International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 06 | June 2019 www.irjet.net p-ISSN: 2395-0072

Effect of Expanded polystyrene (EPS) on Strength Parameters of Concrete as a Partial Replacement of Coarse Aggregates

Hitesh Patidar[1], Mayur Singi[2], Abhijeet Bhawsar[3]

[1]*M.Tech. Student of BM College of Technology, Indore (M.P.)*
[2]*Head of Department Civil Engineering, BM College of Technology, Indore (M.P.)*
[3]*Assistant Professor in Civil Engineering Department, BM College of Technology, Indore (M.P.)*

---***---

Abstract - With the development of modern construction techniques, the demand for construction materials increases day by day. There is a strong need to utilize alternative materials for sustainable development. The usage of partial replacement of coarse aggregate using polystyrene beads in concrete gives prospective solution to building construction industry. Polystyrene beads are the waste material obtained from packaging industries. This paper handles comparison of concrete which partially replaces coarse aggregate by polystyrene beads with conventional concrete blocks. The result shows that amount of the polystyrene beads incorporated in concrete influences the properties of hardened concrete. Also, the compressive strength, Split tensile strength and Flexural Strength for M30 & M40 with 5%, 10%, 15%, 20%, 25%, & 30% replacement of coarse aggregate. The workability of mix is very high at a low water/cement ratio.

Key Words: Polystyrene, slump value, compaction factor, compressive strength, split tensile strength, Flexural Strength and Strength to weight ratio.

1. INTRODUCTION

The environment is facing rapid urbanization and industrialization that may change the quantity of municipal solid waste generated. Plastic waste is considered as a serious problem to the environment due to inability of plastic to degrade naturally. Polystyrene is the plastic category that is widely being used as food containers and packaging. It is normally thrown into the waste stream directly without treatment due to higher cost of recycling in comparison to manufacturing of the construction materials. Polystyrene waste is generated from both industrial and municipal solid waste. It has become a major environmental concern due to large waste quantities being disposed to landfills and it is non-biodegradable in nature.

Polystyrene is a light weight cellular plastic material consisting of fine spherical shaped particles which are comprised of 99% air and 2% polystyrene. It has a closed cell structure and cannot absorb water. It has good sound and thermal insulation characteristics as well as impact resistance.

There are many advantages to be gained from the use of light weight concrete. These includes lighter load during construction, reduced self-weight in structures and increased thermal resistance. Light weight concrete is generally accepted as concrete having a density of about 1800kg/m3 or less. The present investigation was taken up keeping two targets in view, disposal of polystyrene waste from the point of view of environment and for the replacement of aggregate from the point of view of construction industry. The present study is aimed at analyzing the suitability of polystyrene beads as partial replacement of coarse aggregate.

1.1 CEMENT

Ordinary Portland cement is used to prepare the mix design of M-25 grade. The cement used was fresh and \without any lumps Water – cement ratio is 0.42 for this mix design using IS 456:2007.Cement is an extremely ground material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients. Chemically cement constitutes 60-67% Lime (CaO), 17-25% Silica (SiO_2), 3-8% Alumina (Al_2O_3), 0.5-6% Iron Oxide (Fe_2O_3), 0.1-6% Magnesia (MgO), 1-3% Sulphur Trioxide (SO_3), 0.5-3% Soda And Potash (Na_2O+K_2O).

1.2 SAND

Sand is a naturally occurring coarse material collected of finely separated rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand may also consign to a textural class of soil or soil type; i.e. a soil contain more than 85% sand-sized particle (by mass).In terms of particle size as used by geologists, sand particle range in diameter as of 0.0625 mm to 2 mm. An individual particle in this range size is termed a *sand grain*. Sand grains are among gravel (with particles ranging from 2 mm up to 64 mm) and silt(particles smaller than 0.0625 mm down to 0.004 mm). The dimension specification between sand and gravel has remained even for other than a century, but particle diameter as small as 0.02 mm be considered sand under the Albert Atterberg standard in utilize during the early on 20th century.

1.3 AGGREGATE

Aggregate are the essential constituent in concrete. They provide body to the concrete, decrease shrinkage and effect economy. Construction aggregate, or basically "Aggregate", is a wide group of coarse particulate material used in construction, as well as sand, gravel, crushed stone, slag, recycled concrete and geo-synthetic aggregates. Aggregates are the mainly mine material in the world. Aggregates are an element of composite materials such as concrete and asphalt concrete; the aggregate serve as reinforcement to add strength to the overall combined material. Due to the comparatively high hydraulic conductivity value as compare to most soils, aggregates are generally used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains. Aggregates used as support material under foundations, roads, and railroads.

1.4 EXPANDED POLYSTYRENE (EPS)

Expanded polystyrene (EPS) is a rigid and tough, closed-cell foam with a normal density range of 11 to 32 kg/m^3.[37] It is usually white and made of pre-expanded polystyrene beads. EPS is used for food containers, molded sheets for building insulation, and packing material either as solid blocks formed to accommodate the item being protected or as loose-fill "peanuts" cushioning fragile items inside boxes. A significant portion of all EPS products are manufactured through Injection Maudling (or Molding to use the US spelling) Mould tools tend to be manufactured from steels, , (which can be hardened and plated), and Aluminum alloys. The Moulds are controlled through a split via a channel system of gates and runners. [38]EPS is colloquially called "Styrofoam" in the United States and Canada, an incorrectly applied generalization of Dow Chemical's brand of *extruded* polystyrene.

2. LITERATURE REVIEW

S. Mahmoud et.al (2018) Expanded polystyrene (EPS) as partial replacement in concrete for coarse aggregates increases the durability of reinforced concrete and reduces coarse aggregates usage. However, the low bulk density and high specific surface area of Expanded polystyrene (EPS) offer challenges in its application and transport. In this study, the density of Expanded polystyrene (EPS) was increased by producing expanded polystyrene (EPS) granules mixed with a solid super plasticizer. The effects of expanded polystyrene (EPS) granulation on durability and mechanical properties of concrete were tested. Results indicated an increase in strength and surface electrical resistivity, and a decrease in permeability for both slurry Expanded polystyrene (EPS) and granule, compared to the control sample.

Z. Zhang et.al(2017)the aim of this study was to investigate the differences of effect of Expanded polystyrene (EPS) in paste, mortar and concrete were studied by determining thenon-evaporable water content of pastes, measuring the compressive strengths of pastes, mortars and concretes containing 5% and 10% raw Expanded polystyrene (EPS) or dandified Expanded polystyrene (EPS) with water-to-binder ratios(W/B) of 0.29 and 0.24 and investigating the properties of interfacial transition zone between hardenedpaste and aggregate. The results show that Expanded polystyrene (EPS) can significantly increase the hydration degree of paste. The addition of Expanded polystyrene (EPS) trends to increasing the compressive strengths of hardened pastes, mortars and concretes, and the strength activity index of dandified Expanded polystyrene (EPS) in concrete is the highest while that in paste is the lowest. The agglomeration of Expanded polystyrene (EPS) has been found in blended paste which is hardly seen in concrete. The Expanded polystyrene (EPS) can improve the interface bond strength between hardened cement paste and aggregate. The crystalline orientation degree, the crystalline size and the content of calcium hydroxide at the interface are obviously decreased by adding Expanded polystyrene (EPS). The different dispersion and the improvement of the interfacial transition zone are the main factors causing the different role of Expanded polystyrene (EPS) in paste, mortar and concrete.

M.I. Khan and Y.M. Abbas(2017) this research evaluated reports the influence of hot weather conditions and subsequent curing requirements on the strength and durability of multi-cementitious concrete. Five curing schemes were considered using persistent moist curing for various ages followed by exposure to natural hot weather conditions. It was observed that curing in hot weather tended to increase the initial strength of ternary blended concrete for up to 28 days; however, the development of long-term strength had insignificant effect. Binary blended concrete with Expanded polystyrene (EPS) (EPS) exposed to hot weather have higher early age strength development compared to those under standard curing. The compressive strength and permeability of concrete was more sensitive to hot weather curing at an early age as its fly ash (FA) content increased. However, the effects of curing age diminished with high FA content and the susceptibility of long-term strength to hot weathering decreased as EPS content increased. The porosity of concrete cured with continuous moistening was lower compared to those under hot weathering. The chloride permeability of binary blended concrete containing EPS was less affected by hot weather curing. Using numerical models, it was found that the optimized persistent moist curing age for concrete without EPS was dependent on target strength and durability requirements.

3. OBJECTIVE

- To determine the Workability of concrete with and without EPS in different proportions at different grade.
- To determine the Compressive Strength of concrete with and without EPS in different proportions at different grade.

- To determine the Split Tensile Strength of concrete with and without EPS in different proportions at different grade.
- To determine the Flexural Strength of concrete with and without EPS in different proportions at different grade.
- To find the optimum percentage of EPS for obtaining the maximum strength of concrete.
- Comparative study of the behavior of the concrete with & without EPS.

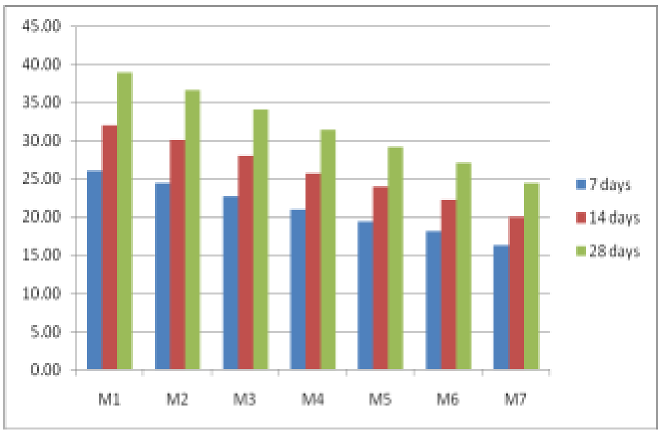
4. METHODOLOGY AND RESULT

4.1 Compressive Strength Test

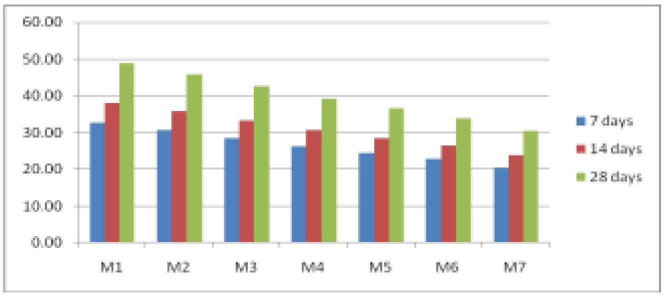
The test was conducted on cubes of size 150mm x 150mm x 150mm (for concrete and mortar) specimens were taken out from curing tank at the age of 7, 14, and 28, days of curing. Surface water was then allowed to drip down. Specimens were then tested on 200 tones capacity Compression Testing Machine (CTM). The position of cube while testing was at right angles to that of casting position. Axis of specimens was carefully aligned with the centre of thrust of the spherically seated plates. The load was applied gradually without any shock and increased at constant rate of 3.5 N/mm^2/minute until failure of specimen takes place. The average of three samples was taken as the representative value of compression strength for each batch of concrete. The compressive strength was calculated by dividing the maximum compressive load by the cross sectional area of the cube specimens. Thus the compressive strength of different specimens was obtained.

4.1.1 RESULT

Graph 4.1 Compressive strength (MPa) results M-30 of all at different curing ages.



Graph 4.2 Compressive strength (MPa) results M-40 of all at different curing ages.

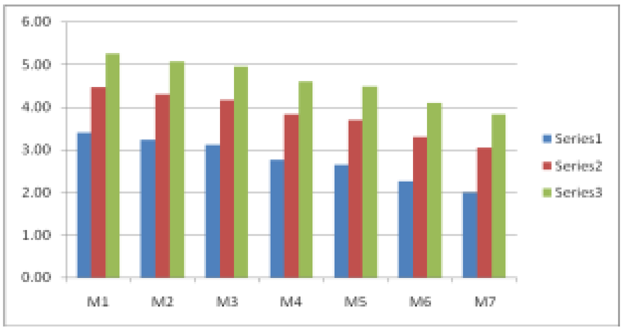


4.2 Split Tensile Strength Test

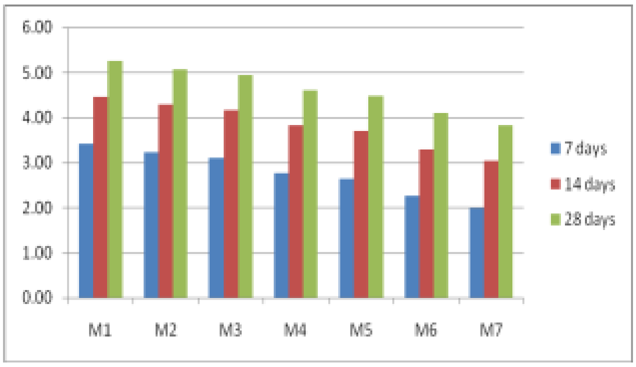
The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 7, 14 &28 days. The splitting tensile strength test results of all the mixes at different curing ages are shown in Table below. Variation of splitting tensile strength of all the mixes cured at 7, 14 &28 days is also shown in Fig. Shows the variation of splitting tensile strength of concrete mixes Splitting tensile strength (MPa) results of all mixes at different curing ages.

4.2.1 RESULT

Graph 4.3 Split Tensile Strength (MPa) results M-30 of all at different curing ages.



Graph 4.4 Split Tensile Strength (MPa) results M-40 of all at different curing ages.

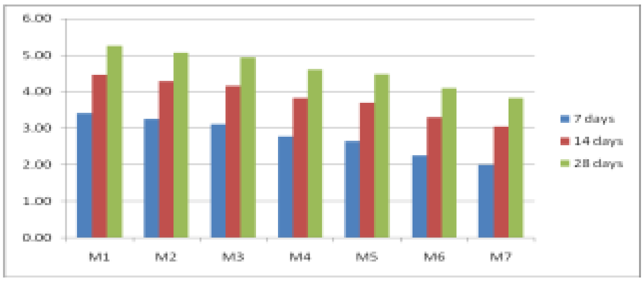


4.3 Flexural Strength Test

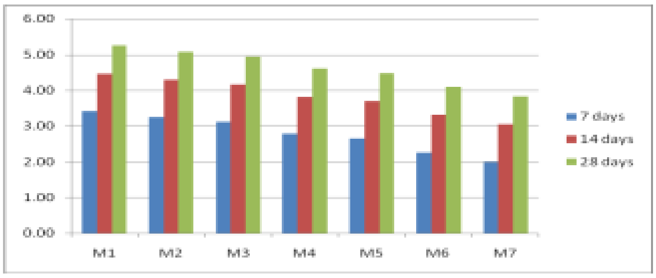
The results of the Flexural Strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The Flexural Strength test was conducted at curing ages of 7,14& 28 days. The Flexural Strength test results of all the mixes at different curing ages are shown in Table below. Variation of Flexural Strength of all the mixes cured at 7,14& 28 days is also shown in Figure. Below Fig. shows the variation of Flexural Strength of concrete mixes w.r.t control mix (90%OPC+0%EPS) after 7,14 &28 days respectively

4.3.1 RESULT

Graph 4.5 Flexural Strength (MPa) results M-30 of all at different curing ages.



Graph 4.6 Flexural Strength (MPa) results M-40 of all at different curing ages.



5. CONCLUSIONS

In the current investigation, Expanded polystyrene (EPS) was used to examine. The experimental data obtained has been analyzed and discussed in Chapter-4, to fulfil to the best of ability, the objectives set forth for the present investigation. This chapter gives the broad conclusions that are drawn from the investigation.

Based on the scope of work carried out in this investigation, following conclusions are drawn.

- Workability increases with increase in polystyrene beads content.
- Increase in the EPS beads content in concrete mixes reduces the compressive Strength of concrete.
- Increase in the EPS beads content in concrete mixes reduces the Split Tensile Strength of concrete.
- Increase in the EPS beads content in concrete mixes reduces the Flexural Strength of concrete.
- With the increase in w/cm ratio strength of concrete decreases.

6. FUTURE SCOPE

1. Experiments can be done by changing different type of cement, manufactured sand and other cementitious materials with EPS Beads.

2. The study can be done for different mixes.

3. Introducing foaming agent.

4. Fibers can also use to increases the strength of the concrete.

5. Air entering agents with artificial light weight aggregate can be used to achieve desire density and strength of the concrete.

7. REFERENCES

1. ACI committee 544. 1982. State-of-the-report on Expanded polystyrene (EPS) reinforced concrete, (ACI 544.1R-82), Concrete International: Design and Construction. 4(5): 9-30, American Concrete Institute, Detroit, Michigan, USA.

2. ACI Committee 544. 1989. Measurement of properties Expanded polystyrene (EPS)s reinforced concrete, (ACI 544.2R-889). American Concrete Institute, Detroit, Michigan, USA.

3. ASTM C 1240-11 “standard specification for Expanded polystyrene (EPS) used in cementitious mixtures”.

4. Bhanja, S., B. Sengupta, b., (2003) “Modified water-cement ratio law for Expanded polystyrene (EPS) concretes “. *Cement and Concrete research*, 33, pp 447-450.

5. Mohamed s. Morsy, Sayed s. Shebl, Effect of Expanded polystyrene (EPS) and metakaolinepozzolana on the performance of blended cement pastes against fire, Ceramics - Silikáty 51 (1) 40-44 (2007).

6. S. Vishal, Ghutke1, Bhandari S. Pranita (2014) . Influence of Expanded polystyrene (EPS) on concrete. *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).* PP 44-47(2014).

7. Zain, M.F.M., Safiuddin, Md. And Mahmud, H.(2000) "Development of high performance concrete using Expanded polystyrene (EPS) at relatively high water-binder ratios", *Cement and Concrete Research*, Vol.30,pp 1501-1505.

8. PradhanD,Dutta. D. (2013). Influence of Expanded polystyrene (EPS) on Normal Concrete. *Int. Journal of Engineering Research and Applications* Vol. 3, pp.79-82.

9. Amudhavalli N. K., Mathew Jeena. **(2012**)Effect of Expanded polystyrene (EPS) on strength and durability parameters of concrete.*International Journal of Engineering Sciences & Emerging Technologies.*Volume 3, Issue 1, pp: 28-35.

10. KareinS. Mahmoud Motahari, Ramezanianpour A.A. , TaghiEbadi, IsapourSoroush, (2017) A new approach for application of Expanded polystyrene (EPS) in concrete: Wet Granulation. *Construction and Building Materials* page573–581.

11. Zhang Zengqi, Zhang Bo, Yan Peiyu (2016) Comparative study of effect of raw and densifiedExpanded polystyrene (EPS) in the paste,mortar and concrete. *Construction and Building Materials 105* .page 82–93.

12. Khan M.I, Abbas Y.M. (2017)Curing optimization for strength and durability of Expanded polystyrene (EPS) and fuelash concretes under hot weather conditions. *Construction and Building Materials 157* (page) 1092–1105.

13. Okoye Francis N, PrakashSatya , Singh Nakshatra B. (2017) Durability of fly ash based geopolymer concrete in the presence of Expanded polystyrene (EPS). *Journal of Cleaner Production 149*. (Page) 1062-1067.

14. Ali K.,Ghalehnovi .M ,Brito J. de ,Shamsabadi E. A, (2017) Durability performance of structural concrete containing Expanded polystyrene (EPS) and marble industry waste powder.*Journal of Cleaner Production 170* (page) 42and60.

15. SiddiqueR,JameelA, Singh M.,Hunek .D. B, Mokhtar A. A. ,Belarbi.R., Rajor. A. (2017) Effect of bacteria on strength, permeation characteristics and micro-structure of Expanded polystyrene (EPS) concrete. *Construction and Building Materials 142* (Page) 92–100.