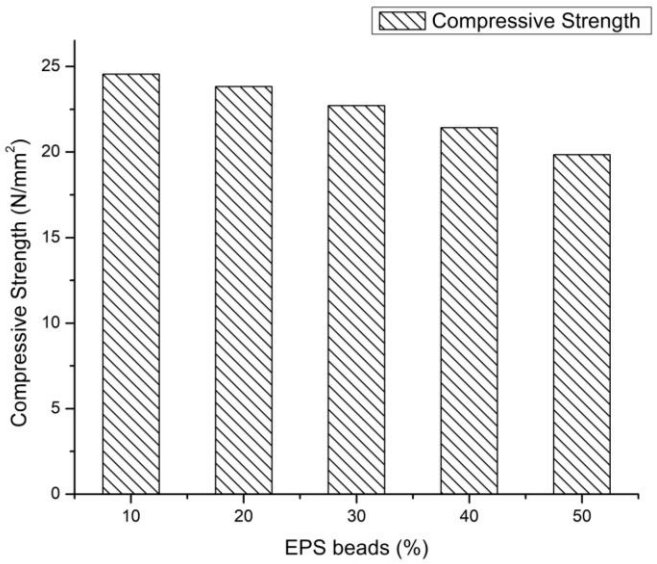

Figure 3.1: Compressive Strength of the Cubes Cast with different percentage EPS beads

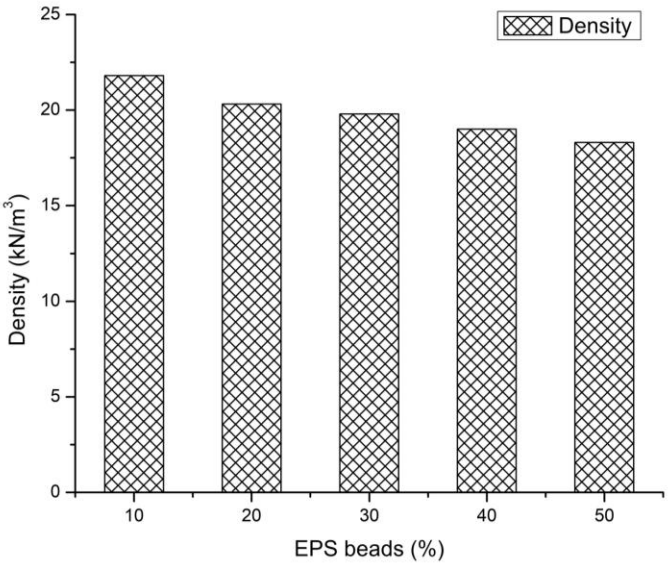

Figure 3.4: Density for different proportions of EPS beads

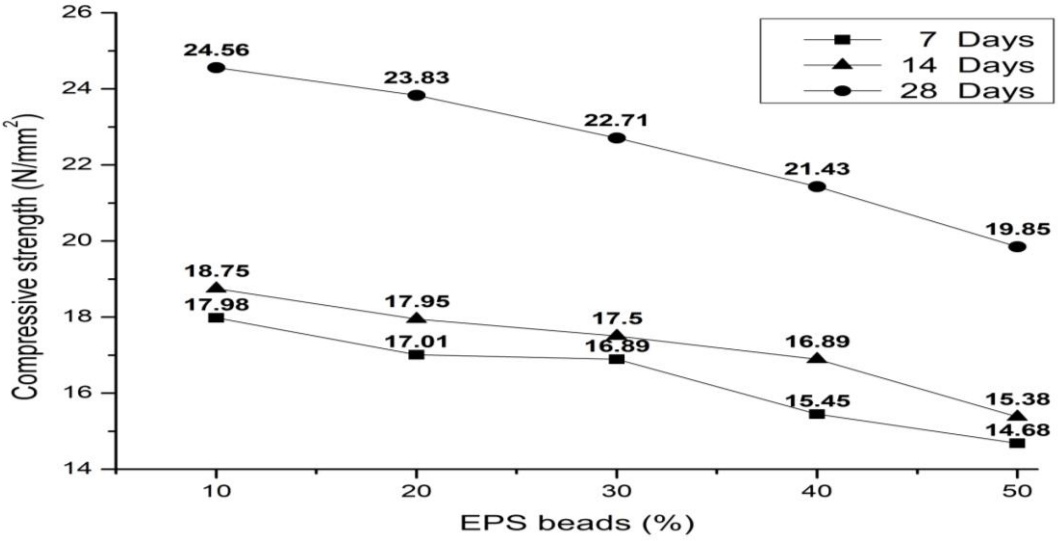

Figure 3.2: Compressive Strength for Period 7 Days, 14 Days and 28 Days

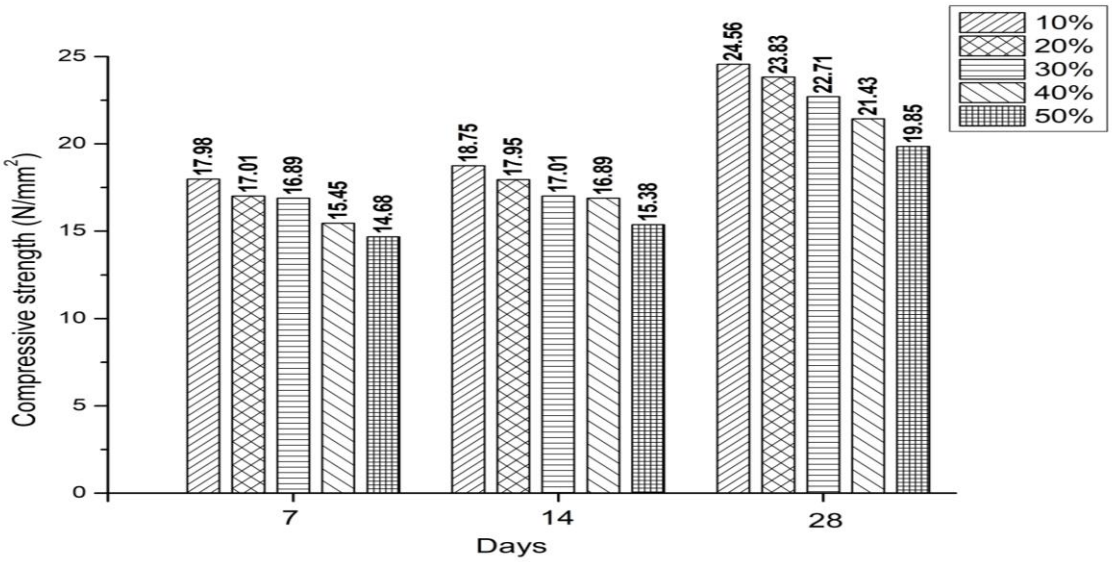

Figure 3.3: Compressive Strength for Curing period of 7 Days, 14 Days and 28 Days for 10%, 20%, 30%, 40%, and 50% EPS beads

From the Figure 3.2, for 50% replacement of EPS beads with that of fine aggregate as achieved a strength of M20 grade concrete but the value obtained for 40% replacement is more feasible than 50% hence, 40% replacement of EPS beads as optimum dosage.

Figure 3.4 shows the Density of concrete for 10%, 20%, 30%, 40%, and 50% of EPS Beads. The density obtained for the conventional concrete is 23.70 kN/m^3, where as the density of Lightweight concrete prepared using 40% EPS beads is 19 kN/m^3.

IV. CONCLUSIONS

Based on the analysis made and results obtained the following concluding remarks are made,

1) The density of the concrete has been reduced without compromising the compressive strength of concrete.
2) The optimum dosage of Expanded Polystyrene beads found to be 40% (by volume of fine aggregate) with a density of 19 kN/m^3.
3) The density of concrete has been reduced by 20% for optimum dosage of Expanded Polystyrene beads compare to conventional concrete.
4) Lightweight Concrete prepared using Expanded Polystyrene beads can be used in the upper floors of high rise buildings as well as in partition walls in order to reduce the self-weight of the structure.

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AUTHORS PROFILE

Mr. RAM KUMAR P is a Undergraduate student in Department of Civil Engineering, Vidyavardhaka College of Engineering, Mysuru. His research interests includes fibre reinforced concret

Mr. ANJAN B K is working as Assistant Professor in the Department of Civil Engineering. Vidyavardhaka College of Engineering, Mysuru. He has Five years of teaching experience. He pursued his M.Tech., on Structural Engineering in Visveswaraya Technological University (VTU), Regional Centre, Mysuru. His areas of interests for the research are Earthquake Engineering, Advanced Concrete technology and Pre-stressed Concrete Structures.

Mr. ARJUN V is working as Assistant Professor in the Department of Civil Engineering. Vidyavardhaka College of Engineering, Mysuru. He has Five years of teaching experience. He pursued his M.Tech., on Structural Engineering in National Institute of Engineering (NIE), Mysuru. His areas of interests for the research are Alternative Building Materials and Concrete technology.