Strength Characteristics of Concrete by Partial Replacement of Coarse Aggregate with Coconut Shells & Cement with Glass Powder

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Abstract. In this study coarse aggregates and cement are partially replaced in the concrete with similar materials like coconut shells and glass powder. While production of the cement there is a lot of pollution to the environment and which causes health issues to the society. In the same way while production of the course aggregates which releases lot of dust into the atmosphere which causes damage to human lives. We can obtain some advantages by partially replacing the coarse aggregates and cement in the concrete. As we all know that the Cement and the coarse aggregates are the main ingredients in the concrete. The cost of these materials is getting increased day by day. There are some of the materials proposed by many researchers to lesser the cost of the concrete and to improve the strength characteristics of the concrete. For coarse aggregates, the coconut shell is the most preferable and it has more potential to the partial replacement of the coarse aggregates in concrete. As well as there is a similar material which used to partially replacement of the cement is waste glass powder. As we observe at many places there is a lot of wastage of glass will produce throughout the year. Mainly glass is the composition of silica. When the glass is crushed into very small size as powder it experienced to the pozzolanic reactions with hydrates in the cement, and calcium silicate hydrate will be formed. The main aim of this research is utilization of the waste material in the concrete as well as decreasing the cost of the construction by using these waste materials in the concrete, by performing all these things we can easily reduce the pollution of the environment and clean the environment by using these waste materials in the concrete.

Keywords: Coconut shells, Crushed Glass powder, Calcium Silicate Hydrate, Replacement, Splitting tensile strength, Pollution, Green house gasses.

1. Introduction

In the construction work concrete is the main element, in the concrete the coarse aggregates and cement are the major ingredients [1]. By using the high amount of cement in the concrete it will produce CO₂ and some other green house gasses into the atmosphere which leads to the damage of the human lives and in the same way the cost of the cement production is also getting expensive now-a-days [2]. Coconut shells are the waste products which are going very high growth on day by day in the daily use. The wastage of these coconut shells are occupying lot of space on the earth and which produces toxic gases into the atmosphere which is very dangerous to the all biological lives [3,4]. To
mitigate those problems, to reduce these waste on the earth, in this research we suggest to use a substitute material in the concrete to partially replacing the cement with glass powder and Course aggregates with coconut shells [5]. By crushing the waste glass into very fine powder it gains pozzolonic actions, which gives strength to the concrete. And it can replace the cement and contributes development in the strength characteristics. Both cement and glass powder has nearly equal chemical composition and the fineness of the glass powder is nearly equal to the cement that is the major reason to use glass powder in the concrete as a partial replacement of cement [9]. The partial replacement of these two materials at a time in the concrete gives good results. The crushed coconut shell gives nearly same properties like coarse aggregates. Both conventional concrete and the concrete with the partial replacement of the material were prepared and tested at room temperature which gives better results than conventional concrete at some % replacement of these materials [12].

2. Materials and Properties

2.1. Coconut shells

Coconut shells are the waste material which is available very easy in the atmosphere; in this research we used coconut shells as a partial replacement of the coarse aggregate. The cost of one unit of the coarse aggregates is more than compared to the preparation of the same amount of coconut shells [6]. By adding the coconut shells to the concrete it will gain more workability due to the smoothen surface of the one side of the shell. Comparing with the conventional concrete the coconut shell concrete has more impact resistance. Water absorption capacity of the coconut shell is higher than the nominal aggregates [16].

![Coconut shells Grinding](image)

**Figure: 1 Coconut shells Grinding**

| Property          | Value |
|-------------------|-------|
| Lignin            | 28.6  |
| Ash               | 0.56  |
| Cellulose         | 26.9  |
| Moisture          | 8.2   |
| Solvents & Anhydrides | 7.5  |

Table: 1 Properties of coconut shell

2.2. Course Aggregates

The shape and texture of coarse aggregate affects the properties of fresh concrete more than hardened concrete. A smooth surface can improve workability, yet a rougher surface generates a stronger bond between the paste and the aggregate creating a higher strength. In coarse aggregates there is a possibility to have both smooth and rough surfaces by that it can increase both workability and bonding of the concrete [8]. Coarse aggregates can increases the dimensional stability and strength of the concrete. The volume and weight of the concrete can be increased by the coarse aggregates.
2.3. **Cement**

The 53-grade (OPC) ordinary Portland cement was used in the designed concrete mix. As per **IS: 12269-2013** the quality of the cement is determined by the test which are shown below table. If the calcium content is present more in the cement it will give high strength properties to the concrete [10]. As we all know that the cement has a very fine particle in size which can increase the binding property in the concrete. There are different grades of the cement available among them in this study we used 53-grade cement.

| Property                  | Test Result |
|---------------------------|-------------|
| Fineness (%)              | 6.78        |
| Specific Gravity          | 2.56        |
| Compressive Strength(M pa)| 46.36       |

2.4. **Glass powder**

Glass powder has more pozzolonic properties when it has milled into very fine powder. By using the waste glass powder in the concrete mix the strength characteristics, binding properties will be increased and heat of hydration will reduces. Glass powder has nearly equal composition like cement that is the major reason that we can comfortably use this glass powder as a partial replacement of cement in the concrete. This glass powder is the waste material which is freely available at the glass design shops [11]. By using this crushed glass powder as a partial replacement of cement in the concrete we can reduce the cost of the preparation of concrete and can minimize the amount of pollution while production of the cement.
Table: 3 Properties of glass powder

| Compound        | Glass powder |
|-----------------|--------------|
| silicon dioxide | 68.1         |
| Aluminum oxide  | 0.9          |
| Calcium oxide   | 14.5         |
| Magnesium oxide | 1.8          |
| Potassium oxide | 0.6          |
| Sodium oxide    | 0.8          |
| Sulfur trioxide | 12.2         |

3. Concrete Mix Proportion

At the room temperature the concrete batching will be done. Different percentages of coconut shells and glass powder were mixed in the concrete like 10%, 20%, 30% and 40% and a standard mix of nominal concrete is mixed and the following mix proportions are designed as per the codal provisions.

Mix Ratio: 1:1.72:2.69
W.C Ratio : 0.42

4. Tests and Results - Comparison

4.1. Workability Test

4.1.1. Slump cone Test

By the test results obtained from the workability test, the workability is increasing with respect to the increasing percentage amount of the partial replacement of the coarse aggregates with coconut shells and cement with crushed glass powder [7]. The coconut shell has smooth surface and smaller in size compared to the nominal coarse aggregates, that is the major reason that replaced material concrete gives more workability than standard nominal mix [13].
Table: 4 Test results

| %Replacement of CA & cement | Slump cone values in mm |
|-----------------------------|-------------------------|
| 0                           | 3.6                     |
| 10                          | 4.3                     |
| 20                          | 6.2                     |
| 30                          | 9.2                     |
| 40                          | 10                      |

Figure: 6 Graphical Representations

4.2. **Compressive Strength**

The resistance to the external loading of the material can be determined by using the compressive strength test [14]. In this study, the 20% replacement of the material mix got a better compressive strength than normal concrete. The test values allow that the coconut shell and glass powder concrete may be used at high strength applications by replacing around 20%, if we replace more than 20% which leads to the decrease of strength.

Table: 5 Test results

| %Replacement of CA & cement | 1 week | 2 weeks | 4 weeks | 8 weeks |
|-----------------------------|--------|---------|---------|---------|
| 0                           | 29     | 38      | 43      | 48.6    |
| 10                          | 28     | 33.1    | 39.8    | 42.4    |
| 20                          | 30     | 37.3    | 44      | 49.8    |
| 30                          | 27     | 34      | 40.6    | 41.4    |
| 40                          | 25     | 33      | 39      | 40      |
4.3. **Splitting Tensile strength test**

The tensile behaviour of the concrete under external loading can be determined by the Splitting tensile strength [15]. The result may allow that the coconut shell and glass powder concrete mostly used in high strength applications by replacement around 20%. The 20% replacement of material mix got a better splitting tensile strength than normal concrete, if we replace more than 20% which leads to the decrease of strength.

![Graphical Representations](image)

**Figure: 8 Graphical Representations**

![Samples](image)

**Figure: 9 Samples**

| % Replacement of CA & cement | 1 week | 2 weeks | 4 weeks | 8 weeks |
|------------------------------|--------|---------|---------|---------|
| 0                            | 2.67   | 3.7     | 4.12    | 4.76    |
| 10                           | 2.47   | 3.42    | 3.8     | 4.23    |
| 20                           | 2.73   | 3.78    | 4.2     | 5.1     |
| 30                           | 2.48   | 3.44    | 3.85    | 4.26    |
| 40                           | 2.36   | 3.25    | 3.62    | 3.92    |

**Table: 6 Test results**
Figure: 10 Graphical Representations

4.4. Flexural strength test

The bending nature of the concrete can be determined by performing this Flexural strength test. The concrete is mixed as per the recommended proportions and tested. Comparison of the results obtained by the flexural test on the prepared specimen with different mixes of concrete by partially replacing the coconut shells and glass powder in the place of coarse aggregates and cement i.e., 0%, 10%, 20%, 30%, 40%. The test results give good results at 20% replacement.

Table: 7 Test results

| % Replacement of CA & cement | 1 week | 2 weeks | 4 weeks | 8 weeks |
|------------------------------|--------|---------|---------|---------|
| 0                            | 2.77   | 3.8     | 4.2     | 4.7     |
| 10                           | 2.53   | 3.52    | 3.8     | 4.2     |
| 20                           | 2.63   | 3.68    | 4.3     | 4.9     |
| 30                           | 2.46   | 3.34    | 3.9     | 4.18    |
| 40                           | 2.23   | 3.35    | 3.7     | 3.9     |

Figure: 11. Graphical Representation
5. Conclusion

From the experimental results the following conclusions were drawn.

- In the concrete mix by adding 20% of coconut shells and glass powder as the partial replacement of coarse aggregates and cement, we can get good strength characteristics to the concrete than the nominal mix.
- The results concluded that the usage of the materials like coconut shells and glass powder is acceptable in the concrete.
- The recycling of the material called coconut shells and waste glass are done.
- If more than 25% of coconut shells and glass powder are partially replaced in the concrete, then the strength characteristics are decreasing gradually.
- To reduce the cost of the materials used in the concrete like cement and coarse aggregates, the coconut shells and glass powder are to be used.
- The workability and the strength characteristics of the concrete is getting increased up to 20-30% replacement of these materials, if it is greater than 25% the performance of the concrete is getting decreased.
- To get good strength characteristics to the concrete, 20% to 30% of coconut shells and glass powder are proposed to replace by this study.
- By using the glass powder and coconut shells in construction materials, it leads to reduce the environmental pollution issues.

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