Experimental Analysis of Concrete Having Partial Replacement of Coarse Aggregate by Capsulated Polystyrene Aggregate

Muhammad Zeeshan Ahad, Fawad Ahmad, Hamza Nasir Baloch

Abstract— *The demand for construction materials is increasing every day. Due to this, there is a need to utilize alternative materials for better sustainable development. An idea of using capsulated polystyrene aggregates in concrete is adopted to minimize the use of natural resources and environmental pollution. Capsulated polystyrene aggregate were used in concrete as a partial replacement of conventional coarse aggregate with 15%, 30%, 45% and 60%. This study holds the comparison of density test, compressive strength test, splitting tensile strength and flexural strength with the controlled mix concrete cured for 28 days. Results showed that concrete having capsulated polystyrene concrete is lighter than normal concrete, with ample strength parameters. Concrete having 30% of the capsulated polystyrene aggregate is recommended for showing better strength with enhancement of workability of concrete as well.*

Index Terms— Light weight concrete, Capsulated Polystyrene, Compressive Strength, Split Tensile Strength, Flexural Strength.

1 Introduction

Polystyrene is one of the most common plastic packaging materials. Consumption and production of polymers are increasing every day. The amount of polystyrene waste is increasing every year, causing serious pollution problems. The disposal and treatment of this waste is becoming increasingly expensive.

Currently, millions of tons of residual polystyrene are produced all over the world. This will eventually cause pollution and damage the ecosystem. National and international environmental regulations are becoming more stringent and disposal is becoming increasingly expensive. Therefore, the use of polystyrene waste in concrete production not only solves the problem of removing these super-light solid waste (up to 95% of the air), but also helps to conserve resources [1].

The environment is facing rapid urbanization and industrialization and there is the possibility of modifying the amount of urban solid waste generated. Plastic waste is considered a serious environmental problem because plastic does not spontaneously break down. Polystyrene is a category of plastic widely used as food packaging. Generally, it is discharged directly into the waste stream due to the high recycling costs compared to the production of construction materials. Polystyrene waste is generated from industrial waste and local waste. This is a serious environmental problem due to the large amount of waste deposited in landfills and is not biodegradable [2].

Polystyrene concrete consists of a mixture of cement, polystyrene granules and natural aggregates and is in the form of expanded polystyrene aggregates (EPB). By incorporating several volumes of polystyrene agglomerates in cement, mortar or cement paste, it can generate building applications and a wide range of base material for flooring and base, building materials of floating marine structures, seabed and marine enclosures, materials that absorb energy for the protection of buried military structures and mudguards of offshore oil fields [3].

The artificial light aggregate consisting of environmental waste such as expanded polystyrene foam (EPB) is a new vital source of structural aggregates. Using lightweight concrete, design flexibility and significant savings, reduced permanent load, improved structural load response, long service life, thin section, smaller structural elements and cost are possible [4].

Concrete is probably the most used building material in the world. Lightweight concrete can be defined as a type of concrete containing volumizing agent. This serves to provide additional quality such as the ability to remove nails and reduce the weight of the body while increasing the amount of mixture. It is lighter than normal cement. The main characteristics of lightweight concrete are low density and thermal conductivity. Reducing dead load is one of the great advantages, followed by the speed of construction, the reduction in transport costs and the costs of use. Lightweight concrete holds a large space. This survey is based solely on the performance of lightweight cellular concrete. However, in order to ensure adequate flocculation of water and cement, an adequate cement water ratio is required. The loss of strength of the concrete can be caused by the lack of water in which the particles do not agglomerate [5].

2 Related work

Concrete can be mitigated by introducing light mineral aggregates such as gasifiers such as aluminum powder or expanding agent, perlite, vermiculite, pumice, expanded shale, slate, slag, clay, plastic balls and expanded polystyrene foam, polyurethane or other polymeric material [6].

Polystyrene is a vinyl polymer produced by the polymerization

of vinyl by free radicals. The expanded polystyrene (EPS) is polystyrene in raw pearl, is steam heated and expands to form a cellular structure. This process is the best when aggregation is required. This is to minimize transport costs. Polystyrene has the same number of trade names as "expanded polystyrene", and is mainly used as an insulating material. The expanded pearls have an apparent density of about 16-27 kg/m^3. The beads are inelastic and can not withstand the stresses when mixing the concrete, although they are not recovered when deformed. The thermal conductivity of polystyrene is very low, improving the thermal properties of the concrete [7, 8].

Concrete produced with polystyrene have densities vary between 220-460 Kg/m^3 and compressive strength between 100-335 psi [9].

This study demonstrated the properties of concrete containing polystyrene and the proposed mixture is very reliable and has a low density and resistance up to 200 kg/cm^2. It has also noted the great maneuverability of the mixture with a very low water to cement ratio (0.35) [7].

Study showed the properties of concrete having polystyrene with respect to density, compression and flexural strength, dynamic modulus and thermal conductivity. These results showed that these properties are highly influenced by water to cement ratio [10, 11].

Polystyrene aggregates are produced to have low density concrete and they are used for many applications [12]. On the other hand, concrete having polystyrene as an aggregate shows more compressive strength than other lightweight aggregate concrete and also have good thermal insolation and fire resistance [13].

3 Materials

Capsulation of Polystyrene

The polystyrene was crushed to the size of coarse aggregates i.e. (3/4in to 3/8in) by hand. Polystyrene were capsulated with mixture of lime, glue, white cement, and sherash with adequate amount of water. Hand mixing was done to capsulate the polystyrene to make it impervious and hard polystyrene aggregate. The polystyrene aggregates, were then, dried for about 24 hours at room temperature.

Mix Design

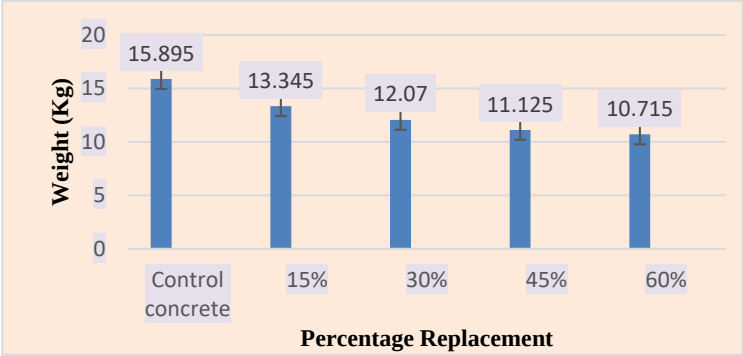
Cement	Fine Aggregate	Capsulated Polystyrene Aggregate	W/C Ratio
1	2.31	2.73	0.47

Casting and Testing

The concrete cylindrical specimens were casted having percentage replacement (15%, 30%, 45% and 60%) of capsulated polystyrene aggregate. 30 No.s of concrete cylindrical specimens were casted for each batch for compressive strength test and spilitting tensile strength test. 6 No.s of beams were casted for the flexural strength test. Before tests, 28 days of curing was done.

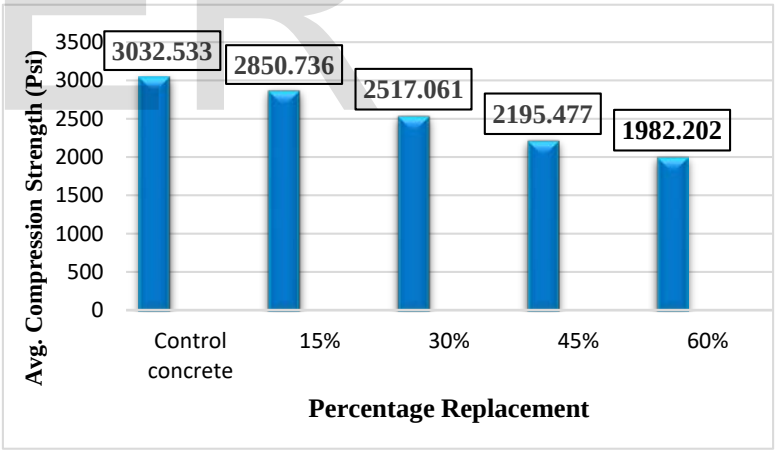
4 Result and Discussion

4.1 Weight Analysis



Weight analysis was done on concrete cylindrical samples having partial replacement of conventional coarse aggregate by capsulated polystyrene aggregate and then compared with controlled concrete for 28 days of curing age. The results showed the decreasing trend of weight with increase in the percentage of capsulated polystyrene aggregate. Controlled Concrete has an average weight of 15.895 kg. 15%, 30%, 45% and 60% of the replacement has weight of 13.345 kg, 12.070 kg, 11.125 kg and 10.715 kg respectively.

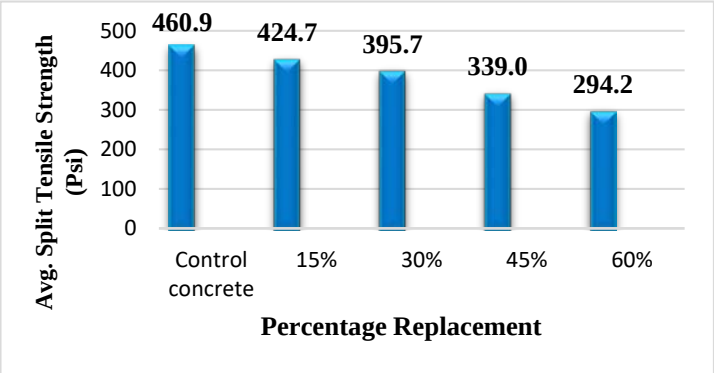
4.2 Compressive Strength of Concrete Cylindrical Samples



Compressive test was conducted on the concrete cylindrical samples having partial replacement of conventional coarse aggregate by capsulated polystyrene aggregate and then compared with controlled concrete for 28 days of curing age. The results showed a decreasing trend of the compressive strength with increase in the percentage of paper aggregate. Controlled Concrete shows compressive strength of 3032.533 psi. 15%, 30%, 45% and 60% of the replacement has showed compressive strength of 2850.736 psi, 2517.061 psi, 2195.477 psi and 1982.202 psi respectively.

Hence it is concluded that compressive strength was decreased for 28 days of curing age but on 30% replacement it give a considerable strength of 2517.061psi.

4.3 Split Tesile Strength of Concrete Cylindrical Specimen



Splitting tensile strength test was conducted on the concrete cylindrical samples having partial replacement of conventional coarse aggregate by capsulated polystyrene aggregate and then compared with controlled concrete for 28 days of curing age. The results showed a decreasing trend of the splitting tensile strength with increase in the percentage of capsulated polystyrene aggregate. Controlled Concrete shows splitting te
nsile strength strength of 460.9 psi. 15%, 30%, 45% and 60% of the replacement has showed compressive strength of 424.7 psi, 395.7 psi, 339.0 psi and 294.2 psi respectively.
Hence it is concluded that splitting tensile strength was decreased for 28 days of curing age but on 30% replacement it give a considerable strength of 424.7psi.

4.4 Flexural Strength of Beam Specimen

Percentage of Polystyrene Aggregate	Flexure strength (psi)			Average (psi)	% Decrease
	28 Days				
	Sample 1	Sample 2	Sample 3		
0%	762	798	757	772.33	0%
30%	743	732	740	738.33	-4.4%

Flexural strength test was conducted on the beam specimens having partial replacement of conventional coarse aggregate by capsulated polystyrene aggregate and then compared with controlled concrete for 28 days of curing age. The results showed a decreasing trend of the flexural strength with increase in the percentage of capsulated polystyrene aggregate. Controlled Mix Beam showed flexural strength of 772.23 psi and 30% of the replacement has showed flexural strength of 738.33 psi respectively.
Hence it is concluded that flexural strength was decreased for 28 days of curing age but on 30% replacement it give a considerable strength of 738.33psi.

5 Conclusion

The use of capsulated polystyrene aggregate in concrete has scope for non structural members. Obtained results showed decrease in the strength perameters and weight with the increase in percentage of capsulated polystyrene aggregate in concrete.
This work can be considered as a new line of research for light-weight concrete.

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