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An experimental investigation utilizing coconut shells in place of coarse aggregate in lightweight and steel fiber concrete

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Abstract - This Concrete is among the most widely used building materials worldwide. Light weight aggregate concrete (LWAC) is a vital and versatile material in modern construction. Due to its lower density and superior thermal insulation qualities, it has grown in popularity. As evidenced by the numerous impressive light weight concrete (LWC) structures found all over the world. Many architects, engineers, and contractors are aware of the inherent economies and advantages offered by this material. Although typically 25–35% lighter than regular concrete, lightweight concrete still has comparable strengths. Because of its reduced self-weight, enhanced seismic structural response, and cheaper foundation costs, structural LWC offers design flexibility and cost savings. When making LWC, this coconut shell can be crushed and used as a coarse aggregate. Coconut shell concrete (CSC) can be used in rural areas, areas with a lot of coconut trees, and locations where it is expensive to use traditional aggregates. Adding a certain amount of steel fibre to concrete will also strengthen it and improve its ductility, energy absorption, impact resistance, and crack resistance qualities. It has been determined that adding 3% steel fibre and replacing 10%, 20%, and 30% of the coarse aggregate in concrete of grade M20 with coconut shell is feasible.

***Key Words*:** Light weight concrete, Coconut Shell Concrete, Steel fiber, compressive strength, split tensile strength and flexural strength

1. INTRODUCTION

The development of a project should include waste management as a key component. Waste management will be a part of the project to some extent for each of the main participants: the Owner, their Architectural and Engineering services (or Construction Management consultant), the Contractor, and Subcontractors. The owner and their A/E must first decide what levels of diversion are feasible and reasonable given the project's circumstances. They must also establish waste reduction goals.

For many years, the use of agricultural wastes in the construction sector has been investigated, but the results have been mixed. The construction industry can use these wastes as potential or replacement materials in nations where agricultural waste is dumped in large quantities. One agricultural waste that is produced in large quantities and that could be used as coarse aggregate in concrete is coconut shells. The Asia Pacific region accounts for eight of the top ten producers. India, the Philippines, and Indonesia are the three major producers, making up 75% of global output. With a 1.9-million-hectare area and an annual production of 2.74 million tons of copra equivalent, India ranks third among countries that produce coconuts. 90% of the people in India

In India, the average annual loss of coconuts is thought to be around 15 billion nuts. The shell of the coconut is typically discarded as waste after it has been hollowed out. The vast majority of this wasted CS resource is still being used for commercial purposes; its application as a building material, particularly in concrete, similar to other lightweight aggregates, is an intriguing area for future research. When making LWC, this coconut shell can be crushed and used as a coarse aggregate. Coconut Shell Concrete (CSC) may be used in rural areas, regions with an abundance of coconuts, and in locations where conventional aggregates are expensive. The crucial mechanical characteristics of CSC, including compressive, flexural, splitting tensile strength, and impact resistance, have been examined in this study.

2. OBJECTIVE OF WORK

1.To investigate waste minimization methods Utilization of new building materials.
2.To determine the mix ratio that provides good strength when coconut shell is substituted.
3.To investigate the use of coconut shell concrete in construction waste management.
4.To contrast the mechanical characteristics of conventional concrete and concrete reinforced with coconut shell.

- Cement
- Fine Aggregate (River sand)
- Coarse aggregate
- Coconut shell
- Steel fibre

3. MIX DESIGN

If you are searching for detail step by step procedure for concrete mix design of M20 grade using IS – 10262: 2009 and IS – 456: 2000.
you aware about the different experimental data required for conducting the mix design of concrete.

Mix Design	
Cement	433 kg / m^3
Water	207 kg / m^3
Fine Aggregate	670 kg / m^3
Coarse Aggregate	1147 kg / m^3

1 : 1.80 : 3.06
Cement : Coarse Aggregate : Fine Aggregate

Table 1 Properties of selected trial mixes of CSC at 28 days.

Cement content (Kg/m)	Water cement ratio	Mix ratio
433	0.42	1 : 1.80 : 3.06

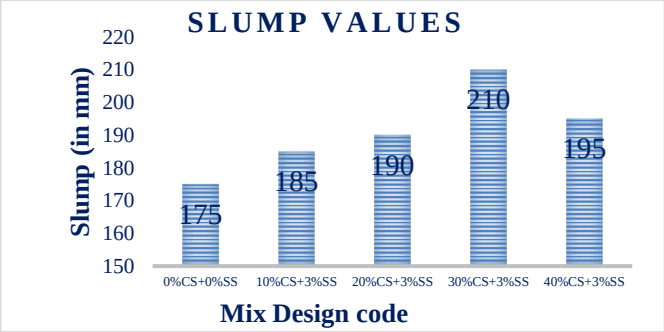
4. RESULT AND DISCUSSION

4.1 Testing of plastic Concrete for Workability

The concrete which is made for casting is tested for slump; both the conventional concrete and coconut shell concrete are tested for the slump value. The obtained slump value is shown in the

Table 2 Slump value of the plastic concrete

Mix-Type	Mix-ID	Slump values
0%CS+0%SS	Mix-CC	175
10%CS+3%SS	MIX-1	185
20%CS+3%SS	MIX-2	190
30%CS+3%SS	MIX-3	210
40%CS+3%SS	MIX-4	195



Graph 1 Slump value of the plastic concrete

Testing of Mechanical Properties of Concrete

The experimental program involves casting and testing of concrete specimens with and without coconut shell. The different specimens considered in this study include 3 cubes for compressive strength and 3 cylinders for tensile strength after 7 days curing for both conventional concrete and coconut shell concrete. And 2 set beams for flexural strength for both type of concretes. And the above tests are carried out for 28 days curing also. All the concrete specimens reported in this study were cast as per the mix design.

4.2 Compressive Strength Test

The measured compressive strength of the specimen is calculated by dividing the maximum obtained load (P) during the test by cross sectional area (A), calculated from the mean dimensions of the section.

$$P_c = P/A$$

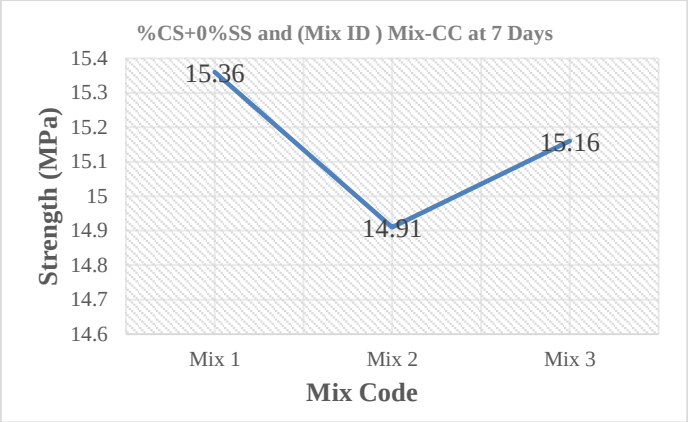
Three numbers of cubes are taken for 7thand 28th day from casting for strength test.

4.2.1 Conventional Concrete

Table 3 Compressive strength of conventional concrete at 7 days (Mix type) 0%CS+0%SS and (Mix ID) Mix-CC

S. No.	Mix Code	Wt. (Kg)	Load (KN)	Strength (N/mm ^{2})
1	Mix 1	8.75	345.5	15.36
2	Mix 2	8.85	335.5	14.91
3	Mix 3	8.65	341	15.16

Average compressive strength of conventional concrete at 7 days =15.44N/mm^2

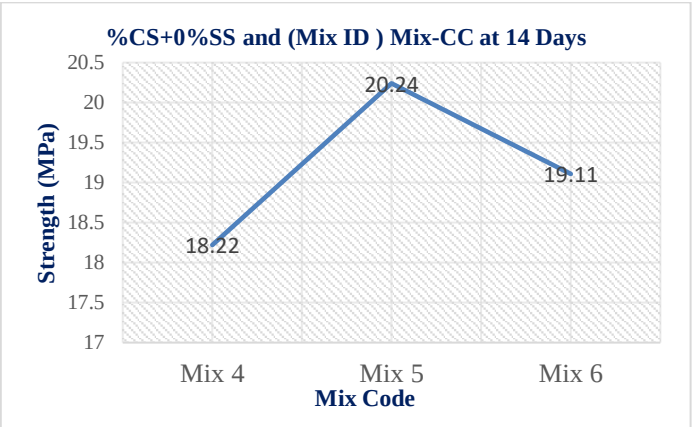


Graph 2 Compressive strength of conventional concrete at 7 days (Mix type) 0%CS+0%SS and (Mix ID) Mix-CC

Table 4 Compressive strength of conventional concrete at 14 days (Mix type) 0%CS+0%SS and (Mix ID) Mix-CC

S. No.	Mix Code	Wt. (Kg)	Load (KN)	Strength (N/mm ^{2})
1	Mix 4	8.75	410.00	18.22
2	Mix 5	8.85	455.50	20.24
3	Mix 6	8.65	430.00	19.11

Average compressive strength of conventional concrete at 14 days =19.99 N/mm^2

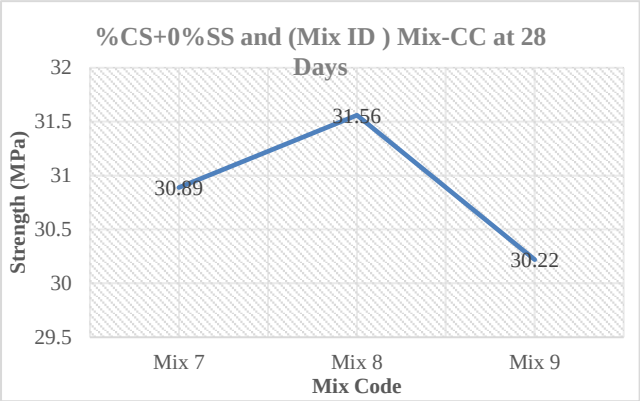


Graph 3 Compressive strength of conventional concrete at 14 days (Mix type) 0%CS+0%SS and (Mix ID) Mix-CC

Table 5 Compressive strength of conventional concrete at 28 days (Mix type) 0%CS+0%SS and (Mix ID) Mix-CC

S. No.	Mix Code	Wt. (Kg)	Load (KN)	Strength (N/mm ^{2})
1	Mix 7	8.70	695.00	30.89
2	Mix 8	8.50	710.00	31.56
3	Mix 9	8.60	680.00	30.22

Average compressive strength of conventional concrete at 28 days=29.86 N/mm^2



Graph 4 Compressive strength of conventional concrete at 28 days (Mix type) 0%CS+0%SS and (Mix ID) Mix-CC

4.2.2 Compressive Strength of Coconut Shell Concrete

Table 6 Compressive strength of coconut shell concrete at 7 days (Mix type) 10%CS+3%SS and (Mix ID) Mix-CSC

S. No.	Mix Code	Wt. (Kg)	Load (KN)	Strength (N/mm ^{2})
1	Mix-CSC-1	6.55	250.00	11.11
2	Mix 8	6.50	230.00	10.22
3	Mix 9	6.55	230.00	10.22

Average compressive strength of coconut shell concrete at 7 days =10.51N/mm^2

Table 7 Compressive strength of coconut shell concrete at 14 days

S. No.	Mix Code	Wt. (Kg)	Load (KN)	Strength (N/mm ^{2})
1	6.55	1940.74	250.00	13.11
2	6.50	1925.92	230.00	12.22
3	6.55	1940.74	230.00	12.22

Average compressive strength of coconut shell concrete at 14 days =12.55N/mm^2

Table 8 Compressive strength of coconut shell concrete at 28 days

S. No.	Mix Code	Wt. (Kg)	Load (KN)	Strength (N/mm ^{2})
1	6.55	1940.74	250.00	16.50
2	6.50	1925.92	230.00	17.00
3	6.55	1940.74	230.00	16.20

Average compressive strength of coconut shell concrete at 28 days =16.87N/mm ^{2}

4.3 Split Tensile Strength Test

The measured strength of the specimen shall be calculated by dividing the maximum obtained load (P) to the specimen during the test by circumferential area. $P_t = 2P / (x D x L)$ Three numbers of cylinders are taken for 7thand 28th day from casting.

4.3.1 Split Tensile Strength of Conventional Concrete

Table 9 Split tensile strength of conventional concrete at 7 days

S. No.	Wt. (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm ^{2})
1	11.90	2249.50	110.00	1.56
2	11.90	2249.50	105.00	1.48
3	12.10	2287.30	110.00	1.56

Average split tensile strength of conventional concrete at 7 days=1.534N/mm

Table 10 Split tensile strength of conventional concrete at 28 days

S. No.	Wt. (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm ^{2})
1	12.10	2287.30	155.00	2.19
2	12.00	2268.43	180.00	2.55
3	12.10	2296.78	150.00	2.29

Average split tensile strength conventional of concrete at 28 days =2.286N/mm ^{2}

4.3.2 Split Tensile Strength of Coconut Shell Concrete

Table 11 Split tensile strength of coconut shell concrete at 7 days

S. No.	Wt. (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm ^{2})
1	10.20	1928.16	90.00	1.27
2	10.20	1928.16	90.00	1.27
3	10.20	1928.16	85.00	1.20

Average split tensile strength of coconut shell concrete at 7 days =1.24N/mm ^{2}

Table 12 Split tensile strength of coconut shell concrete at 28 days

S. No.	Wt. (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm ^{2})
1	9.80	1852.55	110.00	1.56
2	9.80	1852.55	105.00	1.49
3	9.70	1833.64	110.00	1.56

Average split tensile strength of coconut shell concrete at 28 days =1.532N/mm ^{2}

4.4 Flexural Strength Test

The measured strength of the specimen shall be calculated by using the formula P_b= PL / (b x d^2)

Two numbers of beams are taken for 7thand 28th day from casting.

4.4.1 Flexural Strength of Conventional Concrete

Table 13 Flexural strength of conventional concrete at 7 days

S. No.	Wt. (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm ^{2})
1	37.50	2380.95	43.00	7.64
2	37.60	2387.30	42.00	7.46

Average flexural strength conventional of concrete at 7 days =7.55N/mm ^{2}

Table 14 Flexural strength of conventional concrete at 28 days

S. No.	Wt. (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm ^{2})
1	37.30	2371.42	63.00	11.20
2	37.40	2374.60	52.00	9.24

Average flexural strength conventional of concrete at 28 days =10.22N/mm ^{2}

4.4.2 Flexural Strength of Coconut Shell Concrete

Table 15 Flexural strength of coconut shell concrete at 7 days

S. No.	Wt. (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm ^{2})
1	28.80	1828.57	28.00	4.97
2	28.70	1825.39	26.00	4.62

Average flexural strength coconut shell concrete at 7 days =4.795N/mm ^{2}

Table 16 Flexural strength of coconut shell concrete at 28 days

S. No.	Wt. (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm ^{2})
1	28.70	1825.39	33.00	5.86
2	28.60	1819.04	34.00	6.04

Average flexural strength coconut shell concrete at 28 days=5.95N/mm ^{2}

5. CONCLUSIONS

The coconut shell concrete is compared with the conventional concrete for the compression, split tensile strength and flexural strength for 7 and 28 days are plotted below. The splittensile strength of coconut shell concrete is 11.79% for 7 days and 9.08% for 28 days from its compressive strength, and the flexural strength is 45.62% for 7 days and 35.26% for 28 days from its compressive strength.

- **Compressive Strength at 7 days**
  Conventional concrete=15.33 N/mm^2 Coconut shell concrete=10.51N/mm^2
- **Compressive Strength at 14 days**
  Conventional concrete=20.55 N/mm^2 Coconut shell concrete=12.51N/mm^2
- **Compressive Strength at 28 days**
  Conventional concrete=29.86 N/mm^2 Coconut shell concrete=16.8
- **Split tensile Strength at 7 days**
  Conventional concrete=1.53 N/mm^2 Coconut shell concrete=1.24N/mm^2
- **Split Tensile Strength at 28 days**
  Conventional concrete=2. 286N/mm^2 Coconut shell concrete=1.532N/mm^2
- **Flexural Strength at 7 days**
  Conventional concrete=7.55N/mm^2 Coconut shell concrete=4.795N/mm^2
- **Flexural Strength at 28 days**
  Conventional concrete=10.22 N/mm^2 Coconut shell concrete=5.95N/mm^2

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