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RESEARCH ARTICLE

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A STUDY ON PROPERTIES OF LIGHT WEIGHT CONCRETE USING EXPANDED POLY STYRENE BEADS BY OBSERVING WORKABILITY, COMPRESSIVE STRENGTH AND SPLIT TENSILE STRENGTH

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ABSTRACT

Thermocol is a commercial name of Expanded Polystyrene (EPS) which is widely used as equipment 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 Compression Strength and Split Tensile Strength. 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 is represented in the graphical form.

Keywords: Modified Expanded Polystyrene (MEPS), Expanded Polystyrene (EPS), Workability, Compressive Strength, Split Tensile Strength.

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 modem 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/m3 and 1920 kg/m3 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 AGGREAGATES

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 arc 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 granulates 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 a 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.

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 a 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) of concrete.
- To study the hardened properties (compressive strength, split tensile strength) of concrete at 28days 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% and100%.
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.

CONCRETE MIX DESIGN:

Table. Mix proportion for M20 Grade Concrete

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

Table. Mix proportion for M25 Grade Concrete

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

Table. Mix proportion for M30 Grade Concrete

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

EXPERIMENTAL WORK

WORKABILITY: The ease with which the concrete can be mixed, transported and placed is called as workability. It depends on the water content, aggregate, cementitious content and age and it can be modified by adding chemical admixtures, like super plasticizer. Raising the water content or by adding chemical admixtures increases concrete workability. Excessive water leads to the increased bleeding and segregation of aggregates, with the resulting concrete having been reduced quality. The use of an aggregate with an undesirable gradation can result in a very harsh mix design with very low slump, which cannot readily made more workable by adding reasonable amounts of water. The cone is then placed with the wide end down onto a level, non-absorptive surface. It can be filled in three layers of equal volume, with each layers being tamped with a steel rod to consolidate the layers.

A workable concrete is the one which exhibits very little internal friction between particle and particle. When the cone is carefully lifted, the enclosed materials slumps a certain amount due to gravity. A relatively dry sample slumps very little, have slump value one or two inches out of one foot. A relatively wet concrete sample may slump as much as the eight inches. Workability can also measure by using the flow table test.

Assumption of right workability with proper understanding backed by experience will make the concreting operation economical and durable. Slump can be amplified by the adding up of chemical admixtures such as plasticizer without changing water/cement. Some other admixtures, especially air entraining admixture can amplify the slump of mix.

COMPRESSION TEST:

a) Remove the specimens from water after specified curing time and wipe out excess water from the surface.

b) Leave the specimen in the atmosphere for 24hours previous to testing. Put the specimen in the machine in such a way that the load shall be applies to the opposite sides of the specimen cast.

c) line up the specimen centrally on the base plate of the machine for a cubic or cylindrical specimen.

d) Turn the movable portion gently by hand so that it touches the top surface of the specimen.

e) Apply the load slowly without shock and constantly at the rate of 140kg/cm^2 minute till the specimen fails. Increase the load until failure and note the utmost load

Figure Showing Compressive testing machine

SPLIT TENSILE TEST: a) Remove the specimen from water after specific curing time and wipe out excess water from the surface.

b) Leave the specimen in the atmosphere for 24hours previous to testing. Place the specimen in the machine in such a manner that the load shall be applies to the opposite sides of the specimen cast.

c) line up the specimen centrally on the base plate of the machine for a cubic or cylindrical specimen.

d) Rotate the changeable portion gently by hand so that it touches the top surface of the specimen.

e) Apply the load gradually without shock and continuously at the rate of 140kg/cm^2 minute till the specimen fails .Increase the load until failure and note the utmost load.

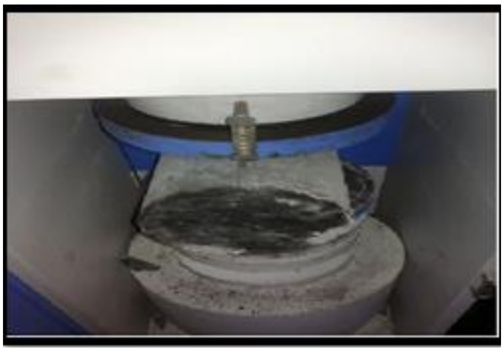
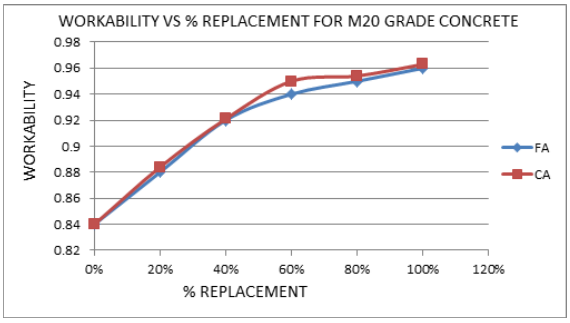
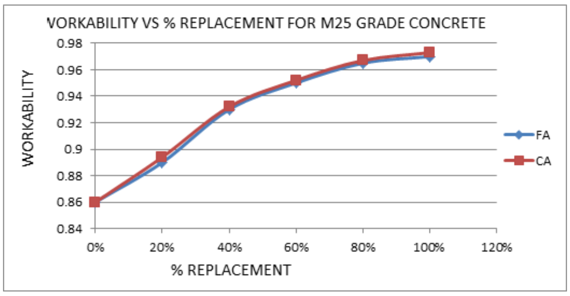


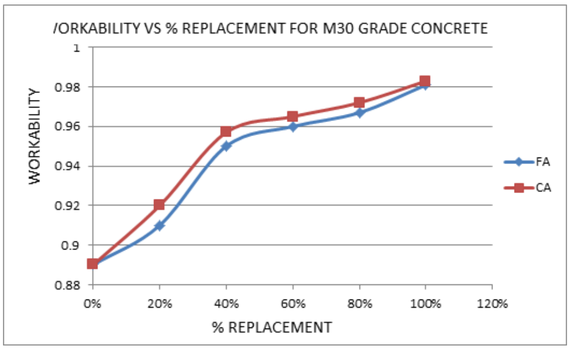
Figure Showing split tensile strength testing

FINAL TEST RESULTS:

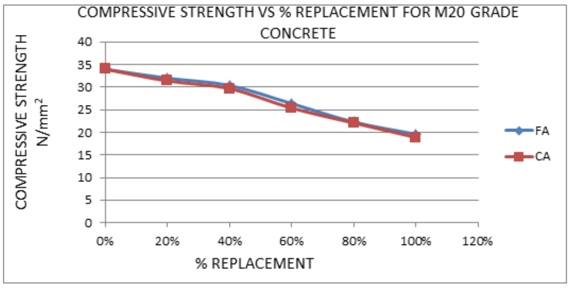
DETERMINATION OF WORKABILITY USING COMPACTION FACOR TEST:

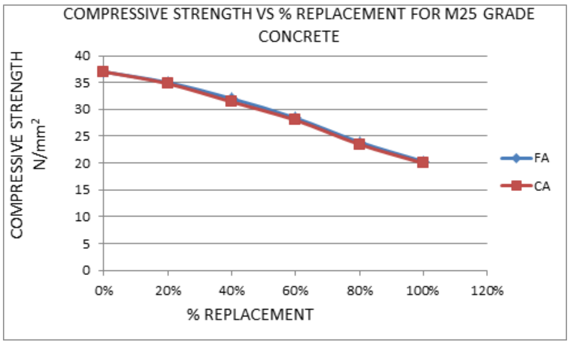


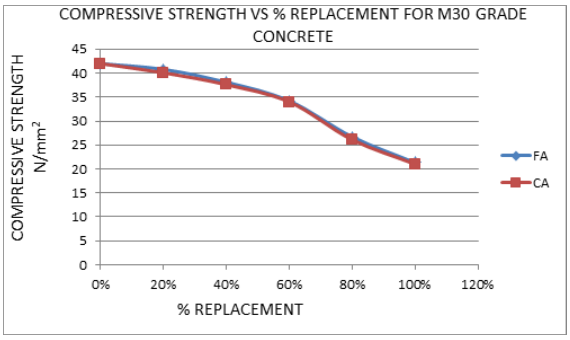




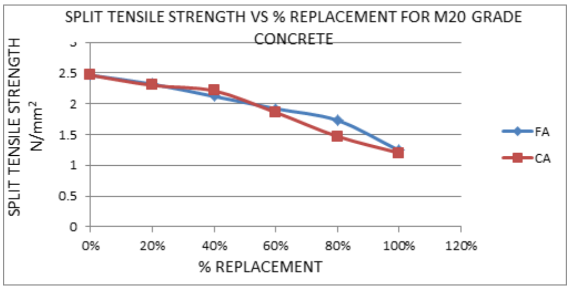
DETERMINATION OF COMPRESSIVE STRENGTH

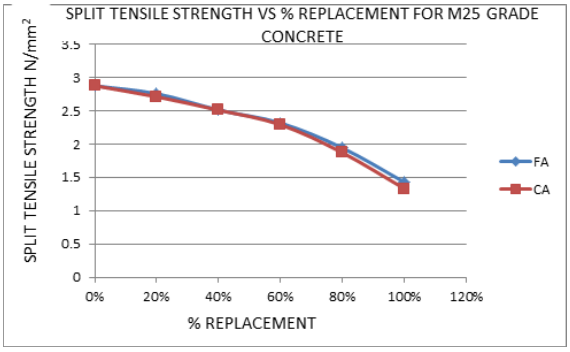


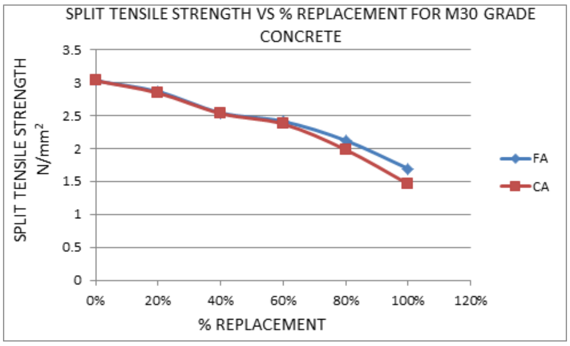




DETERMINATION OF SPLIT TENSILE STRENGTH:







CONCLUSIONS

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. Workability increases with the increase in pre-wetted MEPS aggregate volume.
3. The compressive strength and split tensile strength 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 a decrease in Compressive strength and Split Tensile Strength by 50% and 51.76% respectively.
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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