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Experimental Investigation of the Properties of Light Weight Concrete Wall Panels

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Abstract:

Light weight concrete is desirable to reduce the self weight of the structure. The use of lightweight materials in non-load bearing partition walls separating the floor areas can reduce the potential risk of structural damage due to earthquake forces. Various lightweight materials can be used in manufacturing lightweight concrete. Of those materials, Expanded Polystyrene (EPS) beads can be used as it is a non-biodegradable waste material that will not decay easily by natural means. The waste disposal problem of EPS can also be effectively solved by utilizing it in lightweight concrete. Use of the cement fibre boards further increases the stiffness of the panels.
This study involves replacing the coarse aggregate in concrete with EPS in different proportions and comparing the density, compressive strength, flexural strength and thermal conductivity of the light weight concrete panels.

Keywords: Light weight concrete, Polystyrene beads, sandwich panel, compression, flexure, thermal conductivity.

1. INTRODUCTION

The demand for light weight concrete is increasing as the lowering of density results in elegant and economical structures. Concrete is categorized as conventional and light weight concrete based on its density. The use of conventional concrete for wall panels is not desirable as it is quite heavy. The high density of the concrete considerably increases the self weight of the structure which increases the cost of foundation and affects the seismic performance of the structure. Light weight concrete not only reduces dead weight on structure, but also improves insulation against heat and sound. The strength of such concrete is however low. But it is of no consequence as this concrete is expected to be used for non-load bearing wall panels. Because of the light weight, this concrete is very suitable for earthquake proof structures due to reduced seismic weight. The required properties of the lightweight concrete include structural requirement, high thermal insulation and light weight. There are numerous ways for producing light weight concrete. Replacement of conventional aggregates with light weight aggregates is the most economical method. Light weight aggregates like pumice, diatomite, perlite, volcanic cinders etc. have higher water absorption which results in porous structure of concrete. In order to eliminate these disadvantages EPS beads which are having close cellular structure, hydrophobic and non-absorbent are replaced for coarse aggregates. The utilization of EPS (Expanded polystyrene) beads as coarse aggregates helps in achieving a light weight concrete. Also it has good impact resistance. The experimental investigation is an effort to eliminate the lack of research work in the field of light weight concrete using EPS beads and to promote green construction by utilizing polystyrene waste in light weight concrete.

2. RESEARCH OBJECTIVES

The objectives of the study presented in this paper are as follows:

- To study the effects of EPS beads on the mechanical properties such as compressive strength and flexural strength of lightweight wall panels
- To investigate the thermal conductivity of lightweight concrete wall panels

3. LITERATURE REVIEW

Research on the development on light weight has been widely carried out and one such attempt is to replace aggregate with nearly weightless polystyrene. There are several experimental investigations carried out using polystyrene as light weight aggregate. Suprapto Siswosukarto et al [2] insisted the use of light weight construction materials to reduce the damage of buildings due to earthquake and suggested the application of pre-compaction for the manufacture of polystyrene concrete panels. Ali A Sayadi et al [3] discussed the utilization of EPS beads on concrete and its effects on fire resistance, compressive strength and thermal conductivity of concrete panels and concluded that increase in the volume of EPS in concrete causes reduction in thermal conductivity and compressive strength of concrete. Fernando et al [1] used mechanically recycled EPS beads as aggregates in foam concrete panels to study the structural behavior of such panels in compression and flexure. The research highlighted the use of cement fibre boards as it increases the stiffness. Aman Mulla and Amol Shelake [5] substituted the expanded polystyrene beads in the place of coarse aggregate to find and concluded that this light weight concrete gives good workability and it could easily be compacted and finished. This study recommended that this concrete can be used as pre-cast concrete members with low density and more workability.

4. EXPERIMENTAL INVESTIGATION

4.1 MATERIALS USED:

The following were the materials used:

- Ordinary Portland cement (53 Grade) used as binding material has initial setting time of 345 minutes and final setting time of 510 minutes.
- M Sand used as fine aggregate has fineness modulus of 2.318 (Grading zone II).

4.1.1 EXPANDED POLYSTYRENE (EPS)

- EPS is a stable, low density Foam, which consists of 98% of air and 2% of polystyrene material. It has closed structure and cannot absorb water. It has good impact resistance. It is a non-biodegradable material.
- EPS beads shown in figure 1 can be obtained in various sizes. The beads used in the current study are of spherical shape with uniform size of 2mm diameter. The density of EPS beads used is 22 Kg/mm^3.

Figure 1: EPS Beads

4.2 MIX COMPOSITION

The mix design for M30 concrete was carried out as per IS 10262:2009 moderate exposure condition. The water to cement ratio was kept at 0.45.Mix proportions for the conventional M30 concrete are summarized in table 1.

Table 1: Mix proportion of Concrete

S.No.	Material	Proportion (Kg/m^3)
1	Cement(OPC-53 Grade)	444
2	Fine aggregate	874
3	Coarse aggregate	958
4	Water	200
5	Ratio	1:1.96:2.16

4.3 EXPERIMENTAL PROGRAM

The experimental program consisted of the following:

- Comparison of the density and compressive strength of light weight concrete cubes cast with various percentages of EPS beads.
- Comparison of the thermal conductivity of light weight concrete mixes with various percentages of EPS beads.
- The testing of EPS based light weight concrete sandwich panels for compressive strength and flexural strength.

4.4 SPECIMENS AND TESTING

4.4.1 TEST CUBES AND PANELS

A comparative study was made to estimate the percentage of replacement of Coarse aggregate with EPS beads by comparing different mixes by testing cube specimens for compressive strength and density. The details of the mixes are presented in Table 2.

Table 2: Mix details of specimens

S.No.	Mix	Cement	FA	CA	EPS beads
1	C	100%	100%	100%	0%
2	E20	100%	100%	80%	20%
3	E40	100%	100%	60%	40%
4	E60	100%	100%	40%	60%
5	E80	100%	100%	20%	80%
6	E100	100%	100%	0%	100%

The sandwich panels were cast for a thickness of 75mm with cement fibre boards on either side. Three panels were casted under each type. They were tested for compressive and flexural strength. The completed sandwich panel is as shown in figure 2.

Figure 2: Sandwich wall panels

4.4.2 THERMAL CONDUCTIVITY

Thermal conductivity is determined using Transient Plane source (TPS) thermal conductivity system shown in figure 3. The transient technique has advantage that the measurements can be made relatively faster.

Figure 3: TPS thermal conductivity measurement system

Thermal conductivity is measured based on Fourier law of heat conduction. The basic principle of the method is as follows: A planar heat source (sensor) in the form of a series of concentric circular line sources is placed inside an infinite medium. The sensor generates a constant, step-wise heating power (Joule's heat) which diffuses into the sample. The mean temperature of the sensor raises over time. By measuring the temperature function of the sensor the thermal conductivity can be estimated using the formula.

$$Thermal conductivity, k = P0/(\Pi^{3/2} * a * slope)$$

Where P_0 is the heat liberation from the sensor in Watt and a is the radius of the TPS sensor in m.

5. RESULTS AND DISCUSSION

The results obtained from the experimental investigation are discussed below.

5.1 DENSITY

The hardened cubes are weighed and the density of the particular mix was calculated. The density variation is shown in figure 4.The density for complete replacement of coarse aggregates (Mortar with EPS beads) is 1461 kg/m^3.

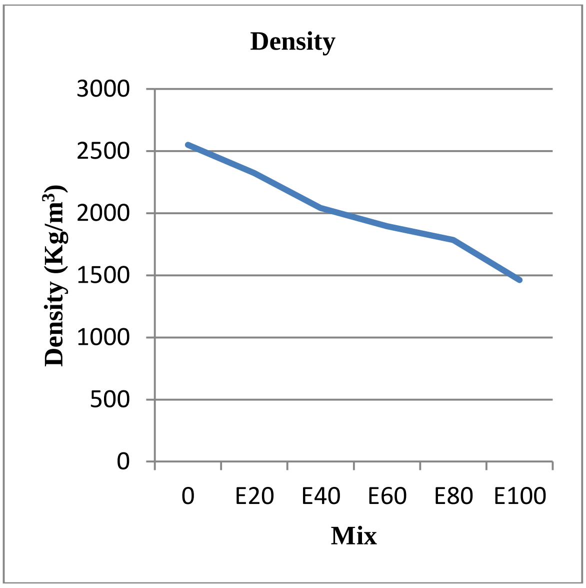

Figure 4: Variation of density

5.2 COMPRESSIVE STRENGTH

A total of three cubes were tested for each mix and the variation of average compressive strengths of the cubes are shown in the figure 5.The compressive strength is reduced to 5.23 N/mm^2 for complete replacement of coarse aggregates.

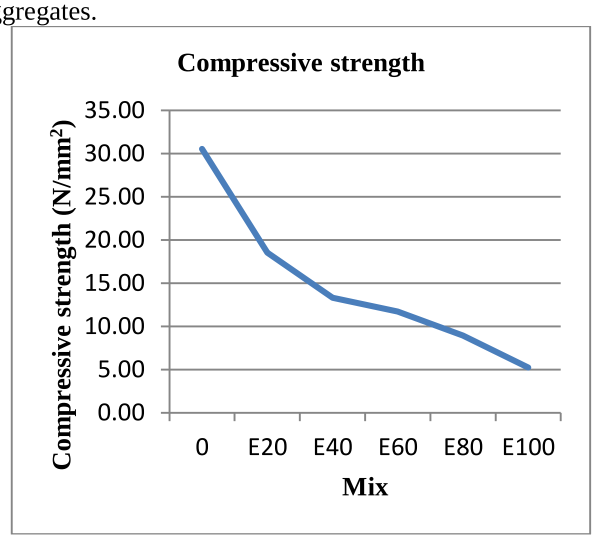

Figure 5: Variation of compressive strength

5.3 THERMAL CONDUCTIVITY

Thermal conductivity test is carried out by using two identical concrete specimens of the same mix. The hot disc (TPS Sensor) is placed between the specimens and a known heat power is supplied to the specimen. A DC supply is used for generating power.

Temperature of the sensor is noted down for every 25 seconds and from the slope of the plotted graph thermal conductivity is estimated. The variation is thermal conductivity is shown in figure 6. The thermal conductivity of the specimens decreases gradually with increase in the percentage of EPS content.

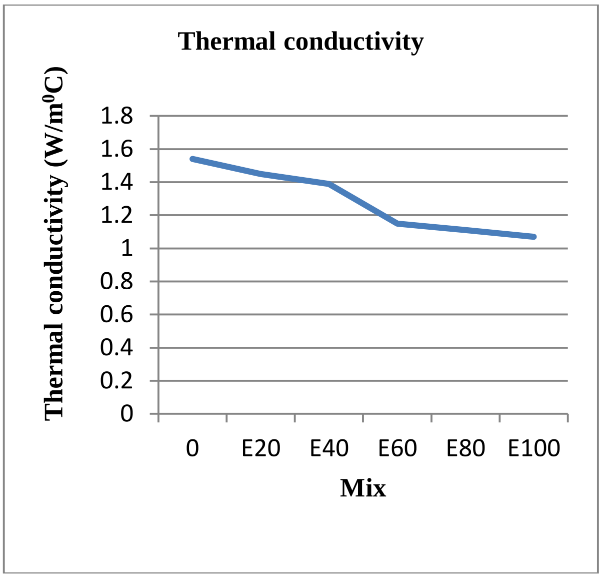

Figure 6: Variation of thermal conductivity

5.4 COMPRESSIVE STRENGTH OF PANELS

Lightweight concrete sandwich panels of section 300mmX75mm were tested for compression. The confinement provided by the fibre boards helps in improving the compressive strength of the panels by achieving composite action. All the panels tested failed due to crushing. The bond between the cement fibre board and concrete is satisfactory as the fibre boards were not disintegrated till failure. This ensures composite action of the sandwich wall panel. The results of the test are plotted as a graph in figure 7.

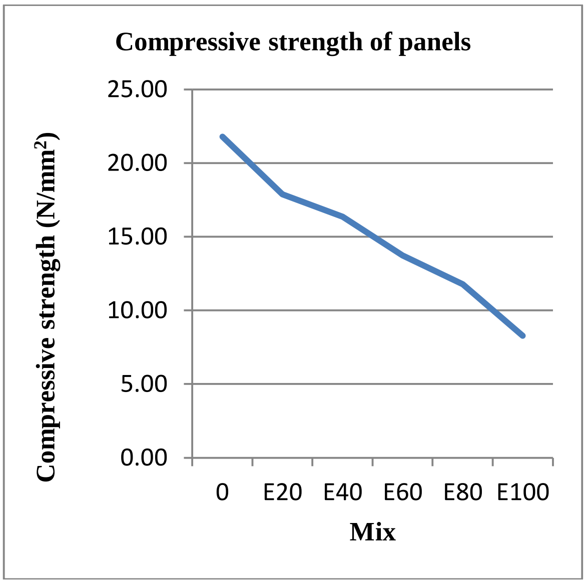

Figure 7: Variation of compressive strength of panels

5.5 FLEXURAL STRENGTH OF PANELS

The sandwich panels were tested for flexure under two point loading to estimate the lateral load resistance. The loading arrangement is as shown in the figure 8. All the panels displayed brittle failure. The failure location is within the middle third for all the specimens. Flexural strength observed varies as shown in figure 9.

Figure 8: Wall panel being tested for flexural strength

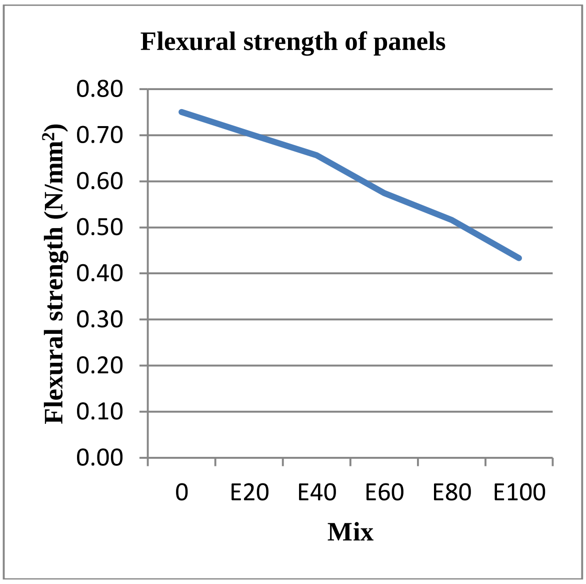

Figure 9: Variation of flexural strength of panels

6. CONCLUSION

Light weight concrete sandwich panels were tested and with the experimental program, the following conclusions were arrived.

- The minimum compressive strength for solid light weight load bearing wall units as per IS 2185(Part 2) is 10.4 N/mm^2. The E60 cubes have a compressive strength of 11.70 N/mm^2.
- The compressive strength and flexural strength of E60 sandwich panels are 13.73 N/mm^{2}and 0.57 N/mm^{2}respectively.
- For E60 mix, the self weight of the concrete is reduced by 25.7%. The thermal conductivity is also reduced by 25.3%.

Light weight concrete sandwich panels can be made by replacing 60% of the volume of aggregates by EPS beads and these panels are recommended for non load bearing walls which significantly reduces the self weight of structure and provides thermal comfort.

7. REFERENCES

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