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Strength and Workability Properties of Concrete replaced by Coconut Shell Powder and GGBS

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Abstract - *Concrete is the most widely used construction material in the world because of its high structural strength and stability. A material is considered better only if it contributes something to upgrade the quality of a building. With all the advancements in construction techniques and methods, and also with the demand of users for smart, eco-friendly and sustainable construction, I've made an attempt to investigate on such materials namely, Coconut Shell Powder and Ground Granulated Blast furnace Slag (GGBS). The present research work was carried out to study the strength and stability of concrete containing Coconut shell powder and GGBS as partial replacement of sand and cement at various percentages. In this research, M30 mix grade concrete is used initially with Coconut shell powder in proportions of 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%. In the next phase M30 mix grade concrete is used with GGBS in proportions of 10%, 20% and 30%, and later with a combination of Coconut shell powder and GGBS. From this research, the changes in strength and stability parameters can be observed.*

Key Words: Concrete, strength, stability, Coconut shell powder, GGBS, replacement, fine aggregate, cement, compressive test, split tensile test.

1.INTRODUCTION

In view of global warming, efforts are being done to reduce the emission of carbon dioxide to the atmosphere. Cement industry is a major contributor in the emission of carbon dioxide as well as in using up high levels of energy resources in its production. By replacing cement with a material to improve its strength characteristics, an attempt has been made with coconut shell powder and GGBS so that, the cement and concrete industry together can meet the growing demand in the field of construction industry as well as help in reducing the environmental pollution.

India is a resourceful country for the availability of waste by-products. Coconuts are used on a large scale here. Coconut shells are thrown away after their use. These shells are ground into powder with grinding equipment available in the market. Coconut shell powder is also available readily. GGBS is also readily available which is used in this investigation.

To study the impact of partial replacement of fine aggregate and cement with Coconut shell powder and GGBS on the properties of concrete, experiments were conducted on M30 mix grade concrete with varying proportions of these waste materials. This paper explains the details of experimental set up and discussion on test results.

1.1 Material Characterization

The materials used in this experimental investigation include:

a. Cement
An ordinary Portland cement 53 grade confirming to IS: 12269: 2013 was used in the study. The specific gravity of the cement was calculated to be 3.11.

b. Fine Aggregates
Good quality river sand was used as a fine aggregate confirming to grading zone I of IS: 383: 1970 was used. The specific gravity of sand was calculated to be 2.6.

c. Coarse Aggregates
Coarse aggregate obtained from local quarry units has been used for this study. Maximum size of aggregates used is 20 mm with a specific gravity of 2.67.

d. Coconut Shell Powder
It is made from coconut shells and is used as filler in the manufacture of thermoset moulding powders like Bakelite, synthetic resin glues or phenol formaldehyde. Coconut shell powder is an industrial product and is considered to be suitable and cheap filler compared to others. It is used as a raw material for activated carbon industries too.

e. Ground Granulated Blast furnace Slag (GGBS)
It is a fine powder which is obtained by quenching molten iron slag from a blast furnace in water. In this investigation specific gravity for GGBS is calculated to be 3.09.

f. Water
In this experimental investigation portable water which is free from organic substances is used for mixing and curing.

2. LITERATURE REVIEW

Praveen Mathew, Shibi Varghese et.al (2013) has investigated on recycled plastics as coarse aggregates for structural concrete. Tests were conducted to find the density, specific gravity and aggregate crushing value. Partial replacement of coarse aggregate with recycled plastics for various proportions was done and the compressive and split tensile strengths were calculated. Heat resisting behaviour was also discussed in their study.

Lakshmi (2010) has studied on concrete containing e-plastic waste. Partial replacement of coarse aggregate with e-plastic waste from 0% to 30% on the strength criteria of M20 mix grade concrete was performed and observed good strength gain.

Ankit Kumar (2016) investigated on partial replacement of cement in concrete with rice husk ash. Compressive strength tests was conducted at 0% , 10% and 20% rice husk ash(RHA) replacement and the highest strength was observed at 20% RHA replacement.

Balaji (2015) investigated on partial replacement of cement in concrete with sugarcane baggase ash in fixed proportions and analysed its effect on concrete. Concrete mix was designed with varying proportions of baggase ash for 5%, 10%, 15%, 20% and 25%. The cubes were casted and cured in normal water with 5% HCl solution for 7, 28 and 60 days. The results indicated that the strength increased up to 10% sugarcane baggase ash replacement.

3. EXPERIMENTAL INVESTIGATION

In the present investigation, M30 grade concrete was designed as per IS: 1262-2009.

a. Workability
Freshly mixed concrete was tested for workability by slump value. In this investigation, M30 mix grade concrete is considered for the test by weight basis by replacing 10%, 20%, 30%,, 40%, 50%, 60%, 70%, 70%, 80%, 90% and 100% of fine aggregate by coconut shell powder. In the next phase, cement is replaced by GGBS in the proportions of 10%, 20% and 30% and the slump values are found out for these proportions.

b. Compressive Strength
In this investigation, M30 mix grade concrete is considered for the test by weight basis by replacing 10%, 20%, 30%,, 40%, 50%, 60%, 70%, 70%, 80%, 90% and 100% of fine aggregate by coconut shell powder. In the next phase, cement is replaced by GGBS in the proportions of 10%, 20% and 30% and later a combination of both coconut shell powder and GGBS in various proportions is considered for compressive test.

Concrete cubes of 150 mm x 150 mm were used as test specimens to determine the compressive strength of the mixed concrete. The ingredients were thoroughly mixed until uniform consistency was achieved. The cubes were properly compacted. All these cubes were de-moulded after 24 hours and kept for curing in a water tank available in the laboratory for 28 days. Compression test was conducted at an age of 28 days on 2000 KN capacity test equipment. The specimen was placed between the loading surfaces of the testing machine and the load was applied without shock until the failure of the specimen occurred.

c. Split Tensile Strength
As discussed above, the same proportion of specimens were considered for split tensile strength test. Cylinders of 150 mm diameter and 300 mm length were used as test specimens to determine the split tensile strength. Ingredients were thoroughly mixed until proper consistency was achieved and were compacted well. These cylinders were de-moulded after 24 hours and kept for curing in a water tank available in the laboratory for 28 days. The Split tensile test was conducted as per IS: 5816-1976. The specimen was placed between the loading surfaces of the testing machine and the load was applied without shock until the failure of the specimen occurred.

4. EXPERIMENTAL RESULTS

a. Workability
Slum test of various mix proportions of coconut shell powder and GGBS in concrete are shown below

Table-1: Slump values with various proportions of Coconut Shell Powder replacing fine aggregates in M30 grade concrete

S.No	Coconut Shell Powder Content	Slump
1	0%	96
2	10%	94
3	20%	92

4	30%	90
5	40%	87
6	50%	85
7	60%	82
8	70%	80
9	80%	78
10	90%	76
11	100%	74

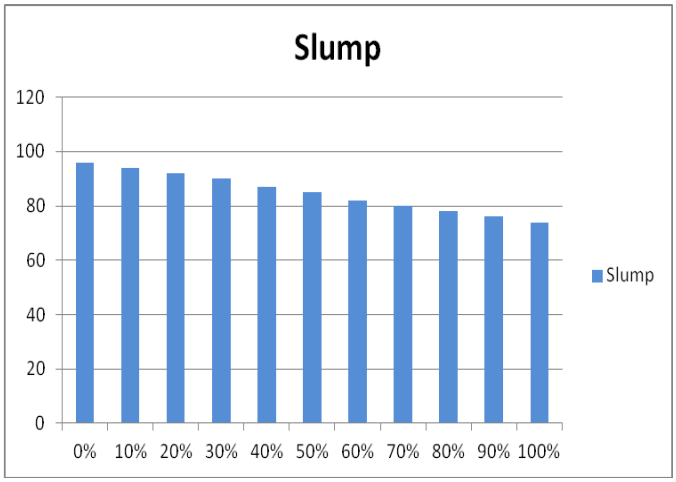

Chart-1: Slump Values for replacement of fine aggregate with coconut shell powder

Table-2: Slump values with various proportions of GGBS replacing cement in M30 grade concrete

S.No	GGBS Content	Slump
1	0%	96
2	10%	97
3	20%	98
4	30%	99

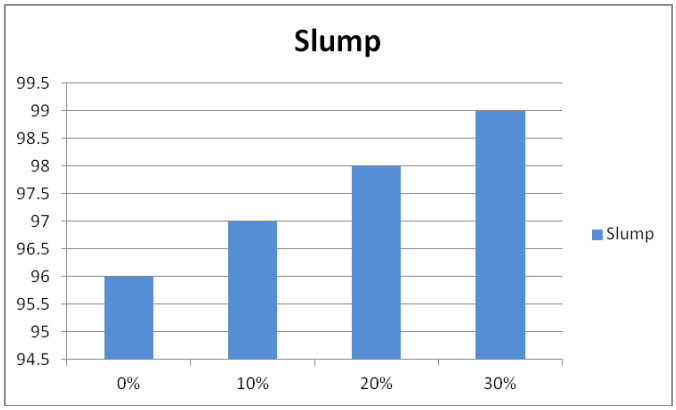

Chart-2: Slump values for replacement of cement with GGBS

b. Compressive strength test

The compressive strength of concrete was achieved in 28days of various proportions and is as shown below. The specimens were casted and tested as per IS: 516-1959.

Table-3: Compression test at 28th Day with various proportions of Coconut Shell Powder replacing fine aggregates in M30 grade concrete

S.No	Coconut Shell Powder Content	Compressive Strength (N/mm²)
1	0%	32
2	10%	33.67
3	20%	34.9
4	30%	36.9
5	40%	35.56
6	50%	33.4
7	60%	32.11
8	70%	30.9
9	80%	26.5
10	90%	24.3
11	100%	22.3

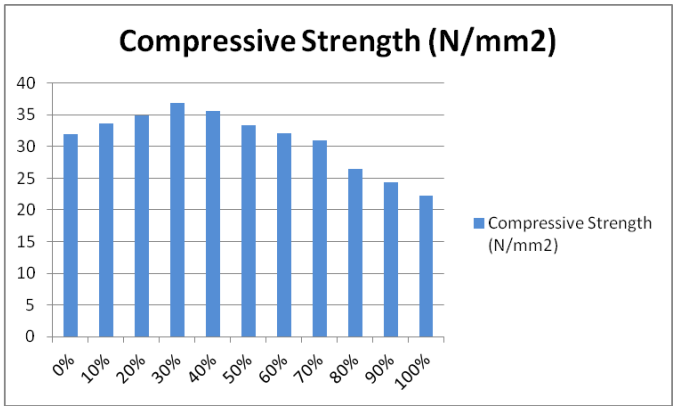

Chart-3: Compressive Strength when fine aggregate is replaced with Coconut shell powder

From the figure 3 and table 3 it is observed that 30% coconut shell powder mixed concrete achieved maximum strength in comparison to normal concrete.

Table-4: Compression test at 28th Day with various proportions of GGBS replacing cement in M30 grade concrete

S.No	GGBS Content	Compressive Strength (N/mm²)
1	0%	32.6
2	10%	36.54
3	20%	39.65
4	30%	26.54

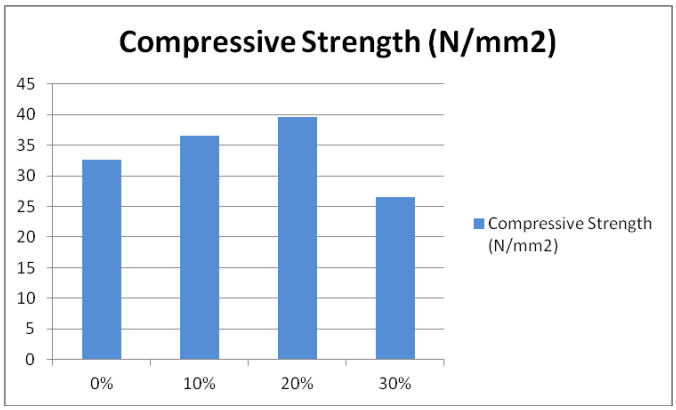

Chart-4: Compressive Strength when cement is replaced with GGBS

From the figure 4 and table 4 it is observed that 20% GGBS mixed concrete achieved maximum strength in comparison to normal concrete.

Table-5: Compression test at 28th Day with various proportions of Coconut Shell Powder and GGBS replacing fine aggregates and Cement in M30 grade concrete

S.No	Coconut Shell Powder + GGBS Content	Compressive Strength (N/mm²)
1	30% CSP + 10% GGBS	35.95
2	30% CSP + 20% GGBS	36.77
3	30% CSP + 30% GGBS	33.64

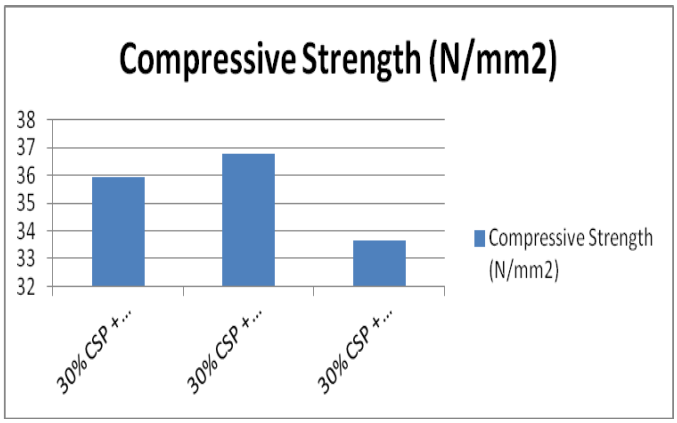

Chart-5: Compressive Strength when fine aggregate is replaced with Coconut shell powder and cement is replaced with GGBS

From the figure 5 and table 5 it is observed that 30% coconut shell powder and 20% GGBS mixed concrete achieved maximum strength in comparison to normal concrete.

c. Split tensile test

The tensile strength of concrete with 28days curing period for various proportions is present at below. The specimens were casted and tested as per IS: 516-1959.

Table-6: Split Tensile test at 28th Day with various proportions of Coconut Shell Powder replacing fine aggregates in M30 grade concrete

S.No	Coconut Shell Powder Content	Split Tensile Strength (N/mm²)
1	0%	3.45
2	10%	3.89
3	20%	4.56
4	30%	5.47
5	40%	4.98
6	50%	3.65
7	60%	2.76
8	70%	2.54
9	80%	2.35
10	90%	2.23
11	100%	2.11

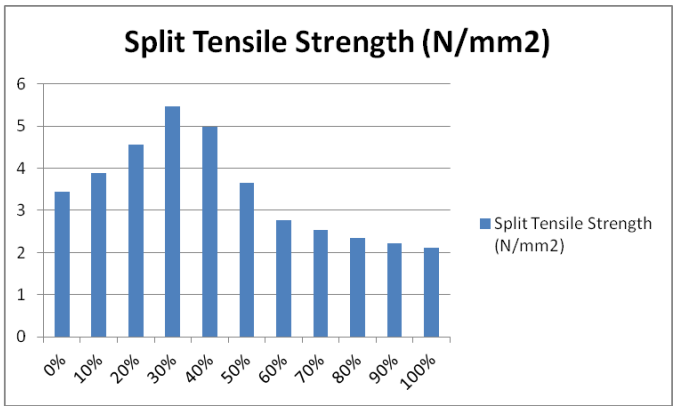

Chart-6: Split Tensile Strength when fine aggregate is replaced with Coconut shell powder

From the figure 6 and table 6 it is observed that 30% coconut shell powder mixed concrete achieved maximum strength in comparison to normal concrete.

Table-7: Split Tensile test at 28th Day with various proportions of GGBS replacing Cement in M30 grade concrete

S.No	GGBS Content	Split Tensile Strength (N/mm²)
1	0%	3.53
2	10%	3.59
3	20%	3.64
4	30%	3.15

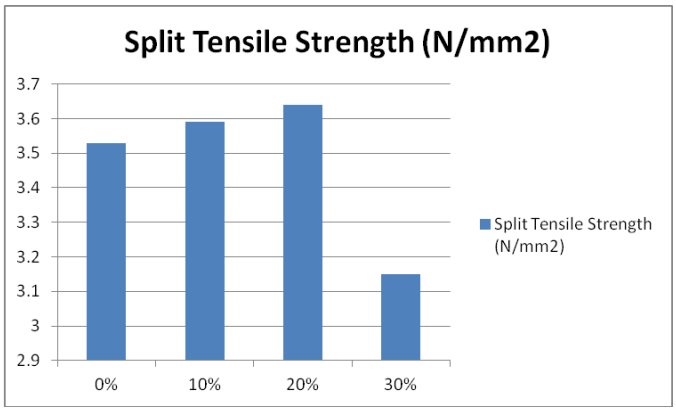

Chart-7: Split Tensile Strength when cement is replaced with GGBS

From the figure 7 and table 7 it is observed that 20% GGBS mixed concrete achieved maximum strength in comparison to normal concrete.

Table-8: Split Tensile test at 28th Day with various proportions of Coconut Shell Powder and GGBS replacing fine aggregates and Cement in M30 grade concrete

S.No	Coconut Shell Powder + GGBS Content	Split Tensile Strength (N/mm²)
1	30% CSP + 10% GGBS	3.7
2	30% CSP + 20% GGBS	3.85
3	30% CSP + 30% GGBS	3.75

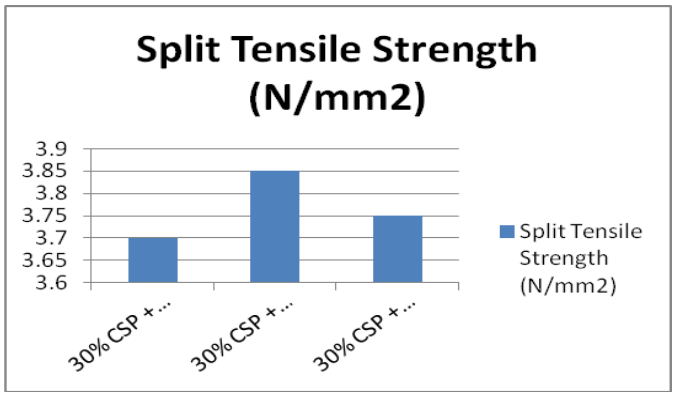

Chart-8: Split Tensile Strength when fine aggregate is replaced with Coconut shell powder and cement is replaced with GGBS

From the figure 8 and table 8 it is observed that 30% coconut shell powder and 20% GGBS mixed concrete achieved maximum strength in comparison to normal concrete.

5. CONCLUSIONS

Based on the experimental investigations the following conclusions are drawn:

- Sand is a natural resource available on earth. Too much usage of sand in construction industry is depleting its resource. In order to overcome this, alternate materials are to found. Coconut shell powder is one such material.
- Both coconut shell powder and GGBS are waste materials. So, as per environmental point of view, these are also helpful in maintaining effective sustainable environment.
- From the compressive strength test results, it is observed that coconut shell powder based concrete has achieved an increase in strength for 30% replacement of fine aggregate and 20% replacement of cement by GGBS and combination of 20% GGBS and 30% coconut shell powder.
- From the split tensile strength test results, it is observed that coconut shell powder based concrete has achieved an increase in strength for 30% replacement of fine aggregate and 20% replacement of cement by GGBS and combination of 20% GGBS and 30% coconut shell powder.
- Coconut shell powder can be used as an alternate material to fine aggregate up to 30% partial replacement.

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