

An Experimental Study of Partial Replacement of Fine Aggregate using Agro-Waste with Steel Fibre and GGBS

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Abstract - Agricultural substances are those substances that are produce on earth with the change of seasons. These substances are widely available on earth can be a good source of energy can be converted into useful products. In India it is observed that mostly 60 tons of wastes have been generated from agricultural wastes which are leading to disposal problem. In this concrete using agro waste with some mineral admixture named GGBS (Ground Granulated Blast Furnace Slag). GGBS is a cementitious material whose main use is in concrete and is by product from the blast furnace used to make Iron. A blast furnace operates at a temperature about 1500°C and is fed with a carefully controlled mixture of iron ore, coke and limestone. In addition to agricultural wastes Steel Fibre is also used partially for fine aggregate. Compacting factor test was carried out on fresh concrete while Compressive Strength test was carried out on hardened 150mm concrete cubes after 7, 14 and 28 days curing in water. The research also revealed that there is the possibility of replacing fine aggregate with rice husk ash and coconut shell and steel fibre with addition of GGBS in the production of structural concrete.

Index Terms - Agro wastes, Compressive strength, Fine aggregate, GGBS, Steel fibre, Partial replacement.

1.INTRODUCTION

In the construction industry relies heavily on conventional materials such as cement, granite and sand for the production of concrete. Concrete is the world's most consumed man-made material. Concrete production is not only a valuable source of societal development, but it is also a significant source of employment. Historically, agricultural, and industrial wastes have created waste management and pollution problems. However, the use of agricultural and

industrial wastes to complement other traditional materials in construction provides both practical and economical advantages. The wastes have generally no commercial value and being locally available transportation cost is minimal. The use of waste materials in construction contribute to conservation of natural resources and the protection of the environment. Reuse of such wastes as sustainable construction materials will take care of that issue. The rice industry produces wastes such as rice husks which are usually dumped in the open thereby impacting the environment negatively without any economic benefits. In Nigeria, rice husks are generally not used in construction. Rice husk is composed of approximately 40% of cellulose and 20% of Silica when it burnt the material is used and good for construction purpose. To review some of the Agro-based waste materials and steel fibre which are used as a partial replacement of fine aggregate with GGBS in concrete. Varieties of admixtures such as Coconut shell, Rice husk ash, and steel fiber are used. GGBS concrete has better water impermeability characteristics as well as improved resistance to corrosion and sulphate attack. The main objective of our project is the partial replacement of fine aggregate with agro waste and steel fiber waste products with Ground Granulated Blast Furnace Slag. To find compressive strength of fine aggregate concrete with various replacements of agro waste and steel fiber waste with GGBS. To determine the percentage of water absorbed by fine aggregate concrete and fine aggregate concrete with various replacements of agro waste and steel fiber waste with GGBS by water absorption test. To determine the effect of acid attack on the compression strength of fine aggregate concrete and fine aggregate concrete with various replacement

of agro waste and steel fiber waste with GGBS. To protect against chloride attack GGBS is used at replacement level of 50% in concrete. In order to make efficient use of locally available materials, this study was conducted to investigate and compare the influence of weight replacement and volume replacement of fine aggregate by rice husk ash, coconut shell, steel fibre, on the workability, bulk density and compressive strength of concrete as well as to assess the suitability of agro waste concrete as a structural material.

2. LITERATURE REVIEW

Obilade, I.O (2014) reported that influence of weight replacement and volume replacement of fine aggregate by rice husk on the workability, bulk density and compressive strength of concrete.

P Lakshmaiah Chowdary, S KhajaKhutubuddin, B Vinayaka, D Saikiran, Y Induja, Y Narasappa (2017) reported that the results of an experimental investigations carried out to find the suitability of GGBS in production of concrete and the experimental study the effect of GGBS on strength of referral concrete M20 was made using 43 Grade PPC and the other mixes were prepared by replacing part of PPC with GGBS.

M.Sivagami, Amulya.P. J (2018) reported that the scope of using coconut shell as an alternative for fine aggregate in concrete. India contributes about 20% of total world's coconut production and aggregates made by crushing coconut shell can be in concrete by partially replacing fine aggregate and this will also reduce the unit weight of concrete.

S. A. Kakade, Dr. A. W. Dhawale. (2015) reported that analysing characteristic compressive and tensile strength of coconut shells of concrete produced. By partial replacement using crushed, granular coconut shells as a substitute for conventional coarse aggregate in M20 grade concrete.

Lamen Sryh and John Forth (2015) reported that experimental investigation into the effect of steel fibres on the mechanical properties of recycled aggregate concrete and the results showed that the addition of steel fibres enhanced the cube compressive strength, splitting tensile strength, flexural strength and the modulus of elasticity by 1-5%, 11-55%, 16-53% and 4-15%, respectively, in comparison to the specimens without fibres.

3. MATERIALS

Constituent materials for modified concrete such as cement, M-Sand, gravel, GGBS, agro wastes were thoroughly studied whether they are suitable for the work in all aspects.

- Cement: Ordinary Portland Cement of 53 grade
- Fine aggregate: M-Sand
- Coarse aggregate: Crushed granular aggregate of size 20 mm passing
- Water: Ordinary water conforming to IS-456
- Partial replacements: Coconut shell, rice husk ash, steel fibre.

3.1 Cement

Cement is a binder, a substance that sets and hardens independently, and can bind other materials together. The word "cement" traces to the Romans, who used the term opus cementicium to describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder. The volcanic ash and pulverized brick additives that were added to the burnt lime to obtain a hydraulic binder were later referred to as cementum, cement, and cement.

Cement used in construction is characterized as hydraulic or non-hydraulic. Hydraulic cements (e.g., Portland) harden because of hydration, chemical reactions that occur independently of the mixture's water content; they can harden even underwater or when constantly exposed to wet weather. The chemical reaction that results when the anhydrous cement powder is mixed with water produces hydrates that are not water-soluble. Non-hydraulic cements (e.g., gypsum plaster) must be kept dry in order to retain their strength.

The most important use of cement is the production of mortar and concrete, which is a combination of cement and an aggregate to form a strong building material that is durable in the face of normal environmental effects. The cement is to be ordinary Portland cement 53 grade and shall conform to IS 8112:2013 Physical properties such as fineness, soundness, setting time, specific gravity and specific gravity of Ordinary Portland Cement are determined by using grain sieve analyzer, le chatlier flask, vicat apparatus respectively are discussed below in table 1.

Table 1 Physical Properties of Cement

Physical Properties	Result
Specific Gravity	3.13
Standard consistency (%)	31%
Initial setting time (min)	35 min
Final setting time (min)	178 min

3.2 Fine Aggregate

The fine aggregate used in this study is M-sand which was passed through IS 4.75 mm sieve. The fine aggregate is tested as per Indian Standard specification IS 383. Sand is naturally occurring granular material composed of finely divided rock and mineral particles. The most common constituent of sand is silicon dioxide, usually in the form of Quartz. Normally fine aggregate is used as fine aggregate for preparing concrete. An individual particle in this range is termed as sand grain. These sand grains are between coarse aggregate (2mm to 64mm) and silt (0.004mm to 0.0625mm). Aggregate most of which passes 4.75mm IS sieve is used. With the use of grain sieve analyzer and pycnometer, the fineness modulus and the specific gravity of the M-sand were calculated and discussed below in table 2.

Table 2 Physical Properties of Fine Aggregate

Physical Properties	Result
Specific Gravity	2.70
Fineness modulus	2.71
Water absorption (%)	1.20%

3.3 Coarse Aggregate

The coarse aggregate used was the locally available gravel which was passed through 20 mm IS sieve. The coarse aggregate is tested as per Indian Standard specification IS 383. Aggregates are the most mined material in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material. Coarse aggregate of size 20mm is sieved and used. With the use of pycnometer, the specific gravity of the 20mm gravel was found to be calculate in below table 3

Table 3 Physical Properties of Coarse aggregate

Physical Properties	Result
Specific Gravity	2.64
Water absorption (%)	0.75%
Fineness modulus	6.816

3.4 Rice Husk Ash

India is major rice producing country. About 649.7 million tons of rice husks are produced worldwide. Rice husk ash is about 25% by weight of rice husk when burnt in boilers. Rice husk is transferred from the mill to the furnace where it is used as fuel for burning. Hot air is passed from the ignition chamber which helps in burning of rice husk. The steam produced heats the water present in the boilers, and along with steam the ash particles travels, and these settled particles are collected at different stages. Hence the rice husk ash is obtained. RHA is a carbon neutral green product. The chemical composition of rice husk is found to vary from one sample to another due to the differences in the type of paddy, crop year, climate and geographical conditions. RHA when burnt below 7500C generates amorphous silica. While when burnt at temperatures greater than 8000C generate crystalline silica.

3.4.1 XRD analysis of RHA

The properties of RHA depend upon its burning conditions. It was observed that with increase in temperature the crystalline form of RHA decreases. There are two types of RHA. The RHA burnt at high temperatures is white in color while the color of RHA burnt at lower temperature is black in color. Black RHA contains high amount of carbon compared to white RHA. The properties of rice husk ash are discussed below in table 4.

Table 4 Physical Properties of Rice husk ash

SNO	PROPERTY	VALUE
1	Length	30 mm
2	Diameter	0.55 mm
3	Density	7850 kg/m ³
4	Tensile strength	1050 Mpa
5	Elastic modulus	200 Mpa
6	Specific gravity	7.8
7	Colour	Gray

3.5 Ground Granulated Blast Furnace Slag (GGBS)

GGBS has been used in construction industry for years as replacement of ordinary Portland cement when molten iron slag is quenched in steam or water, a glassy product is obtained. It is then dried and made into powder. It is called ground granulated blast furnace slag (GGBFS OR GGBS). [24] Addition of GGBS to cement increases the life span from 50 to 100 years. So, it gives greater durability. It has longer settling time. So, there is a risk factor when the work

at the site should be done quickly. It has low heat of hydration and temperature rise is also less [5, 28, 25]. Ground granulated blast furnace slag was supplied by JSW cements. The specific gravity of GGBS was determined using Le Chatelier’s flask. All the other physical and chemical properties are discussed below in table 5.

Table 5 Physical Properties of GGBS

Physical Properties	Result
Specific Gravity	2.93
Colour	off white
Bulk density	1200 Kg/m ³
Fineness	350 m ² /kg

3.6 Coconut Shell Powder

Coconuts are referred to as "man's most useful trees", "king of the tropical flora" and "tree of life". Coconuts or its scientific name *cocosnucifera* are the most important of cultivated palms and the most widely distributed of all palms. Coconut shells are cheap and readily available in high quantity. The coconuts were broken manually to drain out the water. The coconut half shells were sun-dried for three days and the properties are discussed below in table 6



Coconut shell

Table 6 Physical properties of coconut shell aggregate

Physical Properties	Test Results
Specific Gravity	1.33
Water absorption (%)	24
Bulk Density(kg/m)	800
Shell Thickness(mm)	< 4.75

3.7 Steel Fibres (SF)

Glued discontinued hooked-end steel fibres (DRAMIX 3D 65/35BG) from Bekaert as shown in Figure 1 were used in this study. The Steel fibre (SF) is a geosynthetic material used for our experimental study was purchased from a chemical shop in Pondicherry. These steel fibres have a wire hooked

end to increase the strength of the concrete. Steel fibres with aspect ratios in between 40 to 80 are currently in use. The handling of a fibre becomes difficult when the aspect ratio is higher. These fibres are found to be available in various lengths from 20 mm to 40 mm but 30 mm and 35 mm fibres are currently applied most successfully.



3.8 Water

The water used for mixing and curing should be clean and free from injurious quantities of alkalis, acid, oils, salt, sugar, organic materials, vegetable growth and other substances that may be deleterious to bricks, stone, concrete or steel. Potable water is generally considered satisfactory for mixing.

4. METHODOLOGY

A proper methodology plays a vital role in completion of a successful investigation. There is a need to have a proper planning prior to an investigation. To achieve reliable results from the tests, an experimental setup and testing procedures are adopted. The required materials required for the investigation are selected depending upon the requirement. Indian standard code book was used to carry out mix design and suitable ingredients are selected. The workability of concrete was measured using slump cone. The mix design for the GGBS and agro wastes and steel fibre wastes are calculated as per IS-10262:2000. In order to determine the workability of the replaced concrete, the slump value was founded.

4.1 MIX PROPORTIONS

Cement	GGBS	Fine aggregate	Coarse aggregate	Water	Water cement ratio
350.5 kg/m ³	87.63 kg/m ³	696 kg/m ³	1109 kg/m ³	197.16 litres	0.45

4.2 Percentage of replacements of Fine aggregates in different mixes:

Aggregates	Control Mix	Mix 1	Mix 2	Mix 3
Fine aggregate	100%	80%	80%	80%
Rice Husk Ash	0%	5%	10%	15%
Coconut shell	0%	15%	10%	5%

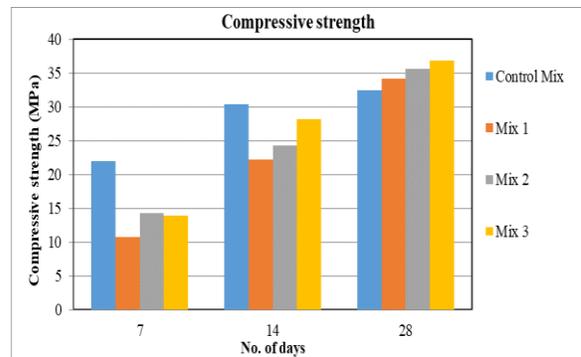
4.3 Quantity of items (in grams) for all mixes:

Items	Control Mix	Mix 1	Mix 2	Mix 3
Cement	8167	8167	8167	8167
GGBS	2042	2042	2042	2042
Water	4600	4600	4600	4600
Fine aggregate	16217	12974	12974	12974
Rice Husk Ash	0	811	1622	2433
Coconut shell	0	2433	1622	811
Coarse aggregate	25840	25840	25840	25840

shell, 5% steel fibre, 10% GGBS) shows the maximum strength compared to the other replacement percentage.

- From the result it is concluded that maximum compressive strength was found at (15% rice husk ash, 5% coconut shell, 5% steel fibre, 10% GGBS) for partial replacement of fine aggregate.

Compressive strength	Control Mix	Mix 1	Mix 2	Mix 3
7 days (MPa)	21.97	10.73	14.31	14
14 days (MPa)	30.42	22.17	24.32	28.2
28 days (MPa)	32.42	34.2	35.6	36.8



5. RESULTS AND DISCUSSIONS

5.1 Compressive strength

The compressive strength of concrete is defined as the maximum stress of concrete after which the concrete cube crushes or fails. It can also be defined as the ability of concrete to resist the applied compressive load. Compression testing machine (CTM) or universal testing machine (UTM) can be used for testing the compressive strength of concrete. The compressive strength is found by dividing the maximum load resisted by concrete by the cross-sectional area of surface on which the compressive load is applied.

- The Compressive strength values using agro wastes and steel fibre wastes as partial replacement of fine aggregate with GGBS was found to be increased.
- The ratio we used are (5% rice husk ash, 15% coconut shell, 5% steel fibre, 10% GGBS), (10% rice husk ash, 10% coconut shell, 5% steel fibre, 10% GGBS), (15% rice husk ash, 5% coconut shell, 5% steel fibre, 10% GGBS) in our concrete.
- From the comparison of the compressive strength test results at 7day, 14days, 28days it was observed that (15% rice husk ash, 5% coconut

6. CONCLUSION

- This research is aimed at using agro waste products in concrete by replacing fine aggregates. Four different types of mix proportions were designed with different percentages of rice husk ash and coconut shell as replacement for fine aggregate.
- Six cubes were casted for each mix of size 150mm x 150mm x 150mm and tested for compressive strength.
- From the result, it is obvious that though the initial strength for all the mixes is less than the control mix, the final strength gained is more than the control mix.
- As the percentage of rice husk ash increases, the final strength of concrete also increases.
- Hence, it is found that the optimum mix can be obtained by replacing 15% of fine aggregate with rice husk ash and 5% with coconut shell.
- It not only increases the strength of concrete but also helps in producing environment friendly

concrete by reducing the intake of fine aggregate and using agro waste products.

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