International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 7, pp: 47-51 www.ijaem.net ISSN: 2395-5252

Experimental Investigation of Concrete for Replacement of Coarse Aggregates by Polystyrene

Akshay shetty BS[1], Dr Neethu Urs[2]
[1]Post graduateStudent, Department of Civil Engineering, Dayananda Sagar College of Engineering, Bangalore.
[2]Associate Professor,Department of Civil Engineering, Dayananda Sagar College of Engineering, Bangalore.
Corresponding author: Akshay shetty BS

Date of Submission: 15-09-2020 Date of Acceptance: 30-09-2020

ABSTRACT: Concreteis the most widely used construction material incivil engineering structures. There is a need to develop alternativematerials due to rise in demand for conventional construction materials. Several studies aredone for replacing coarse aggregates in concrete. Expanded Polystyrene (EPS) beads are used as partial and fully replacement to fine and coarse aggregates respectively. Therearemany advantages from the use of Expanded Polystyrene in lightweight concrete. These includelighter loads during construction, reduced self-weight instructures, and improved thermal resistance. Light weight concrete is usually accepted when it has a density within 1800-2000 kg/m^3 or less. A reduction in the unit weight of concrete and yet providing adequate strength will create a significant economic positive impact to the construction industry. This research paper is limited to studies regarding light weight concrete that are produced from Expanded Polystyrene beads and mainly highlights about waste management of polystyrene by replacing total coarse aggregate in concrete mix to produce light weight concrete by investigating its mechanical properties.

Keywords: Expanded polystyrene, light weight concrete.

I. INTRODUCTION

Polystyrene is a synthetic aromatic hydrocarbon polymer made from the monomer styrene. It is regarded as highly non-biodegradable. Polystyrene is the most commonly used non-biodegradable material next to plastic but waste management of these polystyrene is not effectively done as compared to plastic. As concrete is one of the most extensively used building material, replacement of coarse aggregate by polystyrene helps in waste management.The main features of the lightweight concrete are its low density and low thermal conductivity. Lighter the weight may decrease the overall cost of the construction.Therefor replacement of coarse aggregate by Expanded Polystyrenebeads reduces the dead load on the structure.

Fig.1. Polystyrene beads of size 7.5mm

Concretes having low density about 1800 to 2000 kg/m^3 are termed as lightweight concrete which can be apparently achieved either by using low density aggregates or with the complete elimination of coarser aggregates. A reduction in the unit weight of concrete and yet providing adequate strength will create a significant economic positive impact to the construction industry.Light Weight Concrete(LWC) is a conglomerate of cement and lightweight aggregates. It has a bulk density ranging between 300 and 2000 kg/m^{3}comparedto 2200–2600 kg/m^3 of Normal Weight Concrete. Light Weight Concreteis broadly divided into the following categories based on its bulk density and compressive strength. Thermo insulating light weight concreteis the type of Light Weight Concreteis used as filling material or as an insulating coating. Its bulk density is in the range of 300–800 kg/m^3 while the compressive strength is in the range of 0.5–7 MPa, low strength light weight concrete is the type of Light Weight Concreteis used in structures where the strength of concrete is not important; at the same time, it guarantees an acceptable level of thermal comfort. The bulk density is in the range of 800–1400 kg/m^3 while the compressive strength is in the range of 7–18 MPaStructural light weight concrete is the type of concrete is normally prepared with synthetic aggregates. The reduced bulk density of this type of Light Weight Concreteisdueto the addition favoid. Earlier study to determine the engineering properties of light weight concrete containing crushed expanded polystyrene waste was carried out by[4]. It was found that the properties such as drying shrinkage and creep of polystyrene aggregate concrete increased, whereas compressive strength and modulus of elasticity decreased with decrease in the density of concrete. In an experiment the coarse aggregates were partially replaced by Expanded Polystyrenein 30%, 50% and 70% respectively and found that nominal replacement was 30% [4]. Expanded Polystyrene became the experimental replacement in lightweight concrete world, one such study carried out by [2], to study the behaviour of concrete containing expanded polystyrene beads within the marine floating structures was carried out. It was found that polystyrene concrete is far more repulsive against sulphate solutions than perlite concrete while it's less resistant than normal-weight concrete. The results stated that for an equal density of about 80% as sea water, polystyrene concrete has a compressive strength that is 50% higher, a modulus of elasticity 100% higher, and a modulus of rupture 25% higher than those of perlite concrete. [4,2]In early 21st century experiments on hardened concrete containing Expanded Polystyrenebeads were prominent. One such experiment to determine the properties of hardened concrete bricks containing Expanded Polystyrenewas carried out. Five different specimens were prepared and tagged as PC-Plain Concrete (1:3 cement and sand), P1(1:2.5:0.5 cement, sand and EPS), P2(1:2:1), P3(1:1.5:1.5), P4(1:1:2) respectively. The experiment results that workability characteristics of the mixes are very different from the normal concrete. Although the mixes were cohesive compaction by rodding or vibration was not effective and also quotes that mix P2 with compressive strength of 14 N/mm^2 is most suitable to be used as load bearing internal walls, mix P3 and P4 can be used as non-load bearing walls. Polystyrene concrete bricks thus can be used potentially in the construction industry.[6]Partial replacementof CoarseAggregate byExpanded Polystyrene concrete has scope for non-structural applications like wall panels, partition walls, etc. Author [8] experiment also concludes that partial replacement of coarse aggregate (5%,10% and 15%) with Expanded Polystyrenegives no desired results because of huge variation in densities i.e. 1680 kg/m3 and (15-30 kg/m3). [8]

Lightweight concrete can be produced by replacing the normal aggregate with lightweight aggregate partially or fully depending upon the requirements of density and strength. Work carried out by [10] and team depicts the difference between natural and artificial lightweight aggregate. To this aim, various mixtures were produced by replacing varying percentages of natural aggregates volume with Expanded Polystyrene beads and substituting cement with varying percentage of finely Ground Granulated Blast furnaceSlag and their mechanical properties and durability in terms of sulphate attack was estimated. The results showed that due to the compressibility of the expanded polystyrene material, even though mixing precisely measured quantities of Polystyrene and mortar to give one cubic meter resulted in giving a total volume less than 1 m^3. Addition of Expanded Polystyrenebeads improved the workability of concrete even at a water cement ratio of 0.385. Addition of Ground Granulated Blast furnace Slagimproved consistency and workability of the mixes. By adding Ground Granulated Blast furnaceSlagstrength gain at early as well as later ages was observed and 10 % replacement of cement by Ground Granulated Blast furnace Slag showed better results for the testing period considered as compared to that of 15% replacement of cement. [10]

Mechanical behaviour of plain concrete by partially replacing Fine Aggregates with 0%, 5%, 10%, 15%, 20% and 25% of Expanded Polystyrenebeads by volume respectively were investigated. This study states that the partial replacement of fine aggregate with polystyrene reduces the compressive strength and tensile strength of concrete. This polystyrene based concrete is best suitable for non-structural elements which do not require high compressive and tensile strength also after this study it has proven better way for disposal of polystyrene. [7]

On investigating certain problem statement that currently million of tons of waste polystyrene is produced in the world. This will ultimately cause pollution and in harmful to the ecosystem. National and international environmental regulations have become more inflexible increasingly which have made it expensive to dispose. Therefore using waste polystyrene in concrete production not only solves the problem of disposing this ultra-light solid waste but also helpspreserve natural resources. Author partially replaced coarse aggregate by 20%, 30%, 40% and 50% and tested for its compressive strength. He used both extruded and expanded polystyrene, and found that Extruded Polystyrene (XPS) showed more repulsion towards bonding when compared to Expanded Polystyrene. Its conclusion stated that although densities of these partially replaced coarse aggregate by Expanded

Polystyrene were reduced it cannot be used as a load bearing structure due to reduction in strength. [3]

Since concrete is the most widely used construction material in civil engineering structures. Nowadays, the concrete industry consumes enormous amount of concrete produced daily, even a small reduction in the use of raw materials in concrete mixtures will result in considerable benefit to the environment. An investigation conducted by using Expanded Polystyrene (EPS) beads of 10 mm size as replacement of natural aggregates by volume from 0% to 60% in multiple of 15% (N/EPS00, EPS15, EPS30, EPS45 and EPS60) in cement concrete. The fresh mechanical properties of concrete with and without inclusion of Expanded Polystyrene beads were evaluated in terms of workability, unit weigh or dry density, compressive strength and splitting tensile strength.Also this properties was observed and compare with normal concrete of Expanded Polystyrene beads grade M20. The workability of fresh concrete increases with increase in percentage of Expanded Polystyrene beads whereas the harden properties like unit weight, compressive strength and splitting tensile strength decreases with increase in percentage Expanded Polystyrene beads. Optimum level of replacement of coarse aggregate by Expanded Polystyrene beads is found to be 15% to obtain better compressive strength. [5]

Weight reduction being one of the major factor, the feasibility of using Expanded Polystyrene beads as a replacement for Fine Aggregate by 10%, 20%, 30%, 40% and 50% to check its strength characteristics. Based on the results obtained we can state that the reported problem of segregation of Expanded Polystyrene is reduced by coating them with clay binders. The author also stated that optimum dosage was 40% replacement with fine aggregates and the density was reduced by 23% compared to conventional concrete and for 10% and 20% replacement density of concrete was reduced without compromising the compressive strength. [1]

II. METHODOLOGY

The most prominent study work to becarried out on various topics such as Lightweight concrete, polystyrene concrete, chemical admixtures, mix design, testing methods etc must be done.The basic materials like cement, sand, coarse aggregate of 20mm down size and admixture are utilised as per “Bureau of Indian Standard”(BIS) and then basic testing on materials required areprocured, Mix design for M25 grade with proportion 1:1:2 is to be carried out, Later onComplete replacement of Expanded polystyrene with coarse aggregate is done by measuring the volume of coarse aggregate after completion of mixing.

Casting and curing of beams, cylinders and cubes are done using different shape moulds. NowMechanical strength property tests are carried out for 7, 14 and 28 days respectively for cubes and 28 days for beams and cylinders. casting 30 cubes out of which 10 were conventional, 10 were coated and 10 were non-coated, coated meaning the polystyrene beads were coated with cement mortar for further comparison study and casting 12 beams and 12 cylinders out of which 4 each for conventional, non-coated and pre-coated respectively. After casting of all three specimens, they were kept in the vibrating machine to prevent segregation. De-moulding and curing the same for 7, 14 and 28 days. After curing it was tested for its hardened concrete properties. Conclusions are drawn and tabulated based on the results obtained.

Fig 2. Methodology

III. RESULTS

3.1. CEMENT

Cement being one of the major binding material that is used in the mix, cement of grade OPC 53 is used in the present study. As per IS-12263:1987 basic properties for cement are tested and tabulatedbelow.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 7, pp: 47-51 www.ijaem.net ISSN: 2395-5252

Sl. No	Properties	Test Observations	Required values as per IS 4031 : 1988 (part 1 to 5)
1	Specific gravity	2.85	3.10 - 3.15 but 2.80 - 3.15
2	Initial setting time of cement	48 min	Shall not be less than 30 min
3	Final setting time of cement	240 min	Shall not be greater than 600 min
4	Normal consistency	30%	Not Specified

Table Ⅰ: Test results on cement

3.2 FINE AGGREGATE

Fine aggregate occupies greater amount of space than cement, it occupies more than 20% of volume. Aggregates are the main structural part which gives strength to the concrete mix. Properties of fine aggregates are confirming to IS 383:1970.

Table Ⅱ: Test results on fine aggregate

Properties	Test Observations
Specific gravity	2.57
Moisture content	2.006%
Fineness modulus	3.256

3.3 COARSE AGGREGATE

Coarse aggregate occupies more than 50% of volume. Aggregates are the main structural part which gives strength to the concrete mix. Basic properties of coarse and fine aggregates are mentioned in IS 383:1970.

Table Ⅲ: Tests on coarse aggregates

Properties	Test Observations
Bulk Specific gravity	2.67
Water absorption of aggregates	0.250%

3.4 MIX DESIGN CALCULATIONS

MIX CALCULATION		
Concrete volume	1.000	m^3
Cement volume	0.152	m^3
Superplasticizer volume at 0.5 %	0.0018	m^3
Water volume	0.216	m^3
All – aggregates volume	0.640	m^3
Coarse aggregates volume	1026	Kg
Mass of fine aggregates	658	Kg

Table Ⅳ: Mix design calculation

3.5: COMPARISON OF 28th DAY COMPRESSIVE STRENGTH OF CUBES

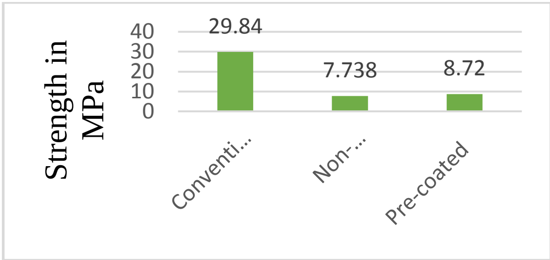

Chart Ⅰ

3.6 COMPARISON OF 28th DAY SPLIT TENSILE STRENGTH

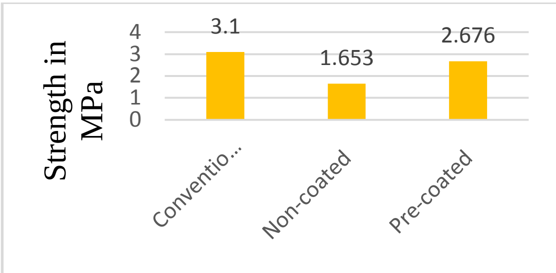

Chart Ⅱ

3.7 COMPARISON OF 28th DAY FLEXURAL STRENGTH

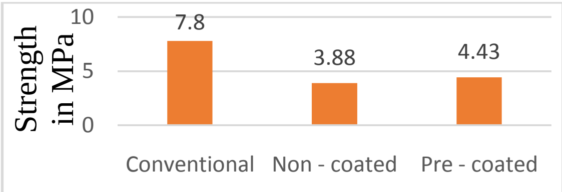

Chart Ⅲ

3.8 COMPARISION OF DENSITIES

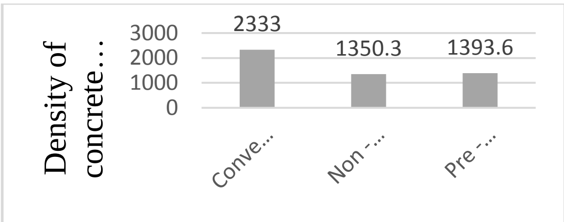

Chart Ⅳ

IV. CONCLUSIONS

A brief conclusion based on the study carried out so far states that Partial replacement of aggregates with expanded polystyrene beads makes the concrete lighter than the conventional normal concrete. Polystyrene is chemically very inert, being resistant to acids and bases but is easily dissolved by many chlorinated solventsand many aromatic hydrocarbon solvents. Due to compressibility property of Polystyrene beads it showed reduction in volume even though the materials were taken with respect to 1 m^3 of normal concrete. Since polystyrene is repellent to water it showed poor bonding with the mortar or concretePre-coating with natural clay binder not only reduced the surface area but also improvised the binding property of Expanded Polystyrene withconcrete. Utilizing crushed polystyrene in concrete is good waste disposal method.

REFERENCES

[1]. Anjan B. K and Arjun V (2019), “Assessment of Lightweight Concrete Using Expanded Polystyrene Beads”, International Journal of Innovative Technology and Exploring Engineering-ISSN: 2278-3075.
[2]. Bagon C (1991), “Research Marine floating concrete made with polystyrene expanded beads" Magazine of Concrete
[3]. Bengin M. A. Herki (2017), “Combined Effects of Densified Polystyrene and Unprocessed Fly Ash on Concrete Engineering Properties”,Buildings 2017.
[4]. Ben Sabaa and Rasiah Sri Ravindrarajah (1997), “Engineering properties of lightweight concrete containing crushed expanded polystyrene waste”, Materials Research Society, 1997 Fall Meeting Symposium MM: Advances in Materials for Cementitious Composites.
[5]. Gupta Milind R, Borhade Siddhi A, KutalPayal C, MehetreVrushali A, Gadekar Swapnali D and TupeRavisha K (2018) “properties of concrete with partial replacement of coarse aggregate with expanded polystyrene (EPS) beads”, IJARIIE-ISSN.
[6]. Ismail and Lateef Saleh (2003), “Properties of hardened concrete bricks containing Expanded Polystyrene Beads”, Asia-Pacific Structural Engineering and Construction Conference 2003.
[7]. Kole and Shyam R. Suryawanshi (2017), “Study of use of Polystyrene as a Partial Replacement for Fine Aggregate in Concrete”.
[8]. RatneshOjha, Sumit Kumar Singh, Rahul Sahan, Anand Mohan Ojha and Anil Pratap Singh (2018), “Use of EPS Beads for Production of Light Weight Concrete”, IJSRD - International Journal for Scientific Research & Development.
[9]. Vishakh T M, Dr Vasudev R (2017), “Lightweight aggregate concrete using expanded polystyrene beads”, International Research Journal of Engineering and Technology (IRJET).
[10]. Dr. Yogesh Aggarawal & S. Naveen Chander (2014), “Properties of Expanded Polystyrene Concrete Containing Ground Granulated Blast Furnace Slag”, National Conference On Innovations In Design And Construction Of Industrial Structures, Nit Durgapur.
[11]. Yuvraj Chavda, Shilpa Kewateb (2015), “Use of vermiculite for light weight floating concrete”, International Journal of Scientific & Engineering Research.