Study on Fly Ash and Rice Husk Ash Based Geopolymer Concrete with Steel Fiber

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ABSTRACT

The concrete is one of the main materials in the construction industry. Geopolymer concrete is a new environment friendly construction material, using fly ash and alkali in place of OPC as the binding agent. In terms of reducing the global warming, cement is replaced by Fly ash. This paper presents the study on fly ash and rice husk ash based geopolymer concrete with steel fibre. To conduct on experimental study on the behavior of geopolymer concrete in which cement is fully replaced by fly ash and rice husk ash, this is activated by alkaline solution. The casted specimens were cured by steam curing and maintained at 60º C for 24 hours in accelerated curing tank. The test result shows that compressive strength decreases when the percentage of rice husk ash increases. At the 10% replacement of fly ash by RHA is suitable for geopolymer concrete. The main aim of this project is to encourage the use of the waste products as construction material.

Keywords: Geopolymer concrete, Fly ash, Rice Husk Ash, Steel Fibre, Alkaline activated solution.

1. INTRODUCTION

Concrete, so commonly accepted in buildings, bridges and in numerous other structures, is taken for granted as massive and weighty construction material. There were many experimental work conducted to improve the properties of the concrete by replacing or adding waste materials in the concrete mix. The waste material can be replacing the aggregates or cement in concrete. In recent year, Many researches has been conducted to reduce the aggregate and cement material in concrete. In terms of reducing the global warming, the Geopolymer technology could reduce the CO2 emission in to the atmosphere, caused by cement and aggregate industries about 80%. In this technology, the source material that is rich in silicon (Si) and Aluminium (Al) is reacted with a highly alkaline solution through the process of geopolymerisation to produce the binding material. Geopolymer concrete has excellent properties and is well-suited to manufacture precast concrete products that are needed in rehabilitation and retrofitting of structures after a disaster [1]. The compressive strength of the geopolymer concrete increases with increase in the curing time. However, the increase in strength beyond 24 hours is not much significant [2]. Due to the high viscosity of geopolymer concrete, no appreciable slump value could be obtained [3]. The two main approaches to reduce CO2emissions associated with the cement supplied for concrete manufacture are reduction of CO2 emissions during clinker production and reduction of the clinker content in cement [4]. In the fresh state, the geopolymer concrete has a stiff consistency. Although adequate compaction was achievable, an improvement in the workability was considered as desirable [5].

In order to study on the behaviour of Geopolymer concrete in which cement is fully replaced by Fly ash and Rice Husk Ash, this is activated by alkaline solution using M25 grade concrete, an experimental study has been carried out. In this experimental study eighteen mixes are prepared by varying the percentage of fly ash with Rice Husk Ash– 0%, 10%, 15%, 20%, 25% and 30% of total volume of concrete. Together with these three different percentages of steel fibers are 0%, 0.5% and 1% of total volume of concrete is added. Three specimens are casted for each mix for conducting compression test. Comparisons have been made with the values obtained and suitable conclusion has been made.

2. MATERIALS

A. Fly ash: Class F fly ash from Thermal Power Plant, was used as the base material in this work. Fly ash is finely grained residue resulting from the combustion of ground or powdered coal. Mean particle size is about 0.1 to 0.2 µm and finer than cement and consist mainly of glassy spherical particles as well as residues of hematite and magnetite. The specific gravity is 2.2.

B. Fine aggregates: Fine aggregate is natural sand which has been washed and sieved. Specific gravity of fine aggregate is 2.74. Fine aggregate particle size varies from 0.075 to 4.75 mm and the Sieve analysis test shows the soil belongs to zone 1 of soil classification.

C. Coarse aggregates: Coarse aggregates consist of aggregates larger than fine aggregate and their sizes vary from 4.75mm to 20mm. The specific gravity of coarse aggregate is 2.74.

D. Rice husk ash: Rice husk is one of the agricultural wastes. Specific gravity of Rice Husk Ash is found using le-chatelier flask is 1.87.

E. Steel fiber: Steel fibers are used for concrete construction. Many types of steel fibers are available in market today, here wavy type steel fiber is used. Diameter of steel fiber is 0.55mm and its length is 25mm. It greatly improves concrete bonding and tensile strength. Improve crack control and ductility of the concrete.

F. Activated alkaline solution:

1. **Sodium Hydroxide:** Commercial grade sodium hydroxide in flake form (97% purity) is used for test. The solution should be prepared before 24 hours to concrete mixing and the same should be used before 36 hours. The specific gravity is 1.66.
2. **Sodium silicate:** Sodium silicate solution is commercially very cheap compared to sodium hydroxide. The specific gravity of sodium silicate is 1.76.

3. EXPERIMENTAL WORK

The M25 grade of geopolymer concrete in which cement is fully replaced by fly ash and rice husk ash with steel fibers. The ratio between Sodium hydroxide to sodium silicate is 1:2.5. Molarity of NaOH to be used in the concrete is 16 molar in which 444 grams of NaOH solids dissolved in 1 liter of water. A total of 54 concrete cubes of size 100mm x 100mm x 100mm are casted. During casting, the inner surface of the mould is coated with a thin layer of oil in order to help the demoulding easy and to have sharp corner. The concrete is filled in three layers. Each layer is compacted with the standard tamping bar and cast. All the ingredients of concrete were kept and mixed at the room temperature. Mixing and placing of the concrete are done as per IS 456-2000. The samples were cured at the accelerated curing tank at 60º C for 24 hours and tested. Compression tests on the cube specimens are carried out to determine the compressive strength. Proportioning of materials for concrete mix under study is given in Table 1 and mix proportion of M25 grade geopolymer concrete is given in Table 2.

Table 1. Proportioning of materials for concrete mix

Fly Ash	100%	90%	85%	80%	75%	70%
Rice Husk Ash	0%	10%	15%	20%	25%	30%

Table 2. Mix proportion of M25 grade geopolymer concrete

Replacement of RHA	0% [kg/m3]	10% [kg/m3]	15% [kg/m3]	20% [kg/m3]	25% [kg/m3]	30% [kg/m3]
Fly ash	320	288.6	271.7	255.7	240	224
RHA	0	27	40.5	54	67.5	81
Fine aggregate	814.2	814.2	814.2	814.2	814.2	814.2
Coarse aggregate	1328.5	1328.5	1328.5	1328.5	1328.5	1328.5
Sodium hydroxide	36.6	36.6	36.6	36.6	36.6	36.6
Sodium silicate	91.5	91.5	91.5	91.5	91.5	91.5

4. RESULTS AND DISCUSSION

A. Compressive strength: The compressive strength of the geopolymer concrete in which cement is fully replaced by fly ash and rice husk ash are tabulated in table [2]. Graphs are plotted for compressive strength vs % replacement of fine aggregate in fig 4. It can be seen that compressive strength of the cubes are gradually decreasing when the percentage of rice husk ash increases.

Table 2. Compressive strength of geopolymer concrete

Percentage of Fly ash replaced by RHA	Compressive strength without steel fibre in [N/mm²]	Compressive strength with 0.5% steel fibre in [N/mm²]	Compressive strength with 1% steel fibre in [N/mm²]
0%	28.30	26.42	24.93
10%	25.42	23.71	22.57
15%	22.41	21.32	21.29
20%	19.91	18.03	17.32
25%	17.60	16.45	15.62
30%	15.89	15.24	14.06

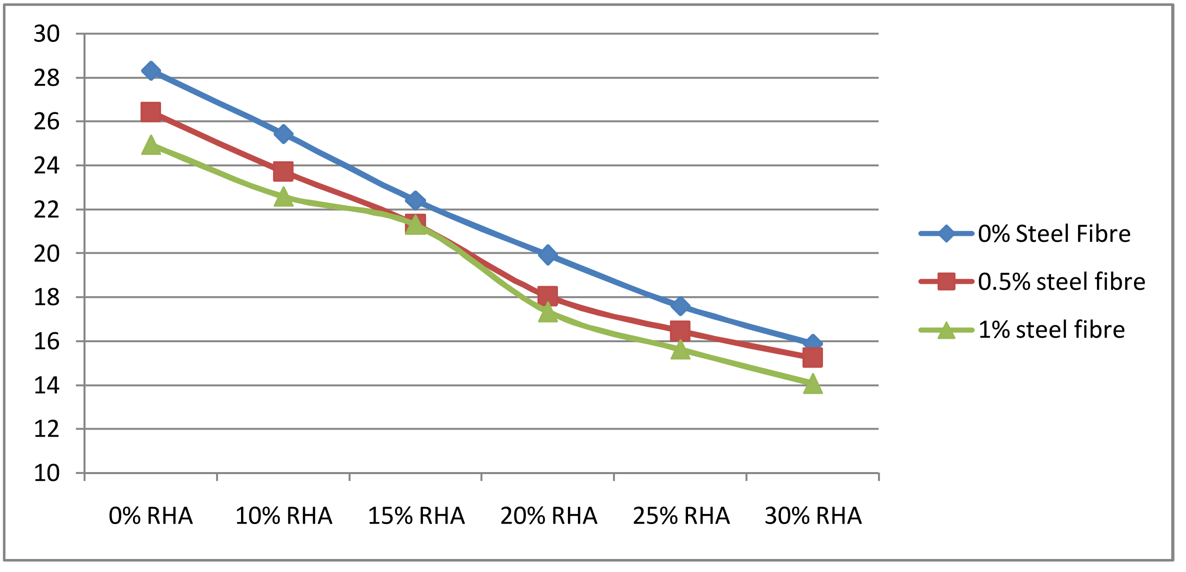

Fig 4. Variation of compressive strength of different mixes

It is observed that 10% replacement of fly ash by RHA decreases 10.2% of compressive strength than the normal geopolymer concrete. The compressive strength of the cubes decreases, when the percentage ratio of rice husk ash increases. When adding 0.5% and 1% of steel fibre into the geopolymer concrete without rice husk ash decreases 6.6% and 11.9% of compressive strength respectively.

B. **Workability:** The workability of the fresh geopolymer concrete decreases when the fly ash is replaced by rice husk ash and the steel fibre is also reducing the workability of concrete. At the 25% and 30% replacement of fly ash with rice husk ash has very low workability. We should use some chemical admixtures to enhance the workability of concrete.

5. CONCLUSION

In this paper an experimental study has been conducted to determine the compressive strength of geopolymer concrete in which fly ash is replaced by rice husk ash and adding the steel fibre into it. In conclusion, the study reveals that 10% replacements of fly ash with rice husk ash are suitable for production of geopolymer concrete. The addition of steel fibre has not affect the compressive strength of the geopolymer concrete. The steam curing using accelerated curing tank has been given very good strength in 24 hours and it can used to produce precast concrete. The workability of the fresh concrete decreases, when the fly ash is replaced by rice husk ash and it can be increase by adding the chemical admixture to enhance it.

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