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# Properties of Concrete on Replacement of Coarse Aggregate and Cementitious Materials with Styfoam And Rice Husk Ash Respectively

Ananya Sheth[1], Anirudh Goel[2], B.H.Venkatram Pai[3]
*[1,2,3]Department of Civil Engineering, Manipal Institute of Technology / Manipal University, India*

***Abstract: -*** This paper reports an experimental investigation on the influence of Rice Husk Ash (RHA)and Expanded Poly Styrene (EPS) on the mechanical properties and the properties of fresh concrete of the produced RHA and EPS blended concrete. EPS aggregates were used to replace coarse aggregates by volume with an aim to decrease the unit weight. Locally produced RHA was used to replace cement by its weight with an aim to increase workability.

Mixture proportioning was performed to produce target strength of 65 MPa. Past researches regarding complete replacement of coarse aggregates with EPS aggregates have shown strength of less than 10 MPa. Hence, our aim is to achieve strength of 25-30 MPa thereby utilizing environmentally sustainable concrete in the rapidly developing low cost housing sectors of developing countries.

***Keywords: –*** *environment, sustainable concrete, expanded polystyrene, rice husk ash, low cost housing, concrete, 25 MPa, 4 more key words.*

## I. INTRODUCTION

Medium weight concrete is the choice of designers owing to lighter and more economic structures. Medium weight concrete is produced by introducing air inside the concrete; either by using gassing and foaming agent or using lightweight aggregate such as natural aggregate (pumice, shale, slate) or industrial by-product (palm oil clinker, sintered fly ash) or plastic granules (Styrofoam or polymer materials). The high porosity of such industrial by-product and natural aggregates would cause adsorption of water and would prove disadvantageous in terms of shrinkage and permeability.

Styrofoam is popularly used as a good thermal insulation material in building construction. Besides, it is widely used in the packaging industry especially as a damping agent to protect soft goods from vibrations and damage during transportation. It has no secondary use and is treated as a waste product. Its is difficult to recycle which as a whole is not a fundamental process in developing countries. We propose the use of Styrofoam cubes in concrete to replace by weight, a percentage of coarse aggregate (grit) with a purpose to make our concrete lighter. The Styrofoam aggregate has a closed cell structure consisting essentially of 98% air. Due to the porosity and buoyancy, the lightweight aggregates in fresh concrete tend to float on the concrete surface.

Rice husk is an agro-by product which is produced in large quantities in agrarian countries. Approximately, 20 Kg of rice husk is obtained from 100 Kg of rice. Rice husk is constituted by 80% organic and 20% inorganic substances. When rice husk is combusted, the ash obtained can be termed Rice Husk Ash (RHA). It contains a high amount of amorphous phase content such as silicon dioxide which is the primary constituent of Portland cement. Therefore, RHA may be used as a constituent material in lime-pozzolana and/or a replacement for both cement as well as silica fumes.

Concrete samples were synthesized by mixing ordinary Portland cement, sand and coarse aggregate (grit) where some part of grit and cement was replaced (by weight), with Styrofoam aggregates and RHA respectively. A comprehensive range of samples having various permutations of density and compressive strength were obtained by proportioning the replacements.

## II. EXPERIMENTAL DETAIL

**2.1 MATERIALS.**

2.1.1 CEMENT.

Ordinary Portland Cement - Grade 42

2.1.1.1 CHEMICAL COMPOSITION.

Silicon dioxide (SIO2) 21.00; Aluminium oxide (AL2O3) 5.30; Ferric oxide (FE2O3) 3.30; Calcium oxide (CAO) 65.60; Magnesium oxide (MGO) 1.10; Sulphur tioxide (SO3) 2.70; Loss of ignition (LOI) 0.90; Tricalcium silicate (C3S) 60.00; Dicalcium Silicate (C2S) 15.00; Tricalcium aluminate (C3A) 8.05; Tricalcium alumino ferrice (C4AF) 9.76.

2.1.1.2 PHYSICAL AND MECHANICAL PROPERTIES.

Blain CM2/GR 3.250, Autoclave expantion 0.02, Initial setting time (VICAT) 105 minutes, Final setting time (VICAT) 135 minutes.

2.1.2 SAND.

Fine sundried sand passing through 475 micron sieve was selected as the most appropriate to make a uniform and homogeneous binding matrix of the concrete to be produced.

2.1.3 COARSE AGGREGATE.

The coarse aggregate selected were 20mm down sized crushed granite aggregates.

2.1.4 STYROFOAM AGGREGATE.

The Styrofoam aggregate were 10 x 10 x 10 mm. cubes, cut from waste EPS (Expanded Polystyrene) sheets.

2.1.5 FLY ASH.

Fly ash material solidifies while suspended in the exhaust gases and is collected by electrostatic precipitatorsor filter bags. Since the particles solidify while suspended in the exhaust gases, fly ash particles are generallyspherical in shape and range in size from 0.5 µm to 100 µm. They consist mostly of silicon dioxide (SiO2), which is present in two forms: amorphous, which is rounded and smooth, and crystalline, which is sharp, pointed and hazardous; aluminium oxide (Al2O3) and iron oxide (Fe2O3). Fly ashes are generally highly heterogeneous, consisting of a mixture of glassy particles with various identifiable crystalline phases such asquartz, mullite, and various iron oxides. For the concrete mix so produced we use Class F flyash.

2.1.6 RICE HUSK ASH (RHA).

Rice milling generates husk as its by-product. About 78 % of weight is that of the rice grain, broken rice and bran. The remaining 22 % weight is husk. This husk is used as fuel in the rice mills to generate steam for the boiling process. Husk contains about 75 % organic volatile matter and the balance 25 % weight is converted into ash during the firing process. This is known as rice husk ash (RHA). RHA contains around 85 – 90 % amorphous silica. Therefore, for every 1000 kgs of paddy milled, about 220 kgs (22%) of husk is produced. This husk when combusted in boilers, generates about 55 kgs (25 %) of RHA.

India is a major producer of rice, and the husk generated during milling is mostly used as a fuel in the boilers for processing paddy , producing energy through direct combustion and / or by gasification . About 20 million tonnes of RHA is produced annually in India. Generally, RHA is dumped in a landfill and thereby causes damage.

The particle size of the cement is about 35 microns, which is why it can reduce the amount of cement in the concrete mix. RHA is a good super-pozzolana.

There is a growing demand for fine amorphous silica in the production of special cement and concrete mixes, high performance concrete, high strength-low permeability concrete, for use in bridges, marine environments , nuclear power plants etc. This is where RHA finds an extensive use.

2.1.7 SUPER PLASTICIZER

Poly carboxylate ether based super-plasticizer, “algihyperplast-n” claims to be a recommended product for batching plant mixed concrete of M50, M60 or higher grade concrete and where very high water reduction of 30-40% early and final strength is required or where colourless superplasticizer is required. It claims application in mix M60 where collapse slump is need at w/c of 0.3. It claims to improve cohesive properties of concrete, reduce segregation and bleeding, save cement through economy in mix design, allow early demoulding. Also speed up construction.

Super plasticizer was added to the concrete mix in the ratio of 100-400ml for 50 kg of cement. Field trials are recommended to determine the optimum ratio.

### 2.2 MIX DESIGN AND PROPORTIONS.

Table 1: Mixture proportions of the synthesized concrete.

| W/C RATIO | FLY ASH | CEMENT | FA | CA |
|---|---|---|---|---|
| 0.3 | 0.6875 | 1 | 1.32 | 5.28 |

Table 2: Mix and replacement proportions.

| Mix. No. | RHA Replacement by weight of the total cementitious material. | STYRO FOAM Replace ment by volume of CA. | WATER (mL) | CEMEN T (g) | FINE AGGREG ATE (g) | COARS E AGGRE GATE (g) | FLY ASH (g) | RHA (g) | STYRO FOAM (g) |
|---|---|---|---|---|---|---|---|---|---|
| C11 | 10 % | 20 % | 1260 | 1450 | 1600 | 5600 | 900 | 260 | 16.65 |
| C12 | 10 % | 25 % | 1470 | 1450 | 1600 | 5250 | 900 | 260 | 20.80 |
| C13 | 10 % | 30 % | 1260 | 1450 | 1600 | 4550 | 900 | 260 | 29.10 |
| C21 | 20 % | 20 % | 1260 | 1280 | 1600 | 5600 | 750 | 520 | 16.65 |
| C22 | 20 % | 25 % | 1260 | 1280 | 1600 | 5250 | 750 | 520 | 20.80 |
| C33 | 30 % | 30 % | 1470 | 1120 | 1600 | 4550 | 700 | 780 | 29.10 |

A fixed amount of super plasticizer i.e. 7ml per 1kg of cementitious material was added. After that, it was tested for the fresh concrete properties of workability (the vee-bee test) and then moulded into cubical specimens of dimensions 15X15X15cm and tested to the simple compressive strength, water absorption by immersion. The tests had been carried through with ages of 7 days with curing in humid chamber.

## III. RESULT

### 3.1 WORKABILITY.

The workability, measured in VB degrees is shown in Table 3. The results show that higher amounts of RHA replacement give a very high flow mix which causes segregation and the cement sand matrix settles down causing a failure to set and harden.

Table 3: Workability, measured in VB Degrees.

| Mix. No. | C11 | C12 | C13 | C21 | C22 | C33 |
|---|---|---|---|---|---|---|
| VB-Degrees (s) | 19 | 17 | 5 | 6 | 17 | 10 |

### 3.2 WATER ABSORPTION.

The results indicate that higher substitution amounts results in lower water absorption values, this occurs due to the fact that RHA is finer than cement. Adding 10% of RHA to the concrete, a reduction of 38.7% in water absorption is observed, but the presence of styrofoam results in a certain higher percentage of water retention because the water is filled in the voids of the styrofoam so used.

### 3.3 SIMPLE COMPRESSIVE STRENGTH.

The compressive strength is shown in Table 4. The addition of RHA caused an increment in the compressive strength due to the capacity of the pozzolana to fix the calcium hydroxide; generated during the hydration of cement. All samples which contained RHA showed increased compressive strength. However, the addition of styrofoam reduced the strength of the concrete. Greater percentage replacement of styrofoam rendered lesser strength owing to the inherent lower compressive strength of the polymer as compared to granite aggregates. Micro-cracks were developed after the hydration process near the styrofoam – cement paste joints.

Table 4: Simple Compressive Strength.

| Mix. No. | C11 | C12 | C13 | C21 | C22 | C33 |
|---|---|---|---|---|---|---|
| Compressive Strength (MPa) | 26.55 | 20.55 | 23.55 | 20 | 18.2 | 15.55 |

## IV. CONCLUSION

The use of RHA in civil construction, besides reducing the environmental pollutants factors, may bring several improvements for the concrete characteristics. With the addition of RHA to concrete, a decreasing in water absorption was verified. According to the results of compressive strength test, all the replacement degrees of RHA researched showed an increase in the compressive strength to a particular level of replacement, but decreased if replaced to a higher degree.

Greater surface area of the aggregate provides a larger area for bonding contact with the cement paste. Therefore, the strength of the concrete matrix will be higher. A smaller sized aggregate would yield greater surface area and hence would provide more surface for coating with binders. Thus, the usage of smaller size aggregates of styrofoam is preferable. Moreover, due to the structure of the Styrofoam cubes, the compressive strength at the corners was observed to be stronger and the faces notably remained soft.

The highest compressive strength was obtained using minimum RHA content with the minimum Styrofoam content of size roughly 10 cubic mm. However, all the Styrofoam concrete series exhibited lower strength compared to the standard concrete mixture referring to the available literature. The concrete mixes under consideration produced strength in the range of 17-26 MPa at 7-days which is beyond the minimum requirement for structural lightweight applications, therefore this series is economical, lighter in weight and suitable for structural use.

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