International Journal of Civil Engineering and Technology (IJCIET)
Volume 8, Issue 8, August 2017, pp. 572–580, Article ID: IJCIET_08_08_058
Available online at http://http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=8&IType=8
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

ECO FRIENDLY LIGHT WEIGHT GEO POLYMER CONCRETE FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT

The global cement industry contributes around 1.35 billion tons of the green house gas emissions annually, or about 7% of the total man-made greenhouse gas emissions to the earth's atmosphere. Due to the production of Portland cement, it is estimated that by the year 2020, the CO^2 emissions will rise by about 50% from the current levels. Therefore, to preserve the environment from the impact of green house gases released during the production of cement, there should be some alternative materials to replace Portland cement. In this context, the Geo polymer concrete is one of the revolutionary developments related to novel materials resulting in low-cost and environmentally friendly material. The normally used coarse aggregate which is granite broken stone partially replaced with coconut shell aggregates and it is lighter than granite stone and it is also an agricultural by product from coconut industries which is disposed as waste material. The study reveals that partial replacement of granite stone aggregate with coconut shell light weight aggregate can be done for making light weight geo polymer concrete which can be used for reinforced concrete construction and also for making light weight concrete elements.

Key words: Geo Polymer Concrete, Coconut Shell, Fly Ash, Alkaline Solution, Compressive Strength, Split tensile strength, Flexural strength.

Cite this Article: K.P. Chandran, Dr. M Natrajan, Dr. C Meiaraj, Eco Friendly Light Weight Geo polymer Concrete for Sustainable Development. *International Journal of Civil Engineering and Technology*, 8(8), 2017, pp. 572–580.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=8

1. INTRODUCTION

The world wide use of concrete is second to water. Port land cement is the prime constituent of concrete. Manufacturing process of port land cement is highly energy intensive. In the present day we are facing the crucial depletion of energy resources. It is high time to switch over to new materials and technologies which are less energy intensive and also eco friendly. The Geo polymer technology was first introduced by Davidovits in 1978. His work considerably shows that the adoption of the geo polymer technology could reduce the CO_2 emission caused due to cement industries. Davidovits proposed that an alkaline liquid could be used to react with alumina silicate in a source material of geological origin or in by product materials such as fly ash to make a binder. The source material should be rich in aluminum and silicon. They may be natural materials like kaolinite, clays, red earth etc or byproduct materials like Fly Ash, Silica fume, blast furnace slag, rice husk ash etc. Fly Ash is a byproduct of thermal power plants which is available at lesser cost as it is available in bulk quantities as a waste material and disposal of it is a major issue. A Typical mix proportion of Geo polymer concrete has been illustrated. Geo polymer concrete is having the desired properties for manufacture of precast concrete elements and it is well suited for rehabilitation works. The coarse aggregate usually used for making concrete is crushed granite or gravel. As these natural resources are non renewable and excessive mining of these resources will have ecological impact, there should be some alternative materials which are either waste materials or available in plenty at lesser cost. India is the third largest producer of coconut in the world. Coconut trees are widely cultivated in south India especially in Kerala. The name Kerala is derived from the word “Kera” which means Coconut. Coconut shell which is a waste material from oil mills or similar coconut industries are available in bulk quantities in states like Kerala. Coconut shell is a hard material and also biologically non degradable. When crushed into pieces it has properties desirable for coarse aggregate. In this study, coconut shell aggregates are used in partial replacement of conventional granite stone aggregates.

2. MATERIALS AND METHODS

The two main constituents of Geo polymer concrete are source materials having Silicon and Aliuminium as their major components, and Alkaline activators. Fly Ash, Silica fume, Metacaolin, Rice husk ash, Red mud etc are examples of good source materials. In this study Fly Ash is used as the source material. The alkaline liquids generally used are hydroxides and silicates of Sodium or Potassium. In this study, Sodium hydroxide and Sodium silicate are used for chemical activation. Coarse aggregate used is hard granite broken stone .Coconut shell aggregate is used in various percentage for replacement of the coarse aggregate. Natural River Sand is used as fine aggregate. Super plasticizer is added to improve workability.

The low calcium fly ash was brought from Thermal Power plant at Uduppi in Karnataka state. Commercially available Sodium hydroxide of 97% purity and Sodium silicate were used in the study. Locally available hard granite broken stone and river sand conforming to zone II were used. Coconut shells were collected locally. Inner concave surface of the coconut shell is somewhat smooth while the outer convex surface is rough. The fibres were cleared and the shells were broken into small chips. The coconut shell aggregates were washed and made it in saturated surface dry condition. The pieces were made to 20 mm and down size. Average value of specific gravity was 1.30.Super plasticizer was used to improve workability.

Alkaline liquids were prepared one day before the preparation of concrete. Sodium hydroxide was prepared for a molar value of 10.The fly ash and aggregates were first mixed thoroughly and then alkaline solutions and super plasticizer were added. Coconut shell aggregate was added to replace granite stone aggregate in 25%, 50%, 75% and 100% in

consecutive trials. Specimens were prepared for conducting tests for compressive strength, split tensile strength and flexural strength.

Curing of Geo polymer concrete may be either heat curing or curing at ambient temperature. But heat curing accelerates gaining of strength. In this study, the specimens are cured in oven at 60^0C for 24 hours.

3. FLY ASH

In thermal power plants, where pulverized coal is used for the generation of heat, Fly ash is produced as a byproduct. The production of Fly ash during this year is estimated as 225 million tones. Fly ash and bottom ash are produced at the rate of 80% and 20% respectively from a power plant where pulverized coal is burnt. The huge quantity of Fly ash to be disposed of is a major concern of the power plants. If disposed in sea, river or the like water bodies it may affect the aquatic life. When the fly ash in slurry form is disposed to settling tanks, marshy land or back waters it will become colony for mosquito breeding and will cause spreading of epidemics. The above methods may also cause contamination of sub surface water storage. In many countries fly ash is being used in an effective manner by utilizing it as a cost effective construction material. But in our country only a meager amount is being utilized in various segments effectively. Hence use of Fly ash for the production of Geo polymer concrete and propagation of the new technology will certainly help in reducing environmental pollution and the product will also become an eco friendly material.

4. COCONUT SHELL AS AN ALTERNATIVE COARSE AGGREGATE

In view of thrust on energy saving and sustainable development, the use of alternative constituents of natural resources and the search of suitable alternative to conventional construction material is now a global concern. To make use of alternative aggregate in concrete, which is coconut shell, has never been a common practice among the people, particularly in areas where light weight concrete is required for non load bearing walls and non structural floors. Concrete obtained using coconut shell as a coarse aggregate satisfies the minimum requirements of concrete. Coconut shell aggregate possesses acceptable strength which is required for structural concrete. Coconut shell may present itself as a potential material in the field of construction industries. The coconut shell is compatible with cement and there is no need to pre-treatment for using it as coarse aggregate. Because of the smooth surface on one side of the shells concrete made with coconut shell presents better workability. Coconut shell concrete shows good impact resistance. As compared to conventional aggregate water absorbing and moisture retaining capacity of coconut shell is more. The presence of sugar in the coconut shell, does not affect the setting and strength of concrete because it is not in a free sugar form. It is found that wood based materials being hard and of organic origin, that will not contaminate or leach to produce toxic substances once they are bound in concrete matrix.

5. PROPERTIES OF COCONUT SHELL

1. Coconut shell has high strength and modulus properties.

2. It has added advantage of high lignin content. High lignin content makes the composites more weather resistant.

3. It has low cellulose content due to which it absorbs less moisture as compared to other agriculture waste.

4. Coconuts being naturally available and since its shells are non-biodegradable; they can be used readily in concrete.

Figure 1 Coconut Shells

Figure 2 Coconut Shell Aggregates

Table 1 Density of Geo polymer concrete with CS aggregates

Percentage of coconut shell aggregate	Density in Kg/m^3
0	2335
25	2298
50	2124
75	1992
100	1827

Table 2 A Typical Proportion of materials for Geo polymer concrete with CS aggregates

Material	Mass Kg/m^3
Coarse aggregate (including coconut shell aggregate)	1200
Fine aggregate	550
Fly Ash	410
Sodium Silicate	110
Sodium Hydroxide	40
Super Plasticizer	6

Figure 3 Compression Test

Table 3 Compressive strength of Geo polymer concrete with CS aggregates

Percentage of coconut shell aggregate	Compressive strength in MPa
0%	27.40
25%	24.32
50%	17.10
75%	12.63
100%	8.02

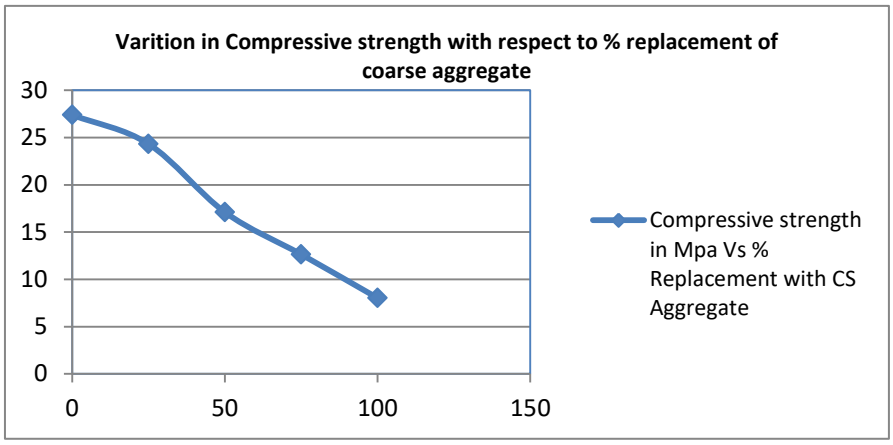

Figure 4 Compressive strength Vs % Replacement of Coarse Aggregate

Figure 5 Split Tensile Test

Table 4 Split Tensile Strength of geo polymer Concrete with CS Aggregate

Percentage of coconut shell aggregate	Split Tensile strength in MPa
0%	2.86
25%	2.47
50%	2.18
75%	1.47
100%	1.23

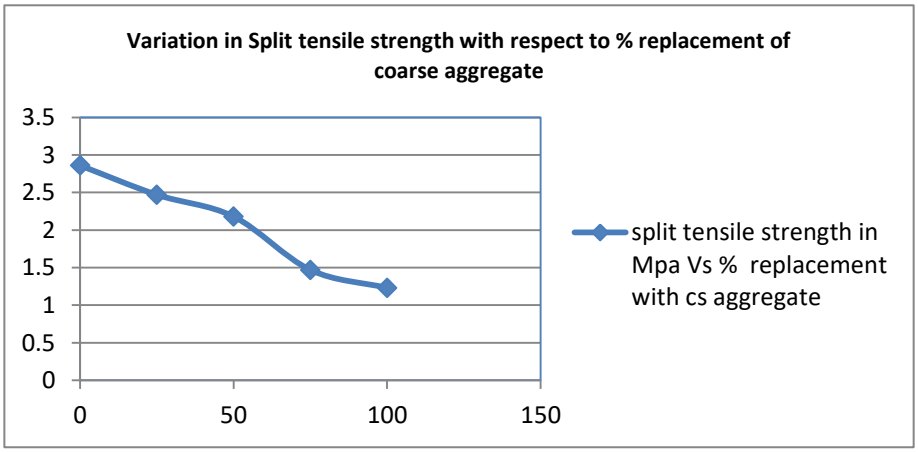

Figure 6 Split Tensile Strength Vs % Replacement of Coarse Aggregate

Figure 7 Flexure Test

Table 5 Flexural Strength of Geo polymer concrete with CS Aggregate

Percentage of coconut shell aggregate	Flexural strength in MPa
0%	5.36
25%	4.32
50%	3.36
75%	2.40
100%	0.15

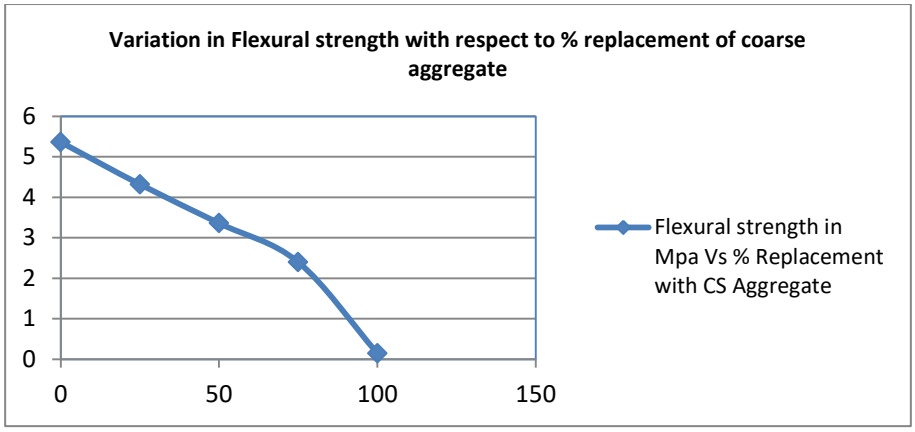

Figure 8 Variation in Flexural Strength Vs % Replacement of CS Aggregate

Table 6 Density of Geo polymer concrete with CS aggregates

Percentage of coconut shell aggregate	Density in Kg/m^3
s0%	2335
25%	2298
50%	2124
75%	1992
100%	1827

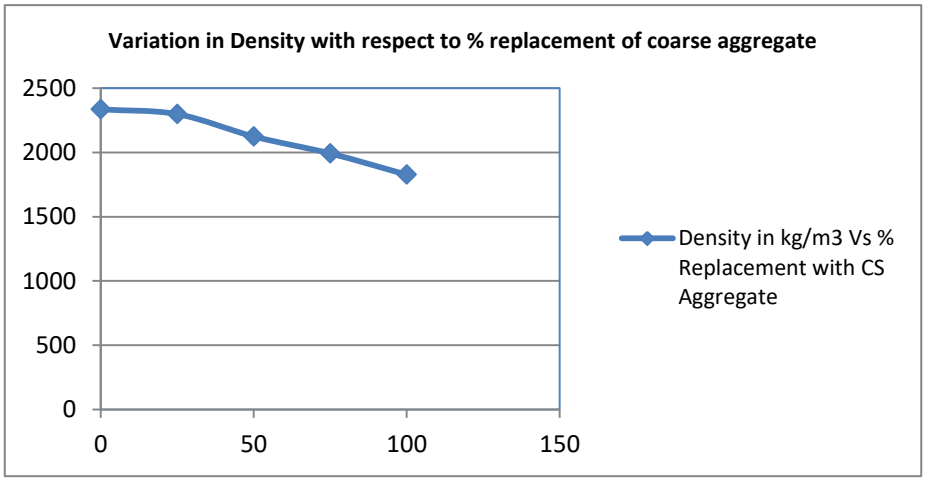

Figure 9 Density Vs % Replacement of Coarse Aggregte

6. RESULTS AND DISCUSSIONS

In this study, strength characteristics of Fly ash based Geo polymer concrete produced by replacing granite stone aggregates with coconut shells aggregate in ratios of 25%, 50%, 75%, and 100% was investigated. Tests were conducted for workability, flexure strength, and compression and split tensile strength. Coconut shell concrete has better workability because of smooth surface on one side of the shell and smaller size of aggregate. The compressive strength of Coconut shell aggregate Geo polymer concrete with alkaline solution of 10M after 24 hours heat curing at 60^0c is approximately 27.4 N/mm^2, 24.32 N/mm^2, 17.10 N/mm^2, 12.63 N/mm^2 and 8.02 N/mm^2 corresponding to 0%, 25%, 50%, 75% and 100% replacement of coarse aggregate. The flexural strength of Coconut shell aggregate Geo polymer concrete is approximately 5.36 N/mm^2, 4.32 N/mm^2, 3.36 N/mm^2, 2.4 N/mm^2 and 0.15 N/mm^2 corresponding to 0%, 25%, 50%, 75% and 100% replacement of coarse aggregate. The split

tensile strength of Coconut shell aggregate Geo polymer concrete was obtained as 2.86 N/mm^2, 2.47 N/mm^2, 2.18 N/mm^2, 1.47 N/mm^2 and 1.23 N/mm^2 corresponding to replacement with coconut shells as above. From the above results, it can be seen that Coconut shell aggregate Geo polymer concrete with 25% of replacement of coarse aggregate shows properties similar to nominal M20 mix and can be used for Reinforced concrete works. Coconut shell aggregate Geo polymer concrete of 50% replacement with coconut aggregates shows properties similar to light weight concrete which can be used as filler material in framed structures, for flooring works, as thermal insulation concrete etc.

The bulk density of coconut shells is approximately 600 kg/m^3 and this is within the specified limit of light weight aggregate. The average moisture content and water absorption of coconut shell was found to be 4.05% and 22% respectively. Due to high water absorption coconut shells were pre soaked for 24 hrs in water prior to the mixing, and were in surface saturated dry condition during the preparation of concrete in order to prevent absorption of mixing water. The slump obtained from trial mix was 57mm which shows that CSC aggregate concrete as a medium degree of workability.

7. CONCLUSIONS

- Density of Geo polymer concrete with coconut shell aggregate reduces with increase in the ratio of replacement of conventional aggregate.
- The compressive strength of Geo polymer concrete with coconut shell aggregate was found to be 24.32 N/mm^2 for 25% replacement of normal aggregates. It satisfies the requirement for structural light weight concrete.
- The compressive strength of Geo polymer concrete with coconut shell aggregates was found to be 17.10 N/mm^2 for 50% replacement of normal aggregates. It can be used for less important works.
- Coconut shell aggregate Geo polymer concrete is less energy intensive, that makes use of waste materials and it is also cost effective.
- Fly ash based Geo polymer concrete with partial replacement of conventional aggregate with coconut shell aggregates proves to be eco friendly green technology for saving energy and protecting the environment.

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