Influence of Coconut Fiber and Shell on Concrete

Prem Prateek, Sukruti Srivastava, Priti Kumari, Chandan Kumar, Krishna Murari

Abstract: Concrete is a composite material which is composed of cement, fine aggregate, coarse aggregate bound together with a definite proportion of water. Concrete is widely used in every single construction work around the world. Due to large scale construction activities using conventional coarse aggregate such as granite as a constructional material extreme reduction in the natural stone deposit has been encountered and is affecting the environment, hence causing ecology imbalance. In current situation of construction, price factor and the wide range of extraction and processing of materials matter of great concern for the people as well as environment. Therefore, introduction of alternate waste material in place of natural aggregate in concrete production not only protects environment but also make concrete a suitable, economical and environment friendly construction material. Different material like Coconut Shell and Fiber can also be used alternatively. In this project CoconutShell and fiber are used as partial replacement for coarse aggregate as well as fine aggregate, respectively. To study characteristic properties of concrete 10% and 20% for coarse aggregate and 1%, and 2% for fine aggregate are replaced by its weight with coconut shell and fiber.

Keywords: CoconutShell, Coconut Fiber, Flexural Strength and Tensile Strength.

I. INTRODUCTION

According to the research, the high cost of conventional building materials plays a major role implanting housing delivery around the world. This leads a necessitated research to accommodate alternative material for future construction. Research for coconut shell and fiber to use as aggregate material, leads to reduction of cost as well as weight of the concrete and enhancing its strength. As introducing coconut shell and fiber as a suitable material, we are accounting for environmental impacts as well. It will be the first project to use coconut fiber and shell together as aggregate material in concrete.

Concrete shell and fiber are byproduct of agriculture. Once the extraction of fruit is done, shell wathrawn as waste material which are rarely used for ornamental work. Coconut shell effectively reduces vulnerability of concrete: against alkali, acid, and salt. Coconut fiber have TensileStrength of 21.5MPa which is the toughest among all natural fibers. They are capable of taking 4-6 times more strains than other fibers.

Although it is a cheap and efficient, a major hindrance towards its wide scale use is high rate of water absorption, which can be reduced by providing oil coating. The advantages of Coconut fiber are: low cost, reasonable specific strength, low density, ease of availability, enhanced energy recovery, biodegradability, Although it is a cheap and efficient, a major hindrance towards its wide scale use is high rate of water absorption, which can be reduced by providing oil coating. The advantages of Coconut fiber are: ability to be recycled in nature in a carbon neutral manner, resistance to fungi moth and rot, excellent insulation to sound, flame, moisture, dampness, toughness, durability and resilience. Whereas coconut shell has high strength and modulus properties. It also has added advantage of high lignin content which makes the composite more weather resistant. It has low cellulose content due to which it absorb less moisture as compare to other agricultural waste. As Coconut being naturally available, its shell are non-biodegradable; they can be used readily in concrete which may fulfill almost all qualities of nominal concrete.

II. MATERIALS AND METHODS

1) Cement–Cement is a binding material used in building construction and civil engineering construction. It is made by grinding calcined limestone and clay to a fine power, which can be mixed with water and poured to set as a solid mass and adheres to other materials to bind them together. In this project work we are going to use Pozzolana Portland Cement (PPC) of brand Birla Cement.

- The physical properties of OPC as determined given in the table (1).

| S.NO | Properties                      | Experimental Value |
|------|--------------------------------|--------------------|
| 1    | Normal consistency % (IS:4031-Part-4:1988) | 39%               |
| 2    | Initial setting time            | 41 min             |
| 3    | Final setting time              | 225 min            |
| 4    | Soundness of Cement (Le chatelier expansion) | 2.75mm          |
| 5    | Fineness of Cement (IS:4031-Part-1:1996) | 8.5               |
| 6    | Specific gravity                | 3.064              |
| 7    | Bulk Density                    | 1450 kg/m³         |
| 8    | Compressive strength at 7 days  | 542.267KN          |
|      |                                 | 28 days            |
|      |                                 | 560.80KN           |

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2) **Fine aggregate:** - aggregates are inert materials mixed with binding material for construction purposes. It is the widely mined material in the world. For fine aggregate we will use locally available sand which pass through 4.75mm sieve. M sand available at NSIT,Bihta having the following characteristics has been used. Sand after Sieve analysis confirm to Zone-2 has been used as per specification IS:456-2000; IS:2386-Part-1-1963; IS:383-1970.

- The physical properties of aggregate are given in table (2)

| S.NO | Properties          | Experimental Value |
|------|---------------------|---------------------|
| 1    | Fineness Modulus    | 2.616               |
| 2    | Water absorption    | 0.80%               |
| 3    | Specific gravity    | 2.7                 |
| 4    | Bulk Density        | 1695 kg/m³          |

3) **Coarse Aggregate:** - Locally available black crushed stone in Bihta with nominal size passing through 20mm IS sieve have been used. The physical properties for coarse aggregate are found through laboratory test in accordance to IS:2386-Part-1-1963; IS:383-1970: IS:456-2000.

- The physical properties of aggregate are given in table (3)

| S.NO | Properties                     | Experimental value |
|------|--------------------------------|---------------------|
| 1    | Aggregate Crushing Value       | 10.45               |
| 2    | Aggregate Impact Value         | 7.92                |
| 3    | Specific Gravity               | 2.9                 |
| 4    | Water Absorption               | 0.35%               |
| 5    | Bulk Density                   | 1590 kg/m³          |
Coconut Shell:- Normal Indian Coconut. They are sun dried before being crushed. Particle size range from 12mm to 20mm. The surface texture of shell was fairly smooth on concave face and rough on convex face.

4) Water: - Water is used as a raw material during the manufacturing of various civil materials and in construction. It plays an important role in concrete preparation as binding the cement with other aggregate and play major role in the chemical process of releasing heat of hydration and hence imparting strength to it. The pH value of water used in concrete should always be greater than 6. In general, water fit for drinking is suitable for mixing concrete.

5) Admixture: - Admixture are natural or manufactured chemicals which are used to give special properties to fresh and hardened concrete. It increases the workability without increasing water content or to decrease the water content at the same workability. In this project we have used CONMIX SP 1030 admixture from Radhekrishna Chemical Company. Technical data of admixture is present in following table 4:

| S.NO | Properties         | Data                          |
|------|--------------------|-------------------------------|
| 1.   | Appearance         | Brown liquid                  |
| 2.   | Main Base          | Sulphonated Naphthalene Formaldehyde |
| 3.   | Ph                 | 7-8                           |
| 4.   | Chloride Content   | Nil                           |
| 5.   | Specific gravity   | 1.2 at room temperature       |
| 6.   | Shelf life         | 12 months in original packing |

6) Concrete Mixes: - Mix design is defined as the process of selecting suitable ratio of ingredient to be mixed to form concrete of certain maximum strength and durability as economically as possible. The concrete mixes will be assigned with the use of type of fine aggregate and grade of the concrete. In this project we are using concrete of grade as M30. A mix design was conducted as per IS:10262-2009 to arrive at M30 mix concrete. The percentage replacement of aggregate added by 10% and 20% by weight with a w/c ratio of 0.442%. The mix proportion of 2.72: 3.43: 7.63 (where 2.72 is for cement 3.43 for fine aggregate and 7.63 for coarse aggregate of size 10mm to 20mm).
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IS method of concrete mix was used to achieve a mix with strength of 30 MPa. Mix proportions were arrived and coconut shell and fiber was added to the concrete mix with a w/c ratio 0.442%. Control mix concrete and modified concrete with varying percentage of coconut shell and fiber and the percentage for various replacement levels are presented in Table 5.

Table 5. Details of concrete fiber and shell mix percentage

| Mix Specification | Control mix (M₀) | Modified Mix 1 (M₁) | Modified Mix 2 (M₂) | Modified Mix 3 (M₃) | Modified Mix 4 (M₄) |
|-------------------|------------------|---------------------|---------------------|---------------------|---------------------|
| Proportion of Coconut Shell added | 0% | 10% | 20% | 10% | 10% |
| Proportion of Coconut Fiber added | 0% | 0% | 0% | 1% | 2% |

Table 6. Details of test specimens

| Test Details | Shape and Dimension of Specimen |
|--------------|---------------------------------|
| Compressive Strength | Cube: 150 × 150 × 150 mm |
| Splitting Tensile Test | Cylinder: 150 × 300 mm |
| Flexural Strength | Beam: 100 × 100 × 500 mm |
| Durability Test | Cube: 150 × 150 × 150 mm |

7) Mixing, Casting And Curing Of Concrete: -The coarse aggregate and fine aggregate were weighted, and the concrete mixture was prepared by hand mixing on a water tight platform and mixed thoroughly until a uniform color is obtained, later to it mixture of coarse aggregate was added and mixed thoroughly. Then water is added carefully, making sure no water is lost during mixing process. Water is added in stages for hydration of the cement which was carried out with preventive measure in place to avoid bleeding which may affect strength formation of concrete. Cleaned and oiled mould was placed on a vibrating table, then concrete mix was placed in three layer, each layer first went through vibration to release air formed during mixing and vibration were stopped as soon as the cement slurry appeared on the top surface of the mould.

The specimen were allowed to remain in the steel mould for the first 24hrs at ambient condition of temperature 27°± 2° C. After that specimen were demoulded with care to prevent edges from breaking apart and specimen were placed in the tank at the ambient temperature for curing. After demoulding of the specimen by loosening the screws of steel mould, they were placed in the water for 7 days, 14 days and 28days. The specimen shall not be allowed to become dry at any time until they have been tested.

Castling Coconut Fiber and Coconut Shell Concrete:-
The calculated amount of cement and fine aggregate are mixed together until a uniform mix is obtained. Fibers at varying amount of 1%, and 2% to that of wt. of cement are taken. It is then added to mix until uniform color is obtained. Coarse aggregate are then added to the same and mixed, followed by addition of water. Care should be taken to add water slowly in stages so as to prevent bleeding which may affect the strength formation of concrete. It is placed in mould of standard dimension, compacted and finished. Casting is done as per IS:516-1959.
### III. RESULTS

#### (1) CONVENTIONAL CONCRETE TEST RESULTS-

| S.NO | Compressive strength (MPa) | Split tensile strength (MPa) |
|------|-----------------------------|-------------------------------|
| Days | 3  | 7  | 28 | 3  | 7  | 28 |
| 1.   | 14.45 | 22.65 | 36.15 | 5.23 | 6.13 | 7.33 |
| 2.   | 12.98 | 22.28 | 35.78 | 4.29 | 5.09 | 6.17 |
| 3.   | 13.43 | 22.43 | 34.87 | 4.40 | 5.85 | 6.34 |

#### (2) 10% REPLACEMENT OF COCONUT SHELL AS COARSE AGGREGATE-

| S.NO | Compressive strength (MPa) | Split tensile strength (MPa) |
|------|-----------------------------|-------------------------------|
| Days | 3  | 7  | 28 | 3  | 7  | 28 |
| 1.   | 15.87 | 25.79 | 35.32 | 4.46 | 5.66 | 7.13 |
| 2.   | 14.45 | 25.23 | 34.00 | 3.45 | 4.45 | 6.00 |
| 3.   | 15.40 | 25.45 | 34.48 | 3.52 | 4.59 | 5.83 |

#### (3) 20% REPLACEMENT OF COCONUT SHELL AS COARSE AGGREGATE-

| S.NO | Compressive strength (MPa) | Split tensile strength (MPa) |
|------|-----------------------------|-------------------------------|
| Days | 3  | 7  | 28 | 3  | 7  | 28 |
| 1.   | 16.58 | 24.19 | 33.41 | 4.06 | 4.80 | 6.93 |
| 2.   | 15.79 | 23.38 | 32.07 | 3.15 | 4.00 | 5.48 |
| 3.   | 16.17 | 22.81 | 30.14 | 3.27 | 4.72 | 5.64 |

#### (4) 10% COCONUT SHELL AGGREGATE + 1% COCONUT FIBER REPLACEMENT-

| S.NO | Compressive strength (MPa) | Split tensile strength (MPa) |
|------|-----------------------------|-------------------------------|
| Days | 3  | 7  | 28 | 3  | 7  | 28 |
| 1.   | 16.56 | 23.55 | 35.52 | 5.53 | 6.36 | 7.32 |
| 2.   | 15.67 | 23.81 | 36.06 | 5.58 | 6.84 | 7.51 |
| 3.   | 16.68 | 23.45 | 35.70 | 5.79 | 6.50 | 7.60 |

#### (5) 10% COCONUT SHELL AGGREGATE + 2% COCONUT FIBRE REPLACEMENT-

| S.NO | Compressive strength (MPa) | Split tensile strength (MPa) |
|------|-----------------------------|-------------------------------|
| Days | 3  | 7  | 28 | 3  | 7  | 28 |
| 1.   | 17.10 | 23.08 | 35.87 | 5.46 | 6.11 | 7.43 |
| 2.   | 15.60 | 23.45 | 36.15 | 5.39 | 5.86 | 7.92 |
| 3.   | 16.03 | 23.19 | 35.79 | 5.39 | 6.33 | 7.35 |
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(6) COMPARISON OF RESULTS: (COMPRESSIVE STRENGTH)

| DAYS  | CONVENTIONAL CONCRETE | 10% COCONUT SHELL | 20% COCONUT SHELL | 10% COCONUT SHELL + 1% COCONUT FIBER | 10% COCONUT SHELL + 2% COCONUT FIBER |
|-------|-----------------------|-------------------|-------------------|-----------------------------------|-----------------------------------|
| 3 days| 13.62                 | 15.34             | 16.18             | 16.30                             | 16.24                             |
| 7 days| 22.45                 | 25.49             | 23.46             | 23.60                             | 23.24                             |
| 28 days| 35.6                 | 34.6              | 31.87             | 35.76                             | 35.93                             |

(7) COMPARISON OF RESULTS: (SPLIT TENSILE STRENGTH)

| DAYS  | CONVENTIONAL CONCRETE | 10% COCONUT SHELL | 20% COCONUT SHELL | 10% COCONUT SHELL + 1% COCONUT FIBER | 10% COCONUT SHELL + 2% COCONUT FIBER |
|-------|-----------------------|-------------------|-------------------|-----------------------------------|-----------------------------------|
| 3 days| 4.64                  | 3.81              | 3.49              | 5.63                              | 5.41                              |
| 7 days| 5.69                  | 4.9               | 4.50              | 6.56                              | 6.1                               |
| 28 days| 6.61                | 6.32              | 6.01              | 7.47                              | 7.56                              |

➢ Graph no.1 – Relationship between % Replacement of coconut shell and fiberVs Compressive strength.
Graph no.2 – Relationship between 10% Coconut Shell with Coconut Fiber Vs Compressive Strength.

Split Tensile strength(Mpa)

- Split Tensile strength(Mpa)

IV. CONCLUSION

Result of following test of Compressive strength and Split tensile strength for given proportion of coconut shell and fiber replacement have been represented with those of conventional concrete. The coconut shell containing concrete shows a minimal variation in normal aggregate concrete. While addition of coconut fiber with coconut shell shows an increase in the compressive as well as tensile strength than conventional concrete.

The following conclusions are made by observing the result of this project:

1. The replacement of coarse aggregate with 10% coconut shell, decreases to minimal variation of 2.7% in compressive strength and 2.72% in split tensile strength.
2. The replacement of coarse aggregate with 20% coconut shell, decreases to minimal variation of 7.5% in compressive strength and 5.45% in split tensile strength.
3. With the addition of coconut fiber in earlier coconut shell concrete, increase in the compressive as well as split tensile strength has been noted.
4. When 1% of coconut fiber is replaced with cement weight, increase of 0.44% in conventional concrete and 3.24% in the coconut shell concrete in compressive strength has been noted, respectively.
5. When 2% of coconut fiber is replaced with cement weight, increase of 0.92% in conventional concrete and 3.70% in the coconut shell concrete in compressive strength has been noted, respectively.
6. When 1% of coconut fiber is replaced with cement weight, increase of 11.51% in conventional concrete and 15.39% in the coconut shell concrete in compressive strength has been noted, respectively.
7. When 2% of coconut fiber is replaced with cement weight, increase of 8.57% in conventional concrete and 12.58% in the coconut shell concrete in split tensile strength has been noted, respectively.
8. From the graph no.1, the compressive strength of concrete will decrease with increase of coconut shell percentage.
9. From the graph no. 2, the compressive strength of concrete increases with addition of coconut fiber with shell.

REFERENCES

1. Chandan Kumar, Priti Kumari, Krishna murari “Utilization of e-waste in geopolymer concrete by partial replacement of coarse aggregate.” IJCRT | Volume 8, Issue 5 May 2020 | ISSN: 2320-28820.
2. Chandan Kumar, Kumar Gaurav, Md. Shahnawaz Ali, Rahul Kumar, Prashant Kumar, Dr. Krishna Murari “Partial Replacement of Coarse Aggregate by E-Waste in Concrete.” IJCRT | Volume 7, Issue 06 June 2020 | ISSN: 2395-0072.
3. “Study of strength of properties of coconut shell concrete” International Journal of Civil Engineering and Technology (IJCIET), ISSN 0976 – 6308 (Print), ISSN 0976 – 6316(Online), Volume 6, Issue 3, March (2015), pp. 42-61 © IAEME.
4. Soumen Santra, Jaydeep Chowdhury “Comparative study on strength of conventional concrete and coconut fiber reinforced concrete.” International Journal of Scientific & Engineering Research, Volume 7, Issue 4, April-2016 ISSN 2229-5518.
5. B. Damodhara Reddy, S. Aruna Jyothy, Fawaz Shaik “Experimental Analysis of the Use of Coconut shell as Coarse Aggregate.” ISOR Journal of Mechanical and Civil Engineering (ISOR-JMCE)e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 10, Issue 6 (Jan. 2014), PP 06-13.

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