International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 04, April-2019

# Experimental study on light weight concrete by partial replacement of cement by flyash, coarse aggregate pumice stone and polystyrene beads: A Review

Harris jameel[1], Saranya ilango[2]

[1]M.Tech. student, Department of civil engineering, Sharda University,
[2]Assistant professor (Department of civil engineering, Sharda University,
School of engineering and technology, sharda university, greater noida 201306- U.P india

***Abstract— - In today's world when focus is on reducing self weight of concrete, light weight concrete has came with the high number of applications to reduce self weight of concrete. In developing countries where lot of construction work is to be done light weight concrete will be of major importance and use as it provides flexibility in structure. This paper presents a review on the significant applications and advantages of using lightweight concrete in the field of civil engineering and to find a significant replacement of conventional materials by light weight materials and verify it experimentally. In the present research focus is given on replacing cement by flyash and coarse aggregate by pumice stone and polystyrene beads by proper percentage to be used as structural concrete.***

***Keywords— light weight concrete, pumice stone, flyash, polystyrene beads, flexural strength, compressive strength,***

## I. INTRODUCTION

Concrete is one of the most popular construction materials used since hundred years ago. Because of its flexibility in usage it becomes more important and is preferred compared to timber or steel. Concrete is defined as the mixture of cement, coarse aggregate, fine aggregate and water. Conventional concrete due to its higher self weight and density ranging from 2200kg/m$^3$-2600kg/m$^3$ is uneconomical to some extent. To reduce the self weight of concrete several attempts have been made one such attempt is light weight concrete.
The concrete made of lightweight aggregates which reduce self and density of concrete is called as lightweight concrete. The density of lightweight concrete ranges from 1440 kg/m$^3$ - 1840 kg/m$^3$. The minimum strength for structural lightweight concrete should not be less than 17 Mpa. Lightweight concrete reduces the self weight of concrete by about 25 to 35%. Pumice stone aggregate due to its cellular structure absorbs about 10-20% water by the mass of the aggregate. Modern technologies have helped engineers in the better study of concrete and come up with the methods to replace constituents of conventional concrete and come with light weight concrete. In this research cement is replaced by flyash and coarse aggregate by pumice stone and polystyrene beads in different proportions to come up with light weight concrete with strength enough to act as structural concrete.

**Table 1.1 Types of light weight aggregates as per Rakesh kumar saini et al. (May2018)**

| Natural light weight Aggregates | Artificial light weight Aggregates |
|---|---|
| Pumice | Artificial cinders |
| Diatomite | Coke breeze |
| Scoria | Foamed slag |
| Volcanic cinders | Expanded shale |
| Sawdust | Expanded perlite |
| Rice husk | Thermocol beads |

### *1.1. Materials and their properties*

**1.1.1.** ***Flyash:*** **-** Flyash is a byproduct obtained from Burning coal in electric power plant in electric power plants. It consists of finely powdered particles whose size is similar to that of silt. Fly ash is environmental friendly as a waste materials from industries are effectively been used to create quality building materials. Fly ash is highly economical it has very small particles which make concrete dense and thus reducing permeability. Fly ash concrete is resistant to acid and sulphate attack. The particle size distribution of fly ash is generally similar to silt less than 0.075mm and specific gravity ranges from 2.1 to 3.0 the colour of fly ash varies from tan grey to black depending upon the presence of unburnt carbon in the ash.

**1.1.2.** ***Pumice Stone:*** **-** Pumice stone is natural lightweight aggregate which is formed by cooling of molten lava. Pumice stone is colorless or light grey colored light weight aggregate. Pumice stone has specific gravity of 1.04. It and the constituents are silica (70%) and alumina (14%), along iron oxide as 2.5%, calcium oxide as 1%, and sodium oxide as 9%.

**Table 1.2 Properties of Pumice stone**

| Specifications | Values |
|---|---|
| Size | 20-40 mm |
| Colour | White |
| Hardness | 6 (on Mohs' scale) |
| Absolute Hardness | 72 |
| Specific gravity | 2.35 g/cm$^3$ |

**1.1.3.** ***Polystyrene beads:*** **-** Polystyrene is rigid closed cell foam. It is also called as expanded polystyrene. It offers a non-hydroscopic, odorless, rigid closed cell. Polystyrene is good in insulation and are often used as insulating material in concrete blocks. Discarded polystyrene does not biodegrade for hundreds of years and is resistant to photolysis. Polystyrene beads being light weight float on water, so they can have serious effects on marine life and life of birds.

**Table 1.3 Properties of Polystyrene beads**

| Specifications | Values |
|---|---|
| Density range | 15-30kg/m |
| Compressive strength | 0.8-1.6kg/cm |
| Tensile strength | 3-6kg/cm |
| Melting range | 100-200$^o$c |
| Thermal conductivity | Low |
| Sound absorption | High |
| Moisture absorption | Low |

## 2. BASIC REQUIREMENTS

i. The Structural light weight concrete should have strength not less than 17 Mpa.
ii. It should reduce the self weight of concrete from 25-35%.
iii. The slump value should be in the range of 50-75mm.
iv. OPC of grade 43 or 53 can be used in this study as per IS-8112 and IS-12269.

***2.1 Tests on fresh concrete***

i. Workability test (slump cone) as per IS: 1199-1959

***2.2 Tests on hardened concrete***

i. Compressive strength test.
ii. Flexural strength test.

## 3 LITERATURE REVIEW

**A. Rakesh kumar saini, et al (May 2018)** investigated the "study of light weight concrete using pumice stone as a partial replacement of coarse aggregate" using M30 grade of concrete. This study replaces coarse aggregate with pumice stone in varying percentage of 8%, 16% and 24%. By replacing 16% of normal coarse aggregate with pumice stone aggregate the compressive strength is promising. They also concluded that with the further increase in percentage replacement the strength of concrete starts decreasing. The experimental results of their work are given below:

**Table 3.1 Compressive Strength table**

| Conventional reading (N/mm$^2$) | No. of days | Replacement percentage (%) | Reading after replacement of Pumice stone (N/mm$^2$) |
|---|---|---|---|
| 20.45 | 7 Days | 8% | 19.02 |
| | | 16% | **17.98** |
| | | 24% | 17.06 |
| 24.13 | 14 Days | 8% | 22.44 |
| | | 16% | **21.17** |
| | | 24% | 20.13 |
| 28.84 | 28 Days | 8% | 26.62 |
| | | 16% | **25.80** |
| | | 24% | 24.76 |

**B. Dr. G. Elangovan (September 2015).** Studied "partial replacement of fine aggregate by fly ash and coarse aggregate by Polystyrene" using M20 grade of concrete. This study replaces fine aggregate by Flyash in varying percentages of 20%, 40%, 60% and 80% and coarse aggregate by polystyrene in varying percentages of 0.1%, 0.2%, 0.3%, and 0.4%. The study concluded that, by replacing fine aggregate by 60% with fly ash and coarse aggregate by 0.3% of Polystyrene the highest strength of 23.5N/mm$^2$ who was achieved and its percentage improvement was 47.28%.This experimental work proves that fly ash can be used as an partially alternative material for fine aggregate in the concrete and makes the concrete more economical and eco-friendly concrete as well. The experimental results of their work are given below:

**Table 3.2 Compressive strength**

| Mix | Compressive strength after 7 days curing | | Compressive strength after 28 days curing | |
|---|---|---|---|---|
| | **Strength** | **% Improvement** | **Strength** | **% Improvement** |
| M20 conventional mix | 15.99 Mpa | - | 20.88Mpa | - |
| M20 (20%flyash-20% fine aggregate+0.1% Thermocol ) | 20.74Mpa | 29.71% | 23.70Mpa | 13.51% |
| M20 (40%flyash-40% fine aggregate+0.2% Thermocol ) | 22.66Mpa | 41.71% | 25.32Mpa | 21.26% |
| M20 (60%flyash-60% fine aggregate+0.3% Thermocol ) | **23.55Mpa** | **47.28%** | **25.62Mpa** | **22.70%** |
| M20 (80%flyash-80% fine aggregate+0.4% Thermocol ) | 16.59Mpa | 3.75% | 19.10Mpa | -8.52% |

**C.** **Nagaswaram Roopa, K. Supriya and P. Rasheed Khan (March 2017),** did the "experimental Study on Light Weight Concrete by Partial Replacement of Cement and Fine Aggregate with Fly Ash and Polystyrene". This project focuses on investigating the characteristics of M25 grade of concrete with cement partially replaced with fly ash 35%, 40% and fine aggregate replaced with Polystyrene 0.2%, 0.3% respectively. The compressive strength of concrete is increases from 33.25 N/mm$^2$ to 35.5 N/mm$^2$ at 35% of fly ash and 0.2% of Polystyrene replacement and increases from 33.25 N/mm$^2$ to 36.8 N/mm$^2$ at 40% of fly ash and 0.3% of Polystyrene replacement. The experimental results of their work are given below:

**Table 3.3 Compressive strength**

| Mix | 3 Days compressive strength (N/mm$^2$) | 7 Days compressive strength (N/mm$^2$) | 28 Days compressive strength (N/mm$^2$) |
|---|---|---|---|
| Normal Mix | 10.7 | 21.2 | 33.25 |
| 35% Flyash + 0.2% of Thermocol | 11.2 | 24.3 | 35.5 |
| 40% Flyash + 0.2% of Thermocol | 12.3 | 25.1 | 36.8 |

**D.** **Lakshmi Kumar, Minapu, et al (Dec 2014).** Investigated the "Study on Light Weight Aggregate Concrete with Pumice Stone, Silica Fume and Fly Ash as a Partial Replacement of Coarse Aggregate"**.** In this study, an attempt has been made to study the Mechanical Properties of a structural grade light weight concrete M30 using the light weight aggregate pumice stone as a partial replacement to coarse aggregate and mineral admixture materials like Fly Ash and Silica Fume. They concluded that by using 20% of light weight aggregate as a partial replacement to natural coarse aggregate the compressive strength is promising. The density of concrete is found to decrease with the increase in percentage replacement of natural aggregate by pumice aggregate. The compressive strength of concrete is found to decrease with the increase in pumice content. With the addition of mineral admixtures, the compressive, split-tensile and flexural strengths of concrete are increased. The experimental results of their work are given below:

**E.** **Rajeswari S, Dr. Sunilla George (May 2016 )** did the experimental study of light weight concrete by partial replacement of coarse aggregate using Pumice stone using M25 grade of concrete. The light weight concrete was made by partial replacement of coarse aggregate by Pumice stone in the varying percentages of 50%, 60% and 70%. They concluded that at 60% replacement the strength of concrete was maximum (22.14Mpa) as compared to 50% and 70% replacement where strength was 13.32Mpa and 8.85Mpa respectively after 28 days of curing. They also concluded that this type of concrete can be utilized in wall panels of non load bearing type for use in precast panels.

**F.** **M Praveen Kumar, Dr. K Rajeskhar (Sept 2016)** investigated light weight concrete by partial replacement of coarse aggregate by pumice stone and cement by GGBS using M30 grade of concrete. The light weight concrete was made by partial replacement of coarse aggregate by Pumice stone in the varying percentages of 25%, 35% and cement by GGBS in varying percentages of 5%, 10%, 15%, 20%, 25% and 30%. The researcher concluded that strength decreases with the increase in light weight aggregate. 25% of light weight aggregate gives higher values for compressive, split tensile and flexural strength. They also found that density is also reduced by 695kg/m$^3$.At 20% GGBS and 25% pumice stone the compressive and split tensile strength was highest valued as 38.25Mpa and 4.86Mpa respectively at 28 days. In case of 35% replacement by pumice stone the compressive and split tensile strength was highest at 20% GGBS as

37.25Mpa and 4.76 Mpa respectively at 28 days. They also concluded that workability of concrete is also very better same as that of normal aggregate. By using 20% of light weight aggregate as partial replacement of normal aggregate the strength was found to be promising.

**G.** **Thousif Khan, et al (May 2018)** Studied floating concrete using lightweight materials. In this study the coarse aggregate was partially replaced by Polystyrene beads and pumice stone in varying ratios. The study concluded that the mix ratio with 50% replacement of coarse aggregate pumice stone and Polystyrene beads show best results for compressive strength and tensile strength. The compressive strength of 5.60 Mpa and tensile strength of 1.14 Mpa can be achieved using the materials chosen in the study. The volume of aggregates can be maintained in the range of 0.7 to 0.75 for achieving floating concrete. They also concluded that pumice and Thermocol beads could be used as an alternative for coarse aggregate. Crushed pumice stone can also be used as a replacement for sand.

**H.** **Kothari Akash and Chaudhari Balasaheb(April 2017)** the study of lightweight precast concrete using polystyrene was done. This paper present of an experimental study on the effect of using industrial waste Polystyrene as a potential aggregate in light weight precast concrete panel. In this study polystyrene aggregate was used as replacement of natural aggregate at the level of 40% 50% and 60% by volume and Crush sand stone was replaced by polystyrene at the level of 10% 20% by volume. The replacement of 40% natural aggregate bipolar string beads and placement of 10% crushed sand stone showed maximum Compressive strength of 6.18 $N/mm^2$. The cost of this panel is 30% - 40% less than conventional concrete panel. Light weight precast concrete panel made using Polystyrene are effectively used in partition walls, compound wall, parapet wall, w/c unit, road divider and other non load bearing elements of the buildings as they provide required compressive strength. These elements show good thermal insulations and durability. Light weight concrete can be made in any size and shape as per the requirement.

**I.** **Vinod Goud, et al (oct 2016)** did the experimental study of partial Replacement of Cement with Fly Ash In Concrete And Its Effect. The research was done on M25 grade of concrete and the replacement of fly ash with cement was 10%, 20% and 30%. The research concluded that slump loss of concrete increases with increase in w/c ratio of concrete. The 10% and 20% replacement of cement with fly ash shows good compressive strength for 28 days and the 30% replacement of cement with fly ash ultimate compressive strength of concrete decreases.

## 3. CONCLUSION

1. Pumice stone being porous light weight aggregate absorbs more water as compared to normal coarse aggregate so it becomes less workable.
2. With the increase in percentage of light weight aggregate density of concrete also decreases thus making concrete lighter as discussed by various papers.
3. The researchers also concluded that with the increase in percentage of light weight aggregate strength of concrete decreases.
4. However with the addition of mineral admixtures the strength of concrete increases considerably.
5. It is also seen in various papers that flyash gives the delayed strength to concrete.
6. It is recommended from the above research papers that flyash should not be used more than 35-40% as delayed strength of flyash may result is delayed use of structure.

## REFERENCES

1. **Rakesh Kumar Saini, Anil Godara, Anurag Maheshwari, Ashish Kumar Meena (May 2018)** Experimental study on Light Weight Concrete with Pumice Stone as a Partial Replacement of Coarse Aggregate.
2. **Dr. G.Elangovan (September 2015)** Experimental Study on Light Weight Concrete by Partial Replacement of Fine Aggregate Using Fly Ash and Adding Thermocol. Dean University College of engineering, Thirukkuvalai.
3. **Nagaswaram Roopa, K. Supriya and P. Rasheed Khan (March 2017)** Experimental study of light weight concrete by partial replacement of cement and fine aggregate by flyash and Thermocol. RGM college of engineering and technology.
4. **Lakshmi Kumar, Minapu, et al (Dec 2014)** Study on Light Weight Aggregate Concrete with Pumice Stone, Silica Fume and Fly Ash as a Partial Replacement of Coarse Aggregate**.**
5. **Rajeswari S, Dr. Sunilla George (May 2016 )** Experimental study of light weight concrete by partial replacement of coarse aggregate using Pumice stone using M25 grade of concrete.
6. **Thousif Khan, et al (May 2018)** floating concrete using lightweight materials.
7. **Kothari Akash and Chaudhari Balasaheb(April 2017)** Study of lightweight precast concrete using polystyrene.
8. **Vinod Goud, et al (oct 2016)** Experimental study of partial Replacement of Cement with Fly Ash In Concrete And Its Effect.
9. **M Praveen Kumar, Dr. K Rajeskhar (Sept 2016)**Light weight concrete by partial replacement of coarse aggregate by pumice stone and cement by GGBS using M30 grade of concrete.