Experimental study on the strength parameter of Quarry Dust mixed Coconut Shell Concrete adding Coconut Fibre

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Abstract. Concrete is a heterogeneous mixture constitute of cement as the main ingredient with a different mix of fine and coarse aggregate. The massive use of conventional concrete has a shortfall in its key ingredients, natural sand and coarse aggregate, due to increased industrialisation and globalisation. To overcome the shortage of material, an alternate material with similar mechanical properties and composition has to be studied, as replacement of conventional concrete. Coconut shell concrete is a prime option as replacement of key ingredients of conventional concrete as coconut is produced in massive quantity in south East Asia. Coconut shell concrete is lightweight concrete and different research is still ongoing concerning about its mix design and composition in the construction industry. Concrete is weak in tension as compared to compression, hence the fibre is used to refrain the crack in the concrete. Coconut fibre is one of many fibres which can be used in concrete. The main aim of this project is to analyse the use of natural by-products in the construction industry, make light weight concrete and eco-friendly construction. This project concerns with the comparison of the mechanical properties of coconut shell concrete and conventional concrete, replacing fine aggregate with quarry dust using coconut fibre. M25 grade of concrete was adopted and testing of concrete was done at the age of 3, 7 and 28 days. In this concrete mix, sand was replaced completely in volumetric measurement by quarry dust. The result was analysed and compared with addition of coconut fibre at varying percentage of 1%, 2%, 3%, 4% and 5%. From the test conducted, coconut shell concrete with quarry dust has the maximum value at 4% of coconut fibre while conventional concrete showed the maximum value at 2% of coconut fibre.
Keywords: conventional concrete, light weight concrete, coconut shell, coconut fibre, quarry dust

1. Introduction

Concrete is an important construction material used in the construction field. The increase in its use and its limited resource has challenged the engineers and scientist in making of lightweight concrete and replace the ingredients used for making a concrete mix. The research has been going on for the use of natural ingredients as replacement of fine and coarse aggregate to make lightweight concrete. Generally, when the density of concrete is lower than 2000 kg/m^3, it is categorized as Light Weight Concrete(Gunasekaran et al). Different waste material such as fly ash, glass, rubber, palm shell, coconut shell, and much other agricultural wastes has been researched as an alternative for replacing coarse aggregates. Similarly, the quarry dust is another waste product formed after crushing the stones. Initially, these were used in road pavements, but after finding the properties and behaviour similar to sand, it is proposed for replacement of sand in concrete(Balamurugan & Perumal). The study shows good strength possessed by Quarry dust during partial or fully replacement of fine aggregate, as an alternate of sand(Balamurugan & Perumal 2013a).

As we all know that Concrete is good in compression than tensile force. To sustain the tensile force different research has been carried out where the use of fibre has so far sustained the impact load and retard the concrete from early failure due to crack and sudden force (Abbass 2015),(Kumar 2012). There are many fibres used such as steel fibre, glass fibre, synthetic fibre and natural fibre. The coconut fibre serves as an alternate of other costly fibre and is light weighted compared to other.

Therefore, use of natural by-products in concrete production helps to make construction eco-friendly and lightweight concrete. These material are not only eco-friendly but also fulfils the requirement of construction material, reduce the material cost and exhibit resistance against impact.

2. Material Properties

The materials used in this project were collected from nearby market and quarry site. The concrete mix of M-25 was designed as per IS10262-1989. This project is for investigation of mechanical properties of lightweight concrete using coconut shell, quarry dust and coconut fibre. Even thou there are numerous design mix codes and procedure carried out for different grade of concrete, there is no definite method available for lightweight concrete. Hence the mix design for lightweight concrete is established by regular trial mix. The trial mix used in this research were selected from previous research work (Gunasekaran et al. 2011). The selected trial mix are given below.

Grade of concrete = M25
Normal concrete = 1:2.22:3.66:0.55
Coconut Shell Concrete = 1:1.47:0.65:0.42

For these concrete mix sand was replaced by quarry dust by volume and coconut fibre were used in the proportion of 1%, 2%, 3%, 4% and 5% by volume of concrete.

2.1 Cement

The cement used in this project was 53-grade OPC cement. The properties of cement are tabulated in Table 1.

Table 1. Properties of Cement

S. No.	Description	Value
1.	Normal Consistency (%)	31.000
2.	Initial setting time, minutes	32.000
3.	Specific Gravity	3.075

2.2 Coconut Shell

The coconut shell was collected from nearby coconut oil mill industry. These were crushed by a mini crusher and only the shells passing through 12.5 mm sieve were used. The surface was properly cleaned with fairly smooth on the inner side and rough on the outer side. Due to the porosity of CS, high water absorption is expected, so coconut shell was dipped in water for 24 hours before its use. These CS were saturated surface-dry (SSD) condition before used in concrete mix.The coconut shell as coarse aggregate has properties (Balamurugan & Perumal 2013b) as shown in Table 2.

Table 2. Properties of Coconut Shell

S. No.	Description	Value
1.	Maximum size used (mm)	12.500
2.	Water Absorption (%)	24.000
3.	Sp. Gravity	1.100
4.	Fineness modulus	6.260
5.	Crushing value (%)	2.580
6.	Shell thickness (mm)	2-4

2.3 Fine aggregate

Quarry dust was used as a complete replacement of Sand as fine aggregate, passing through 4.75 mm sieve, for Conventional concrete and CSC. The sand was air dried and free from any foreign material. The various properties of fine aggregate are tabulated in Table 3.

Table 3. Properties of Fine Aggregate

S. No.	Description	Sand	Quarry dust
1.	Specific Gravity	2.639	2.487
2.	Fineness Modulus	2.730	3.900

2.4 Coconut fibre

Coconut fibre was derived from the coconut seed of 0.2-0.5 mm diameter which is cut into 50 mm in length. The fibre was mixed with Conventional Concrete with Quarry dust (CCQ) and CS Concrete at 1%, 2%, 3%, 4%, and 5% by volume of concrete. The fibre was selected to improve the impact loading in the concrete because it has a high energy absorption capability compared to other natural fibres.

3. Test Result and Discussion

The overall test was conducted to determine the mechanical properties of the specimen. The test was performed on each material before casting and these specimens were tested on the standard compressive machine. The properties determined by the test are shown in tables and results are discussed.

3.1 Mechanical Properties

A different test is carried out to determine the characteristics strength of concrete. This test defines the properties of Conventional concrete and coconut shell concrete, replacing fine aggregate, with an addition of fibre. The ultimate percentage of fibre is determined to make lightweight concrete and use of natural by-products.

3.1.1 Compression test. Compression test is a measure used to determine the properties of concrete formed by mixing of various ingredients. The specimen were cast on 100×100×100mm steel moulds and was tested at the age of 3 days, 7 days, and 28 days, after water pond curing and surface dried. The test result shows that CC with quarry dust has a greater value of 38.567 Mpa at 2% of fibre while CSC with Quarry dust has 25.50 Mpa at 4% of fibre. The mean compressive strength of the specimen is shown in Table 4 and Figure 1.

Table 4. Compressive strength test (in MPa) on CC/ CSC with Quarry Dust on % addition of Coconut Fibre

Mix	Fibre %	3rd day	7th day	28th day
Conventional Concrete with Quarry dust	0	20.267	27.067	33.033
	1	20.200	26.567	36.533
	2	22.833	28.933	38.567
	3	17.400	24.467	34.533
	4	16.900	24.033	32.767
	5	13.667	17.100	28.733
Coconut shell Concrete with Quarry dust	0	10.667	14.900	19.300
	1	13.133	14.867	20.033
	2	13.733	16.500	21.533
	3	14.533	19.133	23.967
	4	17.833	21.533	25.500
	5	13.667	17.333	23.267

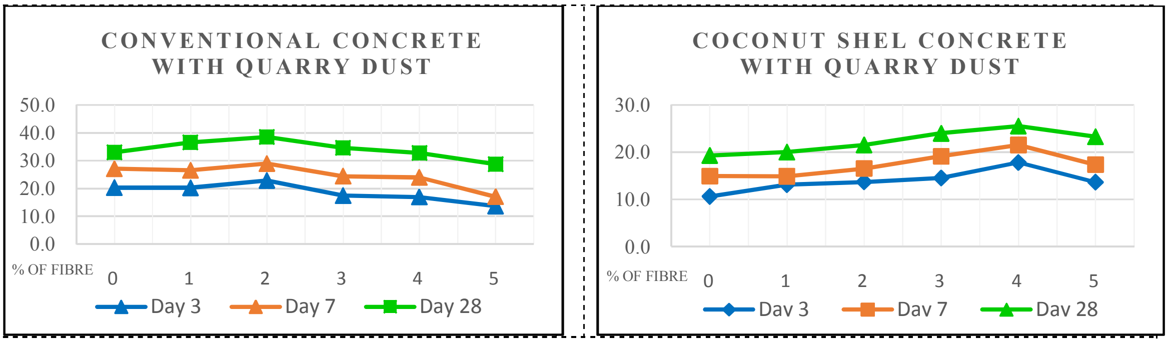

Figure 1. Line chart of CC & CSC with Quarry dust with% of Fibre,

3.1.2 Split tensile test. A steel cylindrical mould of 100×200mm was used for a split tensile test. In this test, a load is applied to a cylindrical specimen, placed horizontally, in a compression test machine until a vertical crack is formed. A strip of wooden plank placed between the testing machine and specimen reduce the magnitude of high compression stress. The value is about 0.05-0.12 times greater than direct tensile strength. The test results are given in Table 5 and their variations are shown in Figure 2.

Table 5. Comparison of Split tensile strength (in MPa) of CCQF with CC and CSCQF with CSC

M25	Fibre %	3 Day	7 Day	28 Day
CC	0	2.22	3.55	3.96
CCQ	2	2.28	3.68	4.04
CSC	0	1.11	2.17	2.56
CSCQ	4	2.04	2.55	2.62

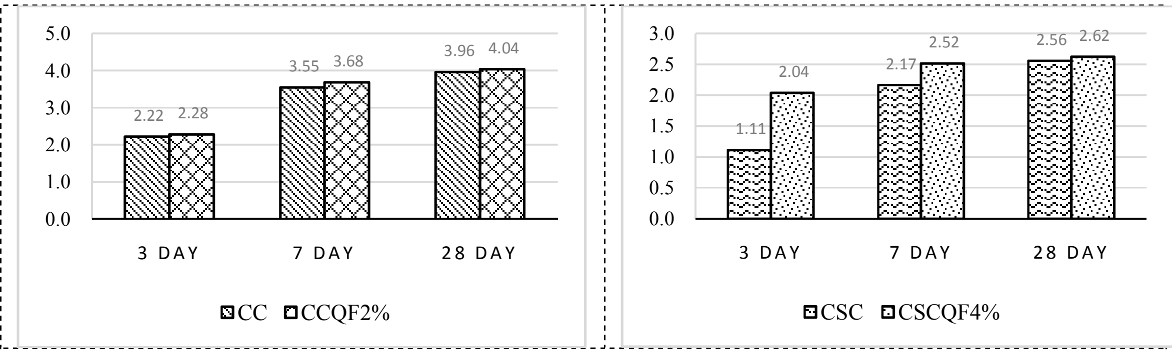

Figure 2. Comparison of Split tensile strength of CCQF with CC and CSCQF with CSC,

3.1.3 Flexure test. The flexure test of the beam (100×100×500mm) was done by four point loading method. The load was applied continuously increasing until the specimen failed. The load is divided equally between the two loading rollers without subjecting the specimen to any torsional stresses. The flexural strength of specimen is expressed as the modulus of rupture f_b. The test result is shown in Table 6 and Figure 3.

Table 6. Comparison of Flexure strength (in MPa) of CCQF with CC and CSCQF with CSC

M25	Fibre %	3 Day	7 Day	28 Day
CC	0	2.13	3.33	4.13
CCQ	2	2.27	3.47	4.67
CSC	0	2.00	2.67	3.73
CSCQ	4	2.13	3.07	4.00

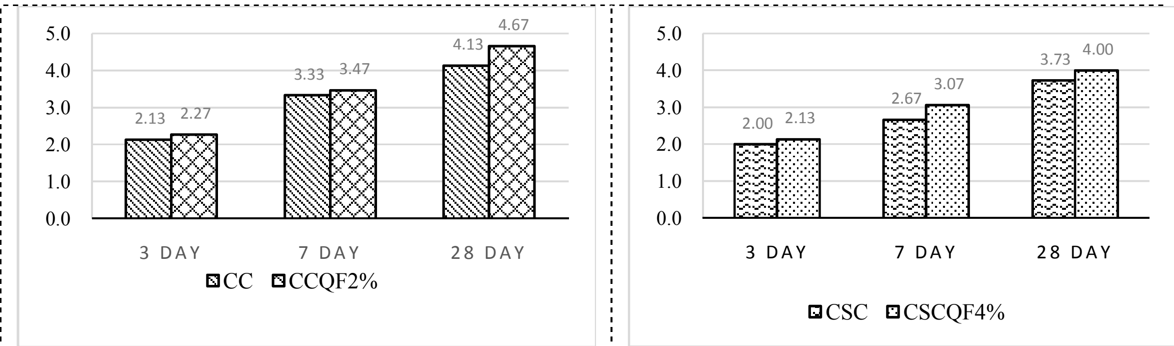

Figure 3. Comparison of Flexure strength of CCQF with CC and CSCQF with CSC,

3.1.4 Impact test. The impact test defines the resistance of the specimen on sudden loading. This test shows the energy resist by the specimen during a number of blows from initial crack until it is broken down. The specimen of 65×150mm disc was used to analyse the impact test. The impact value is tabulated in Table 7.

Table 7. Impact value (in MPa) on CCQ and CSCQ

M25	Fibre %	No of blows in 28 Day	
		Initial Crack	Fractured crack
CCQ	2	256	268
CSCQ	4	182	232

3.2 Discussion

3.2.1 Compressive strength. The compressive strength of coconut shell concrete with quarry dust using coconut fibre has shown the concrete properties gaining the maximum value of 25.50 Mpa at 4% of fibre. Similarly, CC with quarry dust has its maximum value of 38.567 Mpa at 2% of fibre. This shows that the quarry dust and coconut fibre can be used as an alternative material for replacing the fine aggregate in the construction industry.

3.2.2 Split tensile strength. The specimen with quarry dust and coconut fibre has shown the improved value than its conventional concrete. Table 5 shows the comparative chart between the conventional concrete and coconut shell concrete replaced with quarry dust and coconut fibre. Even thou the value are in marginal difference, it shows that quarry dust and coconut fibre are good in tensile strength. The CSCQF4% has the strength of 2.62 Mpa and CCQF2% has the strength of 4.04 Mpa at 28 days. The tensile property was improved due to the use of coconut fibre, which has shown the good tensile property (Zia et al. 2015).

3.2.3 Flexural strength. The flexural strength of CCQF2% (4.67 Mpa- 13.07% increase) and CSCQF4% (4.0 Mpa- 7.23% increase) are better than its conventional concrete in aflexural test at 28 days test. The modulus of rupture or bending strength shows that these materials have the ability to withstand the fracture strength, better than CC & CSC.

3.2.4 Impact test. The impact test is resistance to sudden load. The test performed on CCQF2% & CSCQF4%, as shown in table 7, has good ability to withstand the impact force as compared to conventional concrete. The study shows that the use of fibre improves the properties such as toughness, flexural strength, fatigue and stress. The energy was transformed in the formation of cracks with fibre holding the particles from dissipation rather than spalling in CC.

4. Conclusions

From the test following conclusion were made.

- The compressive strength of CCQF & CSCQF has shown the significant mechanical properties compared to CC and CSC specimen.
- The flexure and split tensile test shows the increased strength in fracture and tensile properties at thereplacement of fine aggregate with quarry dust and theaddition of fibre.
- The impact value shows its resistance against impact and load transfer through the fibre, but the use of fibre should be limited up to 5% where further increasing decreases the strength of the specimen.
- Coconut shell and coconut fibre are natural products and have more water absorption value compared to normal aggregates, hence, increase on these natural aggregates and fibre decrease the workability and form true slump.
- Results showed that quarry dust and coconut fibre produced workable concrete with satisfactory strength, useful for low cost and lightweight building construction, as an alternate to future construction material.

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