

# A Study on properties of Light weight Concrete using Expanded Poly Styrene Beads by observing Density and Stress-Strain Curves

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**Abstract** – Thermocol is a commercial name of Expanded Polystyrene (EPS) which is widely used as equipments handling tool during transportation to absorb vibration. After the EPS becomes a disposal waste. Disposal is difficult because EPS is non-biodegradable. Due to its lightness, it serves as aggregate in concrete as it can be replaced partially or fully in the place of Natural Fine Aggregate or Natural Coarse Aggregate. EPS can be replaced for Coarse or Fine aggregate by making it into different sizes by Modifying Heat Treatment process. The resulting product is called as Modified Polystyrene (MEPS) Beads.

In the present study the natural coarse and fine aggregates are replaced partially with different percentages of MEPS such as 20%,40%,60%,80% and 100% respectively for medium grade concretes to find out the Fresh properties such as Workability, Hardened properties such as Density and Stress-Strain behavior. A series of Cylinders were casted for the above five different proportions and the Mechanical Properties are determined. The variation of each property with respect to the percentage replacement of MEPS are represented in the graphical form.

**Index Terms** – Modified Expanded Polystyrene (MEPS), Expanded Polystyrene (EPS), Workability, Density, Stress-Strain Behavior.

## 1. INTRODUCTION

Concrete is a building material in the human history. It consists of Cement, Coarse and Fine Aggregates and Water. It is no doubt that with the improvement of human civilization concrete will continue to be a governing construction material in the future.

Concrete is probably the most widely used construction material in the world. It is only second to water as the most profoundly consumed substance with about six billion tons being produced every year. There are many types of concrete designed to suit a variety of purposes coupled with a range of compositions finishes and performance characteristics. Some of them are Old Concrete recipes, Modern concrete, High-

Strength concrete, Stamped concrete, High-performance concrete, Ultra-high-performance concrete, Micro-reinforced ultra-high-performance concrete, Self-consolidating concrete, Vacuum concrete, Pervious concrete, Roller compacted concrete, Asphalt concrete, Rapid strength concrete, Rubberized concrete, Gypsum concrete, Regular concrete, Pervious concrete, Cellular concrete, (fork-cement composites, Roller-compacted concrete, Glass concrete, Asphalt concrete, Rapid strength concrete, Refractory Cement, Concrete cloth, Innovative mixtures, Lightweight concrete, Ultra light weight concrete.

The application of concrete and other aggregate based materials is caused by a number of factors including their worldwide availability relatively low price, good mechanical properties and durability. The good stability of concrete in normal exposure conditions has been long recognized. Although, the modern production technology of aggregates, cement and concrete is much better compared to the past, the high cost of construction of new buildings and structures and disruption associated with replacement and removal makes more attention being paid to ensure durable buildings or structures. There are many deleterious substances and deterioration mechanisms that impair the service-ability of concrete. Some of these mechanisms concern the chemical attack on concrete, while some others are related to physical interactions and mechanical damage. The chemical deterioration of concrete can be caused e.g. by chloride attack, decalcification of the cement hydration products, alkali-silica reaction or deterioration of steel re-bars in concrete resulting from the depassivation of steel. The physical deterioration of concrete is most often related to the freeze-thaw induced damage differences between the thermal expansion of aggregates and cement paste and to the exposure of concrete to elevated temperatures. The mechanical damage can be caused by abrasion or impact. Nevertheless, in practice, the most often

occurring mechanisms of deterioration of concrete are closely related to the ease of penetration of deleterious substances into the concrete and subsequent corrosion of steel.

### STRUCTURAL LIGHTWEIGHT CONCRETE

The Structural Lightweight concrete is one of the important materials of the construction. A concrete which is light in weight and sufficient strong and it is to be used in combination with steel reinforcement will be a material which is more economical than the conservative concrete. Therefore, a concrete which combines strength and lightness will have the indisputable economic advantage. According to ACI 213 R, the structural lightweight aggregate concrete can be defined as the concrete which has a minimum 28-d compressive strength of 17 MPa, an equilibrium density between 1120 kg/m<sup>3</sup> and 1920 kg/m<sup>3</sup> and consists entirely of lightweight aggregate or a grouping of lightweight and normal density aggregate.

### IMPORTANCE OF LIGHTWEIGHT AGGREGATES

The use of lightweight aggregate (LWA) in construction industry will increase in near future since it offers functional and economical advantages to the house building projects particularly. The voids and pores in these aggregates improve the thermal and acoustical insulating properties. Moreover, low density products reduce self weight, foundation size, and construction costs. There are different types of LWA suitable for construction purposes. They vary in their composition, density, surface texture, porosity and water absorption capacity. Some LWAs occur naturally; others are manufactured from natural materials or from industrial by products. Because they are found only in some parts of the world, natural LWAs are not extensively used.

Furthermore, the physical and micro structural properties of artificial LWAs can be perfectly controlled since they are produced by some treatments but problems such as low tensile/compressive strength ratio, low flexural strength, low fracture toughness, high brittleness and larger shrinkage, prevented its use in concrete structure. The addition of steel fiber to light-weight concrete has important effects on the improvement on properties of strength of light-weight concrete, especially for improving tensile/compressive ratio, behavior of earthquake resistance, resistance to cracking and fracture toughness. The most widely used artificial LWAs are expanded polystyrene.

Expanded clay, expanded glass, perlite, expanded vermiculite and sintered ash. The production of lightweight expanded polystyrene (EPS) aggregate becomes more popular since the raw material is waste EPS foams which is abundant all over the world.

### THERMOCOL AS AGGREGATES

Thermocol is a commercial name of Expanded polystyrene

(EPS). In 1951 the researchers of a German company named BASF successfully restructured chemical bonding of polystyrene (a synthetic petroleum product) molecules and developed a substance named stretch polystyrene. This substance was named Thermocol, which nowadays is manufactured through a simple process. Thermoplastic granules are expanded through application of steam and air. Expanded granules become much larger in size but remain very light. Thermocol is a good resister of cold and heat but since it is a petroleum product it dissolves in any solvent of petroleum.

The lightweight of this product is largely attributed to a relatively high proportion of semi-closed pores which can account for up to 90 % of the particle volume. The porous structure of loose expanded polystyrene granules is composite and formed by the voids between individual grains and by the air-filled opening in the grain base. The expansion occurring in the ceramic body is caused by steam and gases, forming at different temperatures, which for various reasons are unable to escape from the body. In this experimental investigation, Thermocol waste was used as aggregates which are modified by Heat Treatment Method and the effects of polystyrene aggregate properties, amount of usability, and level of temperature on the physical and micro-structural properties of EPS granules were examined.

### 2. OBJECTIVES OF THE STUDY

The main objective of this project is to provide some basic information on mechanical properties of concrete using artificial MEPS aggregates. MEPS aggregate concrete mixtures were obtained by replacing natural aggregate with the MEPS aggregates. In addition, the effects of the MEPS aggregate on compressive strength, splitting-tensile strength and flexural strength were investigated. To examine the benefits of modified EPS aggregates replaced to natural coarse aggregates (NCA) and natural fine aggregates (NFA) individually and jointly in concrete. In the study, the effects of addition of modified EPS coarse aggregate (MEPS CA) and modified EPS fine aggregate (MEPS PA) as aggregates on fresh and hardened properties of concrete are investigated. The precise objectives of the study are as follows:-

➤ To study the fresh property (compaction factor, fresh density) of concrete.

➤ To study the hardened properties (density) of concrete at 28 days curing age for different replacements of MEPS like:

1. In M20 grade concrete replacing the fine aggregate with EPS at 0%, 20%, 40%, 60%, 80% and 100%.

2. Similarly replacing the coarse aggregate with EPS at 0%, 20%, 40%, 60%, 80% and 100% in the same grade of concrete.

3. In M25 grade concrete replacing the fine aggregate with EPS at 0%, 20%, 40%, 60%, 80% and 100%.

4. Similarly replacing the coarse aggregate with EPS at 0%, 20%, 40%, 60%, 80% and 100% in the same grade of concrete.

5. In M30 grade concrete replacing the fine aggregate with EPS at 0%, 20%, 40%, 60%, 80% and 100%.

6. Similarly replacing the coarse aggregate with EPS at 0%, 20%, 40%, 60%, 80% and 100% in the same grade of concrete.

### 3. CONCRETE MIX DESIGN

Water	cement	Fine agg.	Coarse agg.
191.58 lit	426kg	583kg	1158kg
0.45 :	1	1.37	2.71

Hence the Mix is 1:1.37:2.71 (Designed for M20)

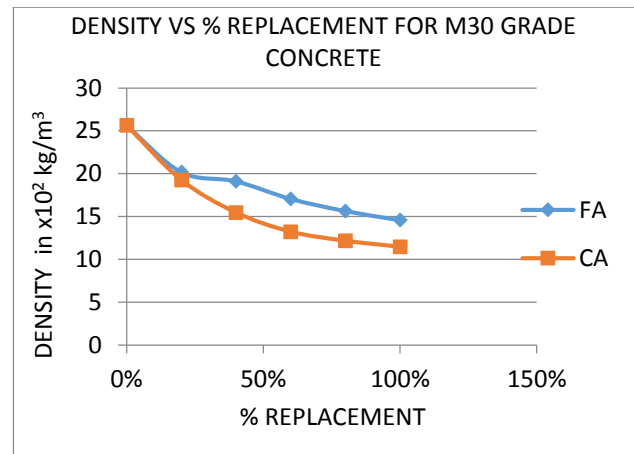
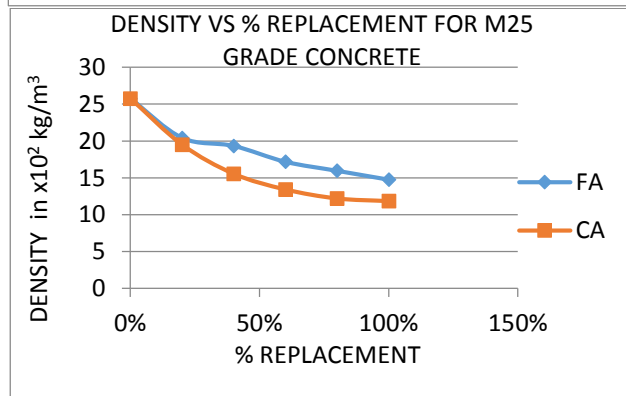
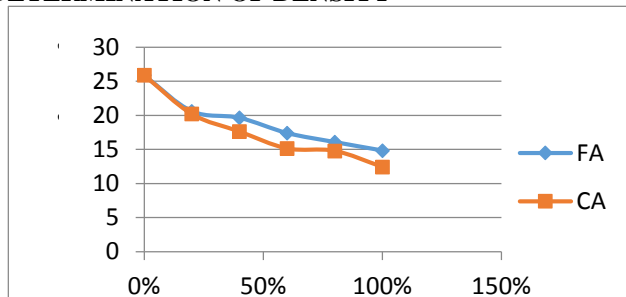
Similarly for M25 & M30 the mix proportions are as follows:

Water	cement	Fine agg.	Coarse agg.
182.25 lit	405kg	515kg	1028.7kg
0.45 :	1	1.274	2.54

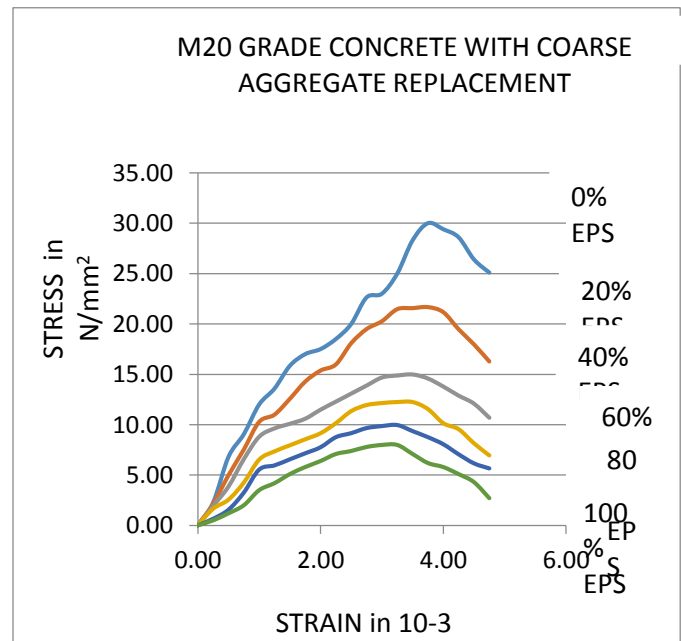
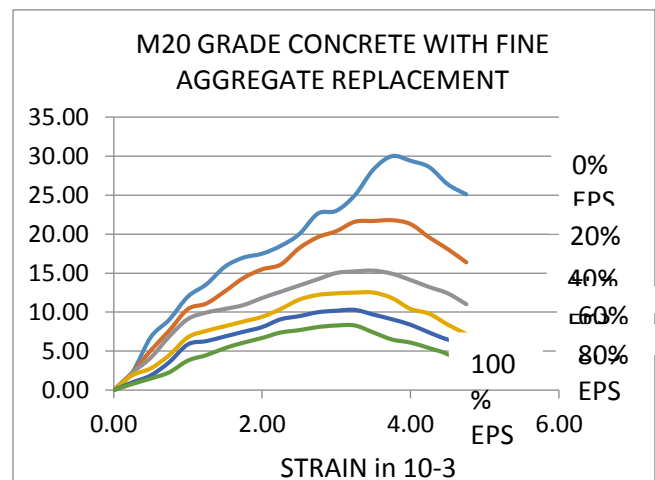
Water	cement	Fine agg.	Coarse agg.
160 lit	380kg	437kg	855kg
0.42 :	1	1.15	2.25

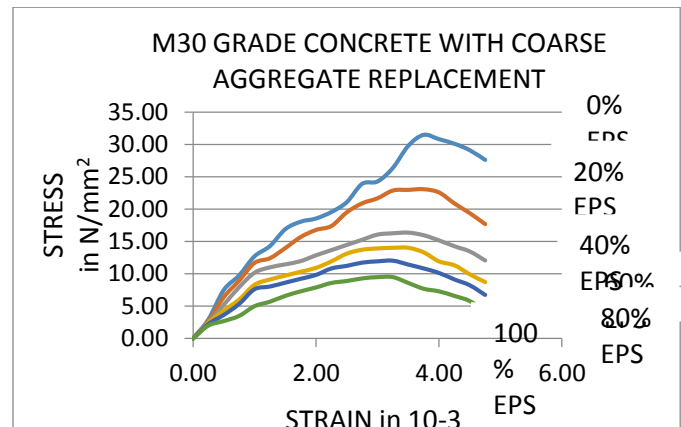
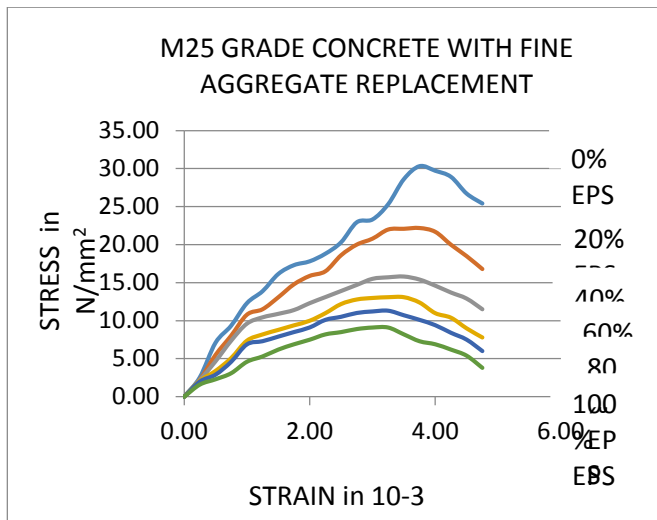
### 4. EXPERIMENTAL RESULTS

#### DETERMINATION OF DENSITY



#### STRESS-STRAIN CURVES

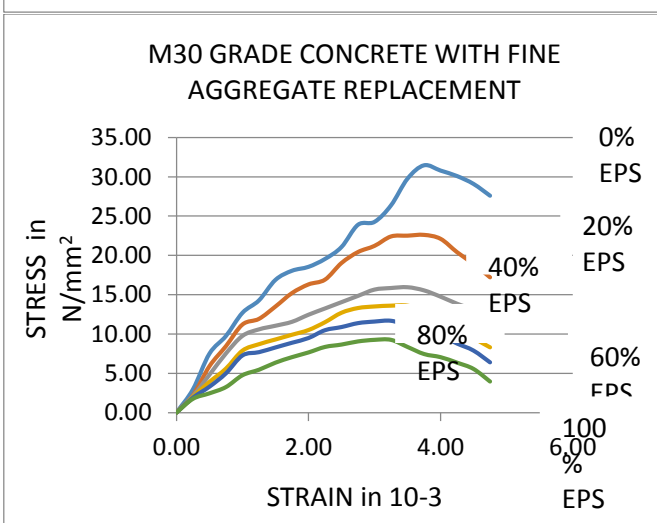
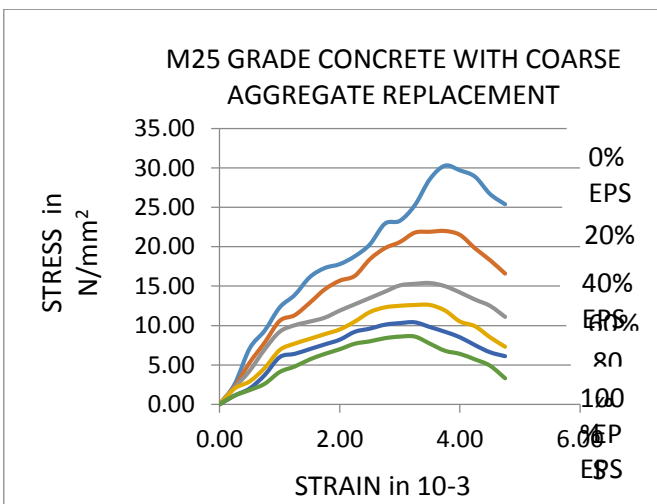




## 5. CONCLUSION

The following conclusions are drawn from the study:

1. The use of EPS waste for making MEPS aggregate not only solves the disposal problems of EPS but also helps to preserve natural resources. A new recycling understanding to shrink waste EPS was built-up by using Heat Treatment Method. Complete replacement of MEPS aggregates with natural aggregates in conventional concrete gives maximum usage of EPS. The distribution of Particle sizes of MEPS CA & FA differs from NCA & NFA, but the grading can be stable as per codal specifications.
2. The pre-wetted MEPS aggregates exhibits retarding action. The concrete with pre-wetted MEPS aggregate without a special bonding agent exhibit good workability. So it is easy to compact and finish.
3. The density of the conventional concrete are reduced by increasing the volume of MEPS Fine aggregate and Coarse aggregate.
4. When the FA and CA are replaced with MEPS at maximum percentages, there is maximum decrease in the density (55.30%).
5. As the strength are considerably decreasing in the above process, this concrete can be used for:
  - (i) Thermal Insulation
  - (ii) Partition Walls
  - (iii) Parking Tiles.
  - (iv) Offshore structures
  - (v) sun shades
  - (vi) False ceilings
  - (vii) Aesthetic decors.
  - (viii) Sound insulation.



6. By using this light weight concrete in the building components, the dead load of the structure reduced considerably thereby the sizes of the members in the design can be reduced and ultimately leads to economy of the structure.

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