

The Mechanical Properties of Coconut Fibre Reinforced Concrete with Foundry Sand as a Partial Replacement of Fine Aggregate

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ABSTRACT: Concrete is a composite material which is comprises of blue metal and sand which are bonded together with a fluid cement which hardens over time. Concrete has been used since ancient times to build massive structures. Various researches have been carried out for a long time looking for replacement materials for the constituents of concrete to improve various properties such as strength, permeability, etc. Researchers have also taken a path to reduce the cost of concrete production by use of various locally available replacement materials. The concrete industry is on the lookout for replacement materials constantly due to various ill effects in the current materials. In this experimental investigation natural sand is partially replaced by foundry sand. This material has been used as replacement in 20, 30 & 40% initially. We are also adding 3% of coconut fibre by the weight of cement in each mix. This research describes experimental studies on the use of coconut fibre to enhance tensile property in concrete. There are very less research papers that indicate the effects of using these materials as individual replacement materials in concrete. There is no evidence of these materials being used together as replacement materials in concrete which led to the ideology of experimenting the usage of combination of replacement materials in concrete. The experimental investigation were carried out using M20 grade concrete. The replacement material was used to replace the conventional elements of concrete in the percentages 20, 30 & 40. The combinations of these percentages have been carried out to keenly to note the results and strength variations.

KEYWORDS: Coconut fibre reinforced concrete, foundry sand, compressive strength, tensile strength, flexural strength.

I. INTRODUCTION

Now-a-days the construction sector is exploring rapidly on a large scale and also involves new techniques for rapid and comfort works on the field. Concrete as a building material plays an important role in this sector. The consumption of natural resources as an ingredient of concrete, costs high as well as it is on verge of extent. These problems force us to recover the natural resources or to find an alternative option to overcome this problem. Presently, the production of waste foundry sand as a by-product of metal casting industries causes various environmental problems. Usage of this waste in building material would help in reduction of stress on environment. Fiber reinforced concrete (FRC) is a promising material in direction possessing higher durability under extreme environments. In this paper, coir fibre is considered which is the natural fiber extracted from coconut husk where it is thick, coarse and durable fibre. The following objectives have been identified:

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- 1) To investigate changes in compressive strength and split tensile strength with CFRC and foundry sand replacement.
- 2) Utilization of foundry sand will reduce the disposal problem of foundry sand.
- 3) To perform the experiments on the time dependent compressive strength, split tensile strength and flexural strength of cement concrete with CFRC. The strengths were measured at the age of 7days &28 days.
- 4) To know at what percentage of foundry sand (20%, 30%, 40%) replacement will concrete attain maximum strength.

II. MATERIALS AND METHODOLOGY

CEMENT:

The most commonly used cement is ordinary Portland cement. Out of total cement production opc accounts for 80-90%. In our study opc of 43 grade is used, many tests were conducted on cement. Some of them are consistency test, setting time test, specific gravity, etc.

Table 1:Physical properties of cement

SL.NO	Particulars	Experim ental Results	As per standard IS 8112:2013
01	Specific gravity	3.05	
02	Setting Time (minutes)		
a)	Initial setting	30 minutes	30minutes (Minimum)
b)	Final setting	450 minutes	600minutes (Maximum)
03	Normal consistency	34%	
04	Fineness	0.5%	

FINE AGGREGATE:

Locally available, debris free riverbed sand is used as fine aggregate. The sand particle should also be packed to give minimum void ratio. Higher void content leads to requirement of more water while mixing. In this study sand confirming to zone II as per Indian Standards has been used. The specific gravity of fine aggregate was found to be 2.64 & the water absorption as 1.36%.

COARSE AGGREGATE:

The crushed aggregate used are of sizes 20mm and12.5mm and are tested as per Indian Standards and the results are within permissible limits. The specific gravity of course aggregate was found to be 2.78 & the water absorption as 1.5%.

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FOUNDRY SAND:

Foundry sand is clean, uniformly sized, High-quality silica sand that is bounded to form Moulds for ferrous (iron and steel) and non-ferrous (copper, aluminium, brass) metals. Type of foundry Sand depends on the casting process in foundries. Foundry sand is generally of two types: green sand, chemically bounded sand. Additive in sand depends on type of metal casting. Use of waste foundry sand as full or partial replacement by fine aggregate helps to achieve different properties or behaviour of concrete. The specific gravity and fineness modulus of foundry sand was found to be 2.31 & 1.653.

NATURAL COCONUT FIBRE:

Coconut fibre is natural fibre extracted from the husk of coconut and used in products such as floor mats, doormats, brushes, mattresses and also in concrete. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut.

MIX DESIGN (IS 10262:2009)

1. Stipulations for Proportioning Grade designation: M20
2. Type of Cement: OPC 43 grade conforming to IS 8112: 2013
3. Maximum Nominal Size of Aggregate: 20mm
4. Minimum Cement Content: 372kg conforming to IS 456: 2000
5. Maximum water cement Ratio: 0.53
6. Workability: 100mm (Slump)
7. Exposure Condition: Moderate
8. Degree of Supervision: Good
9. Type of Aggregate: Crushed Angular Aggregate Maximum Cement Content: 492.5kg

MIX PROPORTIONING

The quantity of concrete for various mix proportions for creating specimens for testing was calculated based on the mix design using IS 10262:2009. The specimens that were cast are cubes, cylinders and beams. The quantity of replacement materials were calculated for using in the concrete based on the weight of conventional materials used for preparation of concrete. The replacement materials are replaced in the percentages 20, 30 & 40 and also 3% coconut fibre in every alternative mix. These materials have been used individually and also in combination.

Table 2: Concrete mix designation

MIX DESIGNATION	DESCRIPTION
M0	NORMAL CONCRETE OF GRADE M ₂₀
M1	NORMAL CONCRETE +3% OF COCONUT FIBER.
M2	80% NATURAL SAND +20% FOUNDRY SAND
M3	80% NATURAL SAND +20% FOUNDRY SAND+3% COCONUT FIBER

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M4	70% NATURAL SAND+30% FOUNDRY SAND
M5	70% NATURAL SAND+30% FOUNDRY SAND+3% COCONUT FIBER
M6	60% NATURAL SAND+40% FOUNDRY SAND
M7	60% NATURAL SAND+40% FOUNDRY SAND+3% COCONUT FIBER

Manufacturing Process:

Experimental Test: Different types of mixes were prepared by changing the percentage of replacement of fine aggregate with foundry sand. Moulds were prepared along with conventional mix. 20%, 30%, 40% of fine aggregate was replaced with foundry sand. And also coconut fiber was also added in alternative mixes as discussed in Table 2.

Sample Preparation and Testing: Before using concrete for any construction work the concrete has to be tested by making specimens of specific sizes. The strength of the specimens gives the strength of concrete.

Test Specimen: The test specimens were cubes, cylinders and Beams. For each ratio 9 cubes, cylinder and beams were cast. For 7th day 3 cubes were tested and their average value were taken. The same procedure was followed for 28th day results. The cubes were of dimension 150mm x 150mm x 150mm. The beams has a nominal dimension of 500mm x 100mm x 100mm & the cylinder has a nominal dimension of 150mm diameter and 300mm in height.

Preparation of Moulds: The moulds were tightened and the inner surface of the moulds were oiled and made ready before placing the fresh concrete.

Mixing: Thorough mixing of materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous and consistent.

Placing: The prepared fresh concrete was laced in the moulds in layers of 3 with placing of each layer followed by manual compaction using tamping rod by tamping it for 25 times to remove the entrapment of air.

Curing: After the placing of concrete, curing of concrete has to be done (Fig 1). Curing is the process in which the concrete is protected from loss of moisture and kept within a reasonable temperature range. This process results in concrete with increased strength and decreased permeability. Curing is also a key player in mitigating cracks, which can severely affect durability. After 24 hours the specimens were removed from the mould and were placed in a curing tank.

Testing procedure:

The cast specimens were tested on their respective scheduled of testing. Cubes were tested compressive strength in compression testing machine. Cylinders were tested for tensile strength in compression testing machine. Beams were tested for flexural strength in UTM.

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COMPRESSIVE STRENGTH:



Fig 1: Compressive strength

Table 3: Overall results of compressive strength.

MIX DESIGNATION	Compressive strength (N/mm ²)	
	7 Days	28 Days
M0	17.44	23.215
M1	18.74	24.23
M2	17.87	24.01
M3	19.62	25.415
M4	19.18	25.51
M5	20.93	26.5
M6	15.7	18.5
M7	17.004	19.7

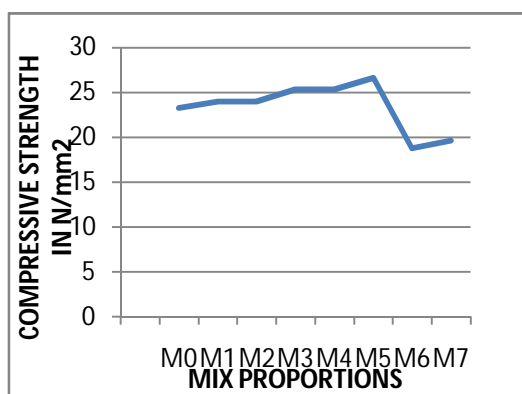


Fig 2:28 days compressive strength

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SPLIT TENSILE STRENGTH:



Table 4: Overall results of split tensile strength

MIX DESIGNATION	Split tensile strength (N/mm ²)	
	7 Days	28 Days
M0	1.52	2.42
M1	1.7	2.6
M2	1.94	2.92
M3	2.22	3.085
M4	2.22	3.35
M5	2.4	3.5
M6	1.3	1.615
M7	1.4	1.8

Fig 3: Tensile testing machine

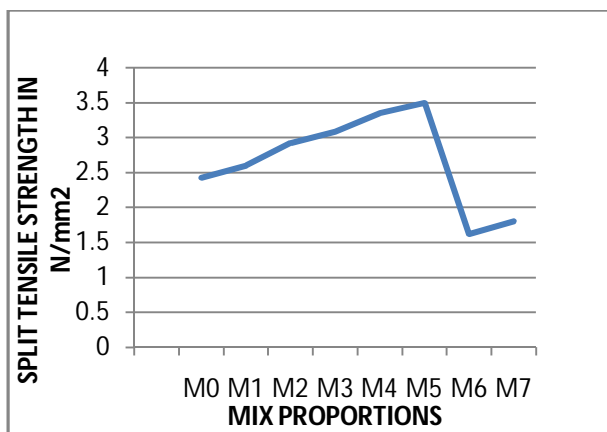


Fig 4: 28days split tensile strength

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FLEXURAL STRENGTH TEST:



Fig 5: Flexural strength testing

Table 5: Overall results of flexural strength

MIX DESIGNATION	Flexural strength (N/mm ²)	
	7 Days	28 Days
M0	3.6	3.83
M1	3.72	4.08
M2	3.4	3.8
M3	3.45	4.17
M4	3.8	4
M5	3.93	4.31
M6	3.93	4.3
M7	4.2	4.72

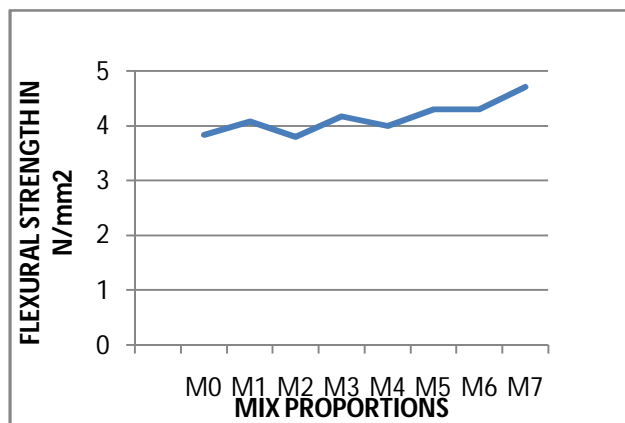


Fig 6: 28 days flexural strength

III. CONCLUSIONS

1. The incorporation of Foundry sand in concrete causes systematic decrease in workability.
2. The combination of Natural sand, Foundry sand and coconut fiber also results in decrease in workability compared to normal concrete made with natural sand.
3. Concrete acquires increase in compressive strength at 30% replacement for mix M4 and M5 by 10%, 20% at 7 days and 9.5%, 15.04% at 28 days compared to normal concrete.
4. Concrete acquires increase in split tensile strength at 30% replacement for mix M4 and M5 at 7 days and at 28 days compared to normal concrete.

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5. Concrete acquires increase in flexural strength at 40% replacement for mix M6 and M7 at 7 days and at 28 days compared to normal concrete.
6. 100% replacement of natural sand with foundry sand is not feasible.
7. By reinforcing the concrete with coconut fibers which are freely available, we can reduce the environmental waste.
8. Making concrete with the combination of natural sand and foundry sand along with coconut fiber with different percentage gives good results compared to normal concrete. So the best way to use this material is in combinations.
9. Non availability of Natural sand at reasonable cost led to the search of alternative materials. Foundry sand is a suitable alternative material for natural sand at very low cost also solving the problem of waste disposal .Using this material in combination makes concrete more eco-friendly.

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