AN EXPERIMENTAL STUDY ON MISSION GRASS CONCRETE AND COCONUT FIBRE REINFORCED CONCRETE

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Abstract: *Although conventional concrete used in nowadays has got sufficient strength, the major concern is on reducing the overall cost, material consumption and environmental hazards. Therefore various materials are incorporated or replaced partially in concrete to improve its strength, savings in cost and material as well. The present work is concerned with use of natural fibres which are cheap and locally available such as Mission grass and coconut fibres in concrete as replacement material for coarse aggregates. Mission grass an uncontrollable weed in southern India which doesn't have any economic value is used as a partial replacement for aggregates (both fine and coarse) in concrete and its positive results in achieving compressive strength was determined which will not only enhance future research but also helps in controlling its population. Also, Coconut fibres (coir and coconut shell) which are usually strong and abundantly available are used for the partial replacement of coarse aggregate but in case of rcc structures like beams, steel which is costly and corrosive in nature are partially replaced by using coir ropes. Compressive strength and two point load flexural test for different mix proportion are done to analyze the strength variation, behavior and properties of concrete.*

Keywords: Tensile strength, Compressive strength, two point load flexural strength, Natural fibres, Mission grass, Coir, Coconut shell, Coir rope

1. INTRODUCTION

Today cement based components generally concrete is one of the most widely used building material all around the world. It is a well-known fact that concrete is strong in compression but weak in tension, hence reinforcement is necessary to improve tensile strength. Usually steel bars are used as reinforcements to improve tensile strength but it is also evident that natural fibres also helps to achieve sufficient strength. Natural fibres are those which are derived from plant, animals or from any other living form which are long and slender. In concrete technology different types of natural fibres are used as an additive or partial replacement materials for cement, aggregates and reinforcements. These fibres are used to increase the post cracking resistance, high energy absorbing characteristics, fatigue strength and other mechanical properties. These behave as crack arresters that prevent micro-cracks and thus restrict the enlargement or deformation in concrete. Due to these reasons natural fibres are extensively used in variety of structural applications such as tunnel lining, pavements, slope stabilization, blast resistant structures etc. It is also evident that natural fibres may also decrease the strength properties of concrete. This may be due to their volume changes, specific gravity and durability criteria. Introducing natural fibres in concrete especially untreated raw natural fibres would alter the properties of concrete and might reduce its quality. But if it satisfies some major advantages such as improving strength, cost savings etc. then use of such natural fibres can be promoted at least for small scale ordinary concrete works.

Pennisetum polystachion. is an erect, annual or perennial grass with extensive and fibrous roots to a depth of 1 m. Flowering culms slender to fairly stout, erect or ascending, 0.3-3 m or more tall, five to ten nodes, with axillary branching, tufted, in dense stands, several emerging from a crown; sometimes rooting at the nodes. Internodes grooved and glabrous. Leaf sheaths thin, keeled toward the blade, usually shorter than the internodes, distinctly nerved and glabrous; ligule a hairy ring, 1.5-2.5 mm long; blades narrow, acuminate, flat, 5-45 cm long, 3-18 mm wide, smooth or hairy with scattered setaceous hairs; prophyllum 5.5-14 cm long. Mission grass is made up of several components such as cellulose, hemicellulose, lignin, pectin and extractives.

There are two types of coconut fibre which are available one is white or raw fibre and the other is brown or dried fibres. Usually brown fibres which are pre-soaked in fresh water and chemically treated are stronger and durable when compared to white fibres due to lower lignocellulose amount, smooth surface and low tensile strength. Hence brown fibres which are thick, strong and abrasion resistant is used as an additive or partial replacement products in concrete. The main advantage of using coconut fibres in concrete structure is that they transform unstable tensile crack propagation to a slow controlled crack growth. It also delays the initiation of flexural and shear cracks. Hence imparts post cracking behaviour in concrete and increases ductility and energy absorption capacity.

Coconut shell is a very hard endocarp of coconut and is one of the light weight aggregate with high percentage lignin and pentose and low cellulose. High lignin content makes the composites weathering resistant. In construction industry shells contribute in making of light weight concrete. They can be used as reinforcing material due to their high strength and modulus properties.

Coconut fibre products such as coir ropes, woven coir mats etc. are also introduced in concrete technology. Coir ropes and mats being cheap and strong are sometimes used as partial reinforcement for steel in rcc structural elements. But they are not yet been fully accepted due to their durability issues.

2. OBJECTIVE OF THE STUDY:

Natural fibres used in this project was Mission grass and Coconut fibres. Both were tested separately in different way. Hence the project consisted of two parts i.e. compression test on the concrete in which fine or coarse aggregates is partially replaced with mission grass. And another part consists of compression test of concrete in which coarse aggregates are partially replace by coir fibres and coconut shells, and flexural test of coconut fibre reinforced beam in which coarse aggregate is partially replaced with coir fibre and shells and steel partially replaced using coir ropes.

The main objectives of this project are:

- To study compression strength of Mission grass fibre concrete in comparison with conventional concrete.
- To study compression strength and flexural behaviour of coconut fibre reinforced concrete in comparison with conventional concrete

3. MATERIALS AND THEIR PROPERTIES

3.1 Materials used in the project

- Ordinary Portland Cement 43 Grade [Brand: ACC]
- Portland Pozzolona Cement (Fly ash based) [Brand: Ultratech]
- River Sand passing 4.75mm IS sieve size
- Aggregates passing through 16mm sieve size taken 60% and 10mm sieve size aggregates taken 40%
- Portable Water
- Soaked and dried Mission grass (2 & 15mm average lengths)
- Chopped Brown Coir fibres (70mm average length)
- Crushed Hard Coconut shells of average size 15-20mm
- Mild Steel bars 8mm and 7mm diameters
- Best quality Coir ropes of 2mm diameter

3.2 Basic test results of materials

- Specific gravity test for cement was done using density bottle method
- Specific gravity test for sand, coarse aggregates, coir, coconut shell and Mission grass was done using Pycnometer method
- Initial and final setting time using Vicat's apparatus
- Sieve analysis using IS sieve sizes
- Flakiness and elongation index tests for coarse aggregates using IS thickness gauge and IS length gauges.
- Impact value of aggregates using Aggregate Impact testing machine
- Crushing value of aggregates using Compression test machine
- Water absorption test for coir, shell and mission grass using oven drying method
- Slump test to find workability and suitable water cement ratio

3.2.1 OPC 43 grade

ACC 43 grade ordinary Portland cement conforming to IS 8112 was used for studying the compressive strength of Mission grass concrete. The properties of cement were tested and results are given in the Table 3.1

Table 3.1: Properties of OPC 43

Sl.no	Particulars	Obtained value
1	Specific gravity	3.15
2	Normal consistency	26.53%
3	Fineness	2.5%
4	Initial setting time	32 minutes
5	Final setting time	600 minutes

3.2.2 PPC (fly ash based)

Ultratech Portland Pozzolona Cement (fly ash based) conforming to IS 1489 Part-1 was used for flexural testing of coir fibre reinforced beam specimens. The properties of cement were tested and results are given in the Table 3.2

Table 3.2: Properties of PPC

Sl.no	Particulars	Obtained value
1	Specific gravity	3.24
2	Normal consistency	29.2%
3	Fineness	7.4%
4	Initial setting time	40 minutes
5	Final setting time	800 minutes

3.2.3 Fine aggregate

Clean and dry locally available River sand was used as fine aggregate conforming to zone-II as per IS 383-1970. Sand passing 4.75 mm IS sieve was used for casting all the specimens. Sand helps to fill voids between coarse aggregates. The table 3.3 shows the test results of sieve analysis and other test results

Table 3.3: Grade limits as per IS 383-1970 and sieve analysis results

IS sieve size(mm)	Zone I	Zone II	Zone III	Zone IV	Percentage of passing
10mm	100	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100	98
2.36mm	60-95	75-100	85-100	95-100	83.26
1.18mm	30-70	55-90	75-100	90-100	67.15
600µ	15-34	35-59	60-79	80-100	39.8
300µ	5-20	8-30	12-40	15-50	15
150µ	0-10	0-10	0-10	0-15	3.5
75µ					2.10

Table 3.4: Properties of Sand/Fine aggregates

Sl.no	Particulars	Obtained value
1	Specific gravity	2.68
2	Grading of sand	Zone II
3	Fineness Modulus	2.81
4	Bulk Density (kg/m^3)	1600

3.2.4 Coarse aggregate

Coarse aggregate consists of 60% of 20mm down and 40% of 10mm down aggregate fractions obtained from local supplier. It is tested as per IS 383-2007. Generally coarse aggregates occupy more than 50% of volume of concrete, hence their properties plays vital role in concrete strength and also influences the properties of concrete. The basic test results are shown in table 3.5

Table 3.5: Properties of Coarse aggregates

Sl.no	Particulars	Obtained value
1	Specific gravity	2.72 (20mm) & 2.658 (10mm)
2	Grading of sand	Zone II
3	Fineness Modulus	2.73
4	Bulk Density (kg/m^3)	1650
5	Flakiness & Elongation index	24.64% & 20.36%
6	Crushing value	20%
7	Water Absorption	0.25

3.2.5 Water

Generally portable water is recommended for concrete mix. In this study tap water was used for both mixing and curing.

3.2.6 Mission grass

Dried Mission grass that grew nearby our campus premises were collected, cleaned, chopped to suitable sizes and then washed and oven dried to remove moisture content and foreign particles. The seed head, spikelet, blades, leaf buds, collars and nodes were removed or excluded during cleaning process. The thickness of the grass is 1-2mm measured using vernier scale. Grasses were cut to average length of 2 mm and 15 mm for fine and coarse aggregate replacement respectively. From the test results it was found that the specific gravity of Mission grass is 0.86, bulk density is 1962 kg/m^3 and water absorption about 15%.

3.2.7 Coir fibre

Coir or brown coconut fibres were obtained from local coconut farms which were of good quality. Usually coconut fibres do not require any pre chemical treatment but due to its high water absorption capacity fibres were pre-soaked in water for 24 hours. The coir fibres were then dried and chopped on an average length of 50-70mm. Thickness of the fibre was found to be 0.1-0.2mm. The basic test results of coir fibres are shown in table 3.6

Table 3.6: Properties of coconut fibre

Sl.no	Particulars	Obtained value
1	Specific gravity	1.12
2	Water absorption	10%
3	Bulk Density (kg/m^3)	1825

3.2.8 Crushed coconut shell

Good quality matured coconut shells were collected from local coconut fields and were crushed manually. Shells with thickness and sizes ranging between 2-5mm and 5-20 mm respectively were used. The shells were hard with fairly smooth surface on concave face and rough surface on convex face. No pre-treatment was done because the shells exhibit same properties as that of stone aggregates. The basic properties are shown in table 3.7

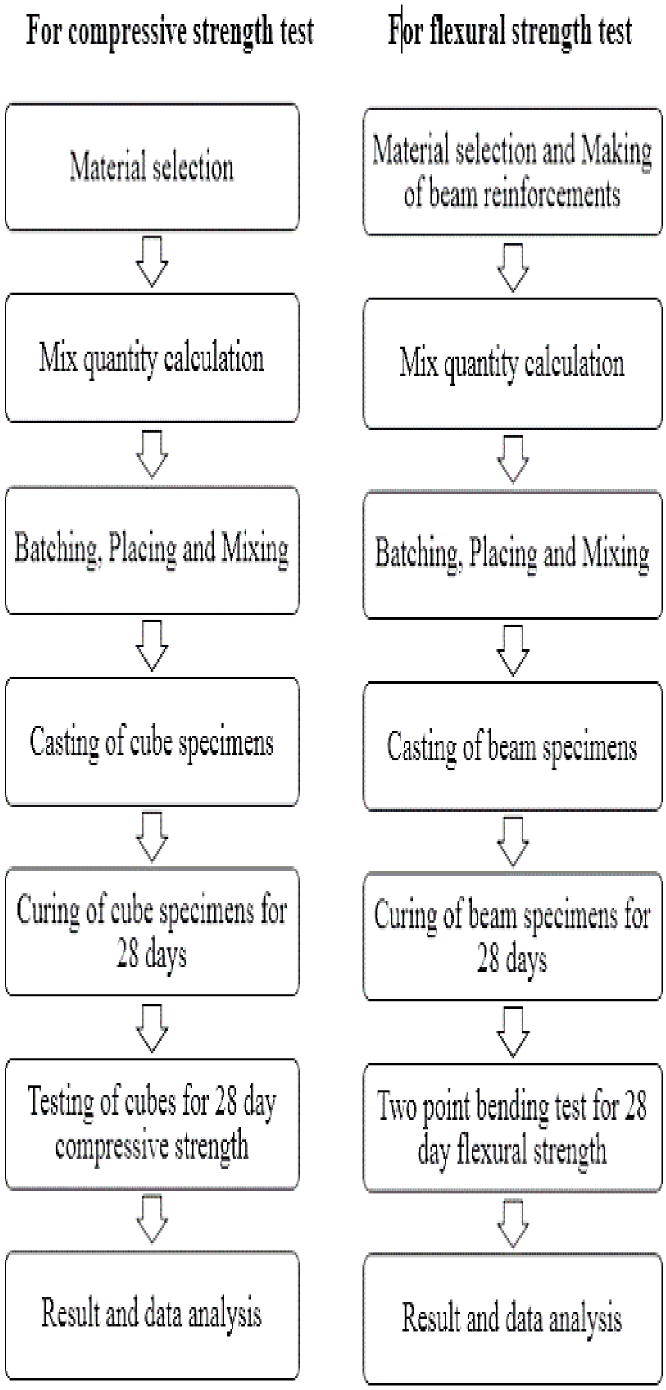
Table 3.7: Properties of crushed coconut shell

Sl.no	Particulars	Obtained value
1	Specific gravity	1.46
2	Water absorption	27%
3	Bulk Density (kg/m^3)	735
4	Crushing value	2.5%
5	Impact value	8.6%

4. METHODOLOGY

The project utilizes two type of natural fibres i.e. Mission grass and coconut fibre products such as coir, coir rope and coconut shells. Their effect on concrete is studied separately, hence project consists of two different methodologies i.e. one for Mission grass concrete and another for Coir fibre reinforced concrete beam. Mission grass concrete cube specimens are casted for compression strength test. Coconut fibre reinforced concrete cube and beam specimens are tested for compression and flexural strength respectively. In this study Mission grass is used as replacement material for fine and coarse aggregates and their compressive strength at 28th day is determined. On the other hand, in the project a special type of beam is casted using coconut products such as coir fibre and coconut shells which are used as replacement materials for coarse aggregates and also the steel rebar is partially replaced by wounding coir ropes of 2mm diameter over them. Cube specimens are casted with varying percentage of coir fibre and coconut shells. Beam specimens are casted with same varying percentage of coir and shells but rebar wounded with 2mm diameter coir ropes.

Figure 4.1: Flowchart



4.1 Compression test on mission grass concrete

4.1.1 Preparation of materials

- For fine aggregate replacement dried Mission grasses are chopped for an average length of 2 mm
- For coarse aggregate replacement dried Mission grasses are chopped for an average length of 15 mm
- Both the chopped grasses are soaked in water before concrete mixing
- Key ingredients such as OPC 43, sand passing 4.75mm sieve, coarse aggregate (60% 20 mm down and 40% 10 mm down), portable water were collected

41.2 material quantity calculation

- The mix was designed for M25 grade (cement : sand : coarse aggregate = 1 : 1 : 2)
- From slump test result, 0.48 WCR was selected
- Quantities of each materials were calculated as per M25 grade
- Calculations for five different concrete mixes were computed
- For fine aggregate replacement, mission grass of 2mm average length were added to mix at 1, 2, 3, 4, 5 percentage by weight of sand
- For coarse aggregate replacement, mission grass of 15mm average length were added to mix at 1, 2, 3, 4, 5 percentage by weight of coarse aggregates

4.1.3 Preparation of concrete mix

- Before mixing, the cube moulds of size (150*150*150)mm were kept ready with inner surface oiled
- All the mix ingredients are weigh batched as per mix calculation and kept ready in trays separately
- A big metal tray was placed on the floor for placing and mixing
- Dry mixing of cement, sand and coarse aggregates (Mission grass, 10mm and 20mm down aggregates) was done
- Measured quantity of water (for 0.48 WCR) was added after uniform mixture of above ingredients
- Mixing was done manually using hand trowel for less than 10 minutes until uniform, workable and cohesive mix was formed

4.1.4 Casting of cube specimens

- After uniform mixing the cube moulds were filled with fresh concrete mix in 3 layers
- Each layer was tamped for about 25 strokes using standard tamping rod
- The top layer was made smooth and was tamped slowly so as to remove the entrapped air voids
- The casted cubes were kept as it is for 24 hour.
- A conventional cube specimen was casted
- All the concrete mix were casted with two same trial specimens

4.1.5 Curing of specimens

- The concrete cubes were de-moulded from the moulds and completely immersed in a pool of portable water
- Concrete cubes were cured for 28 days to gain ultimate compressive strength

4.1.6 Testing of specimens

- The concrete cubes were removed from the pool after 28 days of curing and kept for drying
- The dried specimens were then tested for compressive strength individually using compression testing machine (with dial gauge having 1 division = 10 kN and max. load = 2000 kN)
- The machine was initially set up and loading was gradually applied on the specimen. The ultimate load (kN) at which the cube fails by developing cracks was noted

4.1.7 Results and data analysis

- Using the ultimate failure load of the specimens the compressive strength at 28 days was calculated
- Graphs of compressive strength versus percentage replacement of mission grass in concrete was plotted and the behaviour was studied

Figure 4.2: Mission grass cut for required length

Figure 4.3: Mission grass cut for 2mm average length

Figure 4.4: Mission grass cut for 7mm average length


Figure 4.5: Dry mixing


Figure 4.6: Wet mixing


Figure 4.7: Casting and curing


Figure 4.8: Compression test


Figure 4.9: Compression test dial gauge


Figure 4.10: Specimen after compression test

4.2 Compression test on coconut fibre reinforced concrete

4.2.1 Preparation/collection of materials

- Coarse aggregate was replaced by two materials (coir fibre and coconut shells). Hence coir fibres were chopped for an average length 70 mm and coconut shells were crushed manually for an average size of 15-20 mm.
- Coir fibres were pre-soaked in water before adding to concrete mixing
- Key ingredients such as PPC (flyash based), sand passing 4.75mm sieve, coarse aggregate (60% 20 mm down and 40% 10 mm down), portable water were collected

4.2.2 Material quantity calculation

- The mix was designed for M25 grade (cement : sand : coarse aggregate = 1 : 1 : 2)
- From slump test result, 0.48 WCR was selected
- Quantities of each materials were calculated as per M25 grade
- Calculations for five different concrete mixes were computed
- For coarse aggregate replacement, coir fibres and coconut shells were added to mix at (0.5, 0.75, 1, 1.25, 1.5) % and (1, 1.5, 2, 2.5, 3) % respectively by weight of coarse aggregate. The percentage variation is done such a way that total coarse aggregate replacement remains less than 5%

4.2.3 Preparation of concrete mix

- Before mixing, the cube moulds of size (150*150*150)mm were kept ready with inner surface oiled
- All the mix ingredients were weigh batched as per mix calculation and kept ready in trays separately
- A big metal tray was placed on the floor for placing and mixing
- Dry mixing of cement, sand and coarse aggregates (Coir fibres, coconut shells, 10mm and 20mm down aggregates) was done
- Measured quantity of water (for 0.48 WCR) was added after uniform mixture of above ingredients
- Mixing was done manually using hand trowel for less than 10 minutes until uniform, workable and cohesive mix was formed

4.2.4 Casting of cube specimens

- After uniform mixing the cube moulds were filled with fresh concrete mix in 3 layers
- Each layer was tamped for about 25 strokes using standard tamping rod
- The top layer was made smooth and was tamped slowly so as to remove the entrapped air voids
- The casted cubes were kept as it is for 24 hour
- A conventional cube specimen was casted
- All the concrete mix were casted with two same trial specimens

4.2.5 Curing of specimens

- The concrete cubes were de-moulded from the moulds and completely immersed in a pool of portable water
- Concrete cubes were cured for 28 days to gain ultimate compressive strength

4.2.6 Testing of specimens

- The concrete cubes were removed from the pool after 28 days of curing and kept for drying
- The dried specimens were then tested for compressive strength individually using compression testing machine (with dial gauge having 1 division = 10 kN and max. load = 2000 kN)
- The machine was initially set up and loading was gradually applied on the specimen. The ultimate load (kN) at which the cube fails by developing cracks was noted

4.3 Two point flexural test on coconut fibre reinforced concrete beam

4.3.1 Preparation of materials

- Coarse aggregate was replaced by two materials (coir fibre and coconut shells). Hence coir fibres were chopped for an average length 70 mm and coconut shells were crushed manually for an average size of 15-20 mm.
- Coir fibres were pre-soaked in water before adding to concrete mixing

- Key ingredients such as PPC (flyash based), sand passing 4.75mm sieve, coarse aggregate (60% 20 mm down and 40% 10 mm down), portable water were collected
- Steel bars for each beam specimen: Top main reinforcement #2-8mm & bottom main #3-8mm, Stirrups #6- 7mm. In these specimens the 2 mm thick quantity of steel is wound by 2 mm coir ropes
- Steel bars for conventional beam specimen: Top main reinforcement #2-10mm & bottom main #3-10mm, Stirrups #6- 7mm
- The bars and stirrups were bent at correct angles and were made ready for all the specimens

4.3.2 Material quantity calculation

- The mix was designed for M25 grade (cement : sand : coarse aggregate = 1 : 1 : 2)
- From slump test result, 0.48 WCR was selected
- Quantities of each materials were calculated as per M25 grade
- Calculations for five different concrete mixes were computed
- For coarse aggregate replacement, coir fibres and coconut shells were added to mix at (0.5, 0.75, 1, 1.25, 1.5) % and (1, 1.5, 2, 2.5, 3) % respectively by weight of coarse aggregate. The percentage variation is done such a way that total coarse aggregate replacement remains less than 5%

4.3.3 Preparation of concrete mix

- Before mixing, the beam moulds of size (750*150*150)mm were kept ready with inner surface oiled
- All the mix ingredients were weigh batched as per mix calculation and kept ready in trays separately
- A big metal tray was placed on the floor for placing and mixing
- Dry mixing of cement, sand and coarse aggregates (Coir fibres, coconut shells, 10mm and 20mm down aggregates) was done
- Measured quantity of water (for 0.48 WCR) was added after uniform mixture of above ingredients
- Mixing was done manually using hand trowel for less than 10 minutes until uniform, workable and cohesive mix was formed

4.3.4 Casting of beam specimens

- Reinforcements were kept in exact position inside the mould with 50 mm cover all around the rebars
- After uniform mixing the beam moulds were filled with fresh concrete mix in 3-4 layers
- Each layer was tamped for about 50-75 strokes using standard tamping rod
- The top layer was made smooth and was tamped slowly so as to remove the entrapped air voids
- The casted beams were kept as it is for 24 hour
- A conventional beam specimen was casted

4.3.5 Curing of specimens

- The concrete beams were de-moulded from the moulds and completely immersed in a pool of portable water
- Concrete beams were cured for 28 days to gain ultimate compressive and flexural strength

4.3.6 Testing of specimens

- The concrete beams were removed from the pool after 28 days of curing and kept for drying
- The dried specimens are then tested for two point load bending test (L/3 distance from the ends) to find flexural strength, individually using two point load flexural testing apparatus
- The machine was initially set up with all initial adjustments including the proving ring dial gauge and loading was gradually applied on the specimen. Proving ring consists of two scale i.e. main (MSR) and small scale reading (SSR). Main scale has 25 divisions with least count 0.2 mm and small scale has 100 divisions with least count 0.002 mm. When load is applied if small scale rotates one cycle the 0.2 mm will be the deflection value which is seen on main scale reading.
- The proving ring readings were noted for each crack. Load was applied until the beam fails by developing shear cracks

4.3.7 Results and data analysis

- Using the proving ring readings the load at each crack and at failure was calculated. To calculate load, if the needle covers 103 divisions in the small scale then the load value is taken as 20 kN. The flexural strength and deflection values for each specimen were calculated. Load v/s deflection graphs are drawn for each specimens


Figure 4.15: Materials for concrete mix


Figure 4.16: Bending of bars for beam reinforcements


Figure 4.17: Steel reinforcements for conventional and CFRC


Figure 4.18: Placing of reinforcements into the moulds


Figure 4.19: Dry mixing of materials


Figure 4.20: Wet mixing of materials


Figure 4.21: Filing the concrete into the mould


Figure 4.22: Casting of beam in the moulds


Figure 4.23: Proving ring dial gauge


Figure 4.24: Two point load flexural test of beam specimens

Figure 4.25: Beam specimen after flexural test

5. RESULTS AND ANALYSIS

5.1 Compression test on mission grass concrete

28 days compression test results of cube specimens are shown in the table 5.1 in which Mission grass is used as partial replacement by percentage weight of fine aggregates.

Table 5.1: Compression test results of Mission grass concrete (as fine aggregates)

F.A replacement by weight (grass 2 mm)	Trial 1 load in kN	Trial 2 load in kN	Avg. compressive strength (N/mm^2)
Conventional	640	630	27.44
1%	510	490	22.66
2%	370	330	16.67
3%	210	230	9.33
4%	150	140	6.15
5%	90	90	4

28 days compression test results of cube specimens are shown in the table 5.2 in which Mission grass is used as partial replacement by percentage weight of coarse aggregates.

Table 5.2: Compression test results of Mission grass concrete (as coarse aggregates)

C.A replacement by weight (grass 15mm)	Trial 1 load in kN	Trial 2 load in kN	Avg. compressive strength (N/mm^2)
Conventional	640	630	27.44
1%	300	320	13.33
2%	250	240	11.1
3%	125	110	5.55
4%	75	80	3.33
5%	25	20	1.11

5.2 Compression strength test on coconut fibre reinforced concrete

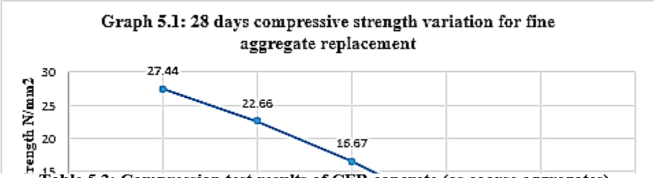
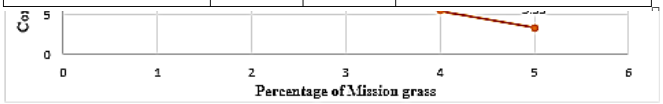


Table 5.3: Compression test results of CFR concrete (as coarse aggregates)

C.A replacement by weight	Trial 1 load in kN	Trial 2 load in kN	Avg. compressive strength (N/mm^2)
Conventional	870	865	25.70
Mix 1 (1%shell, 0.5%coir)	640	620	18.96
Mix 2 (1.5%shell, 0.75%coir)	600	590	17.77
Mix 3 (2%shell, 1%coir)	350	350	10.70
Mix 4 (2.5%shell, 1.25%coir)	340	350	10.07
Mix 5 (3%shell, 1.5%coir)	330	300	9.77



28 days compression strength test results of cube specimens are shown in the table 5.3 in which coir fibres and coconut shells were used as partial replacements by percentage weight of coarse aggregates.

5.3 Two point bending test on coconut fibre- steel reinforced concrete beam

28 days flexural test results of beam specimens are shown in the table 5.4 in which brown coir fibres and coconut shells were used as partial replacement by percentage weight of coarse aggregates. Also the main steel rebars were wound with 2 mm coir ropes for steel replacement.

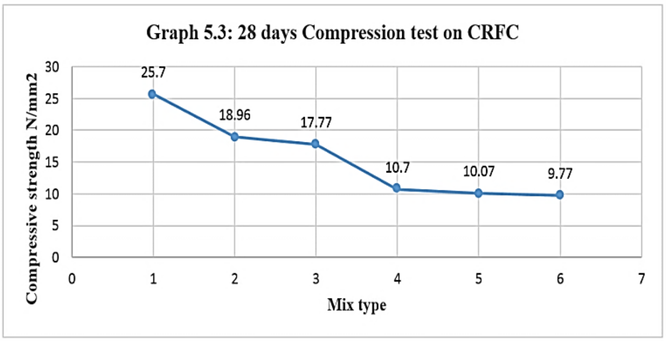
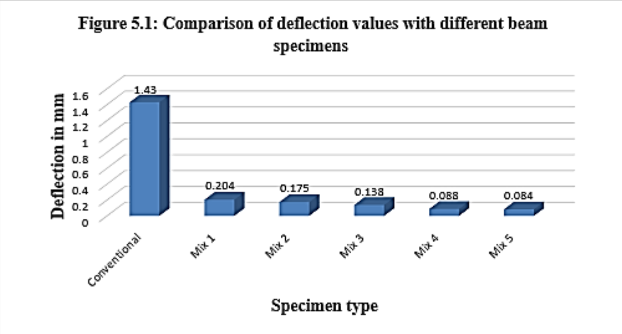


Table 5.4: Flexural test results of CFR concrete beam

SPECIMEN	CRACK	MSR	SSR	LOAD (kN)	DEFLECTION (mm)
Conventional	I	3*100	(1*5)+3	62.72	0.616
	II	4*100	(5*5)+2	82.91	0.854
	III	5*100	(12*5)	108.74	1.12
	IV	7*100	(3*5)+2	139.563	1.43
Mix 1 (1%shell, 0.5%coir)	I	1*100	2*5	21.35	0.042
	II	2*100	15*5	53.4	0.106
	III	3*100	(8*5)+1	66.21	0.132
	IV	5*100	(6*5)+2	102.34	0.204
Mix 2 (1.5%shell, 0.75%coir)	I	1*100	(2*5)+4	22.13	0.044
	II	2*100	(4*5)+4	43.49	0.086
	III	3*100	(14*5)+0	52.43	0.104
	IV	4*100	(6*5)+1	87.68	0.175
Mix 3 (2%shell, 1%coir)	I	1*100	(3*5)+2	22.72	0.045
	II	2*100	(16*5)+1	35.15	0.01
	III	2*100	(1*5)+2	40.78	0.081
	IV	3*100	(7*5)+1	59.74	0.134
	V	3*100	(12*5)+2	76.21	0.138
Mix 4 (2.5%shell, 1.25%coir)	I	1*100	(14*5)+1	13.78	0.027
	II	1*100	(8*5)+4	27.96	0.055
	III	2*100	(16*5)+3	32.62	0.065
	IV	2*100	(4*5)+4	43.82	0.088
Mix 5 (3%shell, 1.25%coir)	I	1*100	(12*5)+1	11.84	0.023
	II	1*100	(16*5)+2	15.92	0.031
	III	1*100	(8*5)+2	27.57	0.05
	IV	2*100	(7*5)+1	37.52	0.084



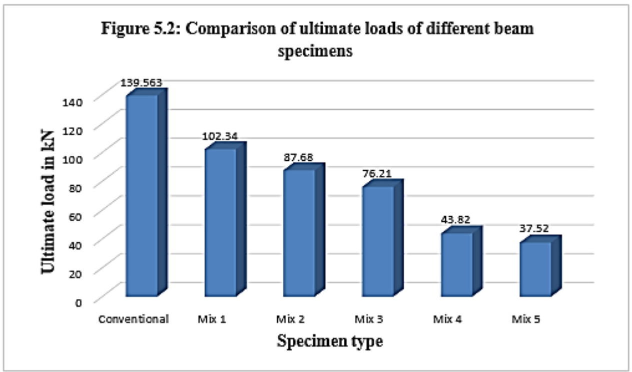


Table 5.5: Cost analysis of mission grass concrete in which fine aggregates were replaced by 2mm mission grass

Cube type (150*150*150)mm	Cost of materials for 0.033 m³ (1 cube) M25 concrete (Rs.)				Total cost Rs./ m³	cost difference Rs.
	OPC	F.A	C.A	Mission grass		
Conventional	13.85	1.730	5.960	-	6383	
1%	13.85	1.710	5.960	-	6376	7
2%	13.85	1.690	5.960	-	6370	13
3%	13.85	1.670	5.960	-	6364	19
4%	13.85	1.660	5.960	-	6361	22
5%	13.85	1.640	5.960	-	6355	28

Table 5.6: Cost analysis of mission grass concrete in which coarse aggregates were replaced by 15 mm mission grass

Cube type (150*150*150)mm	Cost of materials for 0.033 m³ (1 cube) of M25 concrete (Rs.)				Total cost Rs./ m³	cost difference Rs.
	OPC	F.A	C.A	Mission grass		
Conventional	13.85	1.730	5.960	-	6383	
1%	13.85	1.730	5.840	-	6346	37
2%	13.85	1.730	5.780	-	6328	55
3%	13.85	1.730	5.720	-	6311	72
4%	13.85	1.730	5.660	-	6293	90
5%	13.85	1.730	5.590	-	6272	111

Figure 5.1 and 5.2 shows the ultimate load deflection values of various beam specimens. Figure 5.2 shows ultimate load at failure of different spcimens.

Table 5.7: Cost analysis of CFR concrete in which coarse aggregates were replaced by coir fibres and coconut shells

Cube type (150*150*150)mm	Cost of materials for 0.033 m³ (1 cube) of M25 concrete (Rs.)				Total cost Rs./ m³	cost difference Rs.
	PPC	F.A	C.A	Coconut fibres & shells		
Conventional	13.85	1.730	5.960	-	6383	
Mix 1	13.85	1.730	5.790	-	6332	51
Mix 2	13.85	1.730	5.590	-	6272	111
Mix 3	13.85	1.730	5.390	-	6213	170
Mix 4	13.85	1.730	5.220	-	6163	220
Mix 5	13.85	1.730	5.020	-	6104	279

Table 5.8: Cost analysis of CFR concrete beam in which coarse aggregates were replaced by coir fibres and coconut shells and steel replaced by 2mm coir ropes

Beam type (150*150*750) mm	Cost of materials for 0.016 m³ (1 beam) of M25 concrete (Rs.)						Total cost Rs./ m³	cost difference Rs.
	PPC	F.A	C.A	Coconut fibres & shells	Coir ropes	Steel		
Conventional	64.80	8.10	27.3	-	-	336	26074	
Mix 1	64.80	8.10	26.8	-	8	288	23448	2626
Mix 2	64.80	8.10	26.5	-	8	288	23431	2643
Mix 3	64.80	8.10	26.3	-	8	288	23419	2655
Mix 4	64.80	8.10	26.1	-	8	288	23407	2667
Mix 5	64.80	8.10	26.0	-	8	288	23401	2673

Table 5.5 and 5.6 shows cost analysis of concrete in which fine and coarse aggregates are replaced by Mission grass respectively. Cost difference between conventional and replaced mix concrete are also tabulated.

Table 5.7 and 5.8 shows cost analysis of concrete in which coarse aggregates are replaced with coconut fibres and shells. Cost savings in each of the concrete mix are also tabulated.

4. CONCLUSIONS

- From the results of compressive strength test of mission grass concrete it was found that the strength gradually decreases with replacement of sand and coarse aggregates with Mission grass
- Replacement of sand with 2 mm average length Mission grass in concrete can achieve sufficient strength at least for smaller percentages (1% & 2%)
- Replacement of coarse aggregate with 7mm average length mission grass fibres in concrete

cannot achieve sufficient strength even for smaller percentages

- From the results of flexural strength test of beam specimens it was found that the strength gradually reduced with increase in the percentage replacement using coconut fibre and coconut shell as coarse aggregates
- It was observed that no shear cracks were developed in beam reinforced with coir fibres
- There was overall material savings in coarse aggregate and steel using coir fibres and ropes that resulted in cost savings

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