INTERNATIONAL JOURNAL OF RESEARCH IN MECHANICAL, MECHATRONICS AND AUTOMOBILE ENGINEERING (IJRMMAE)
ISSN: 2454-1435 (Print) | 2454-1443 (online)
Volume 4 Issue 2 – www.ijrmmae.in – Pages 29-38

EXPERIMENTAL STUDY ON CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY SISAL AND HEMP FIBER

Seetharam P G
seetharampg@jnn.edu.in
Assistant Professor (JNN Institute of Engineering, Chennai.

ABSTRACT
Replacement of cement with natural fibers like sisal and hemp with certain percentage can enhance many of the properties of the material. Investigations have been carried out in many countries on various mechanical properties, physical properties and durability of cement matrices with fibers such as sisal and hemp. The optimum strength of fiber reinforced concrete is found by carrying out compression, flexural and split tensile strength test with partial replacement of cement by certain percentage of fiber. The fibers are added at proportions of 1%, 1.5% and 2% to the M25 grade of concrete. The effect of properties of the fibers in concrete on compressive, flexural and tensile strength was studied experimentally and its performance is evaluated.
Keywords: Sisal fiber, Hemp fiber, Compression, Flexural, Split tensile test

1. INTRODUCTION

Concrete is an important application in construction field in all over the world because of the positive impute such as high resistance to load, good in compression and possibility of using local or available materials in the preparation of concrete. In this project, we would like to take the natural fiber like sisal and hemp fiber in a small percentage with partial replacement of cement along with other materials in concrete and study their properties and their effects in concrete
We know that conventional concrete is strong in compression and weak in tension. Hence to overcome this drawback in concrete hemp fibers are used in small amount in replacement of cement. Because hemp fibers are so strong they can also replace metal and glass. Hemp fibre also has incredible tensile strength and tear strength of 102% and 62% compared to other fibers. This addition of sisal and hemp fiber in concrete shows improved characteristics of workability, strength and durability. Generally, the bond strength of fibers depends upon characteristics of fibers and its aspect ratio.
GROSS R.A AND KARLE studied that environmental as well as economic factors are now driving important towards consumption of natural fibers and bio based polymers due to their light weight, low cost, availability of fibers and its renewable and bio-degradable nature.

PJ HERRERA-FRANCO studied that the untreated sisal fiber produced best extension before fracture and the chemical treatment improves the tensile properties of sisal fiber. The tensile strength of untreated sisal fiber value is 0.5N/mm2 and thus tensile strength of the natural fiber only depends on its length, were length increases the tensile strength decreases.

INTERNATIONAL JOURNAL OF RESEARCH IN MECHANICAL, MECHATRONICS AND AUTOMOBILE ENGINEERING (IJRMMAE)
ISSN: 2454-1435 (Print) | 2454-1443 (online)
Volume 4 Issue 2 – www.ijrmmae.in – Pages 29-38

MERTA E.K.TSCHEGG reported that the concrete specimens containing 0.19% of fibers by weight and of 40 mm of length were uniaxially tested with the wedge splitting test (WST) method. The addition of fibers was found to improve the fracture toughness of plain concrete. The beneficial effect of hemp fibers is believed to be the result of the fiber's high tensile strength and the fiber's fineness, resulting in a better bonding between fibers and concrete matrix.

ROBERT S.P.COUTTS made some experiments on free, restrained and drying shrinkage of cement mortar composites reinforced with sisal fibers. It was concluded that free plastic shrinkage is significantly reduced by the inclusion of 0.2% volume fraction of 25mm short sisal fiber in cement mortar. Also it was stated that the presence of sisal and hemp fibers promotes an effective self-healing of Concrete.

2.MATERIALS

2.1 Natural Fibres

Natural fibers are used in building materials were the natural fibers are the lightest fiber all among the known fibers. Their density ranges to (1.25 – 1.4gm/cc). The Natural fibers are light in weight and produce the high strength in concrete. Natural fibers are the fibers, they are not synthetic or manmade. The natural fibers are produced from

plants like (leaves, wood, and vegetables). Animals etc.,

They are more numbers of fibers, in which the most popular natural fibers are, Flax, Jute, Hemp, Sisal, Ramie etc.In our project we used sisal fiber and hemp fiber.

2.2 SISAL FIBER:

It is a hard fiber, coarse and firm fiber. It is extracted from the sisal plant & its botanical name is (Agave sisalana). Sisal fiber contains lower cellulose content with high tensile and stiffness properties. Some of the characteristic properties of sisal are shown in Table 1

Table 1 Sisal Fibre Characteristics

S.No	Characteristics	Values
1	Density (g/m^3)	1.5
2	Elongation at break (%)	2-2.5
3	Tensile strength (MPa)	511-700
4	Young's modulus (GPa)	9.4-22
5	Cellulose (%)	65
6	Lignin (%)	9.9
7	Microfibrillar angle	22^o
8	Wax (%)	2
9	Hemi-cellulose (%)	22
10	Pectin (%)	10
11	Ash (%)	0.6-1

INTERNATIONAL JOURNAL OF RESEARCH IN MECHANICAL, MECHATRONICS AND AUTOMOBILE ENGINEERING (IJRMMAE)
ISSN: 2454-1435 (Print) | 2454-1443 (online)
Volume 4 Issue 2 – www.ijrmmae.in – Pages 29-38

It occupies an important place among natural fibres because of its strength, durability, ability to stretch and resistance to deterioration in salt water.

2.3 HEMP FIBER:

After Sisal, the most widely used natural fiber will be Hemp Fiber. The high strength and stiffness of hemp fiber will be used as reinforcement in composite material. Properties of Hemp fibre are given in Table 2.

Table 2 Hemp Fibre Characteristics

S.No	Characteristics	Values
1	Density (g/cc)	1.6
2	Diameter (mm)	0.35
3	Tensile strength (MPa)	192.26
4	Young's modulus (GPa)	4.3
5	Strain (%)	1.1-1.6
6	Length (mm)	5-55
7	Elongation at break (%)	3-4

It is used in this project because of its weather resistant, strength & environment friendly reinforcing material. The reinforcement of hemp fibre to the polymeric matrix reduces the density of the composite as a whole.

3. Concrete Mix Design:

3.1 Mix Design for M25 Concrete:

Based on the test results obtained the mix design for M25 concrete is done as per IS:10262-2009.

3.2 STIPULATION FOR PROPORTIONING:

Grade designation : M25
Type of cement : OPC 53
Maximum nominal size of aggregate : 20 mm
Minimum cement content : 320 kg/m3

Maximum water-cement ratio : 0.45
Workability (slump) : 100 mm
Type of aggregate : crushed
Maximum cement content : 450kg/m3
Chemical admixture type : plasticizer

3.3 TEST DATA FOR MATERIALS

Cement used : OPC 53
Specific gravity of cement : 3.24

INTERNATIONAL JOURNAL OF RESEARCH IN MECHANICAL, MECHATRONICS AND AUTOMOBILE ENGINEERING (IJRMMAE)
ISSN: 2454-1435 (Print) | 2454-1443 (online)
Volume 4 Issue 2 – www.ijrmmae.in – Pages 29-38

Specific gravity of Coarse aggregate : 2.6
Specific gravity of Fine aggregate : 2.4
Specific gravity of sisal fibre : 1370 kg/m3
Specific gravity of hemp fibre : 1500 kg/m3

3.4 TARGET STRENGTH FOR MIX PROPORTION

fck = f ‘ck +1.65 s

Where,
fck= target average compressive strength at 28 days
fck= characteristic compressive strength at 28days s = standard deviation
From table 1 of IS 10262:2009, s = 4.0N/mm2 Therefore, f 'ck = 25+ (1.65x4)

= 31.6 N/mm2

3.5 SELECTION OF WATER-CEMENT RATIO
From table 5 of IS 456:2000,
Maximum water-cement ratio = 0.45
Hence adopt water-cement ratio as 0.45

3.6 SELECTION OF WATER CONTENT

From table 2, of IS 10262:2009
Maximum water content for 20mm aggregate = 186 liters

Estimated water content for 100mm slump = 186+ ((6/100) x186)
= 197 liters.

As super plasticizer is used, the water content can be reduced up to 30 percent. Based on trials with super plasticizer water content reduction of 25 percent has been achieved. Hence, the arrived water content = 197 × 0.75 = 148 litres.

3.7 MIX DESIGN:

Cement	**Fine Aggregate**	**Coarse aggregate**	**water**
329 kg/m^3	846 kg/m^3	995 kg/m^3	148 kg/m^3
1	2.6	3	0.45

INTERNATIONAL JOURNAL OF RESEARCH IN MECHANICAL, MECHATRONICS AND AUTOMOBILE ENGINEERING (IJRMMAE)
ISSN: 2454-1435 (Print) | 2454-1443 (online)
Volume 4 Issue 2 – www.ijrmmae.in – Pages 29-38

3.8 MIX DESIGN FOR A CUBE

Materials	0%	1%	1.5%	2%
Cement	1.44	1.41	1.39	1.38
Sisal	0	0.01	0.02	0.03
Hemp	0	0.01	0.02	0.03
F A	3.71	3.71	3.71	3.71
C A	4.37	4.37	4.37	4.37
Admixture	0.02	0.02	0.02	0.02
Water	0.5	0.5	0.5	0.5

3.9 MIX DESIGN FOR A PRISM

Materials	0%	1%	1.5%	2%
Cement	2.08	2.08	2.08	2.08
Sisal	0	0.01	0.02	0.03
Hemp	0	0.01	0.02	0.03
F A	5.5	5.5	5.5	5.5
C A	6.46	6.46	6.46	6.46
Admixture	0.02	0.02	0.02	0.02
Water	0.5	0.5	0.5	0.5

3.10 MIX DESIGN FOR A CYLINDER

Materials	0%	1%	1.5%	2%
Cement	2.26	2.26	2.26	2.26
Sisal	0	0.01	0.02	0.03
Hemp	0	0.01	0.02	0.03
F A	5.88	5.88	5.88	5.88
C A	6.78	6.78	6.78	6.78
Admixture	0.02	0.02	0.02	0.02
Water	0.5	0.5	0.5	0.5

Cement, aggregates and fibers are taken in kilograms. Admixtures are taken in litres.

4. TESTINGS:

4.1 Compressive strength Test Objective

This test is conducted to calculate the strength of concrete

INTERNATIONAL JOURNAL OF RESEARCH IN MECHANICAL, MECHATRONICS AND AUTOMOBILE ENGINEERING (IJRMMAE)
ISSN: 2454-1435 (Print) | 2454-1443 (online)
Volume 4 Issue 2 – www.ijrmmae.in – Pages 29-38

Apparatus Required

1.Compression testing machine
2.Weigh balance

Procedure for compression strength test:

1. The size of the specimen used for the compression strength test will be 150mm*150mm*150mm.
2. The moulds are filled with concrete in layers approximately 5 cm deep, it would be distributed uniformly.
3. The moulds are compacted by hand compacting (Tamping Rods). After the compaction the surface layer should have to be finished by using a trowel.
4. The specimen shall be kept for 24 hour under damp matting or sack. After that the specimen should be in curing until the time of the test i.e (after 7 th and 28th day).
5. Specimen should be tested immediately after Curing.
6. The specimen will be placed in the machine and load is transferred to the cube.
7. The load should be applied slowly without any shock and increased continuously. The maximum load applied to the specimen shall be recorded and crack formation notes at the time of failure , in which they are noted in report.

Compression testing machine:

CALCULATION

Compressive strength is calculated using the following formula,
Compressive strength (Kg/cm2) =P / A Where ,
P = maximum applied load just before breaking point
A = plan area of cube mould (mm2)

Test results:

Specimen	7 Days	28 Days
M25	17.33 N/mm^2	28.04 N/mm^2
1%	20.09 N/mm^2	27.11 N/mm^2
2%	25.78 N/mm^2	35.56 N/mm^2
3%	23.11 N/mm^2	32.93 N/mm^2

INTERNATIONAL JOURNAL OF RESEARCH IN MECHANICAL, MECHATRONICS AND AUTOMOBILE ENGINEERING (IJRMMAE)
ISSN: 2454-1435 (Print) | 2454-1443 (online)
Volume 4 Issue 2 – www.ijrmmae.in – Pages 29-38

4.2 Flexural Strength Test:

Objective

This test is conducted to calculate the flexural strength of concrete.

Reference standards

IS: 516 – 1959 – This code is referred to determine the strength of concrete.

Apparatus Required

1.Beam mould size (10cm*10cm*50cm)
2.Weigh balance
3.Digital universal testing machine with capacity kN.

Procedure for Flexural Strength Test

1.The specimen is filled with concrete in three layers. The compaction is done manually by tamping rods for 35 times. The tamping should be done uniformly to the entire cross section of the specimen .
2.And thus the mould casting will be taken place for 24hours and curing time starts after the casting is removed . Curing duration (7th,28th day).
3.Then mould is taken for testing , before testing the bearing surface of the supporting and loading rollers should be cleaned and remove if sand or any material is in contact with the rollers.
4.The test specimen (Beam) should be placed in
the machine correctly centered with the longitudinal axis of the specimen at right to the rollers .The mould should have to be normal to the loading condition.
5.The load applied at rate of 140 Kg/min.

Flexural testing machine:

Calculation

The flexural strength of concrete is calculated by Fb = pl / bd2 (When a>20.0 cm for 15.0 cm specimen or > 13.0 cm for 10 cm specimen)

Where,

b = width of the specimen
d = failure point depth of the specimen
l = supported length p = maximum load

INTERNATIONAL JOURNAL OF RESEARCH IN MECHANICAL, MECHATRONICS AND AUTOMOBILE ENGINEERING (IJRMMAE)
ISSN: 2454-1435 (Print) | 2454-1443 (online)
Volume 4 Issue 2 – www.ijrmmae.in – Pages 29-38

Test Results

Specimen	7 Days	28 Days
M_{25}	2.3 N/mm^2	3.5 N/mm^2
1%	2.44 N/mm^2	3.72 N/mm^2
2%	3.32 N/mm^2	4.5 N/mm^2
3%	2.72 N/mm^2	4.08 N/mm^2

4.3 Split Tensile Test

Objective

This test is conducted to calculate the strength of concrete .

Apparatus Required

1. Compression testing machine
2. Cylindrical mould (150mm dia & 300 mm height)
3. Two packing plates of plywood (30 cm long and 12cm wide)
4. Weighing balance

Procedure for Split Tensile Strength Test

1. After curing for 28th days . The weight and dimensions of the specimen are noted.
2. The lines are drawn on the two ends of the specimen to ensure that they are on the same axis.
3. Place the plywood strip upper and lower ends of the specimen.
4. Bring down the upper plate to touch the plywood strip. Apply the load continuously without shock at a rate of 0.7 to 0.14 Mpa/min . The breaking load is noted on report.

Split tensile strength testing machine:

INTERNATIONAL JOURNAL OF RESEARCH IN MECHANICAL, MECHATRONICS AND AUTOMOBILE ENGINEERING (IJRMMAE)
ISSN: 2454-1435 (Print) | 2454-1443 (online)
Volume 4 Issue 2 – www.ijrmmae.in – Pages 29-38

Calculation

Calculate the splitting tensile strength of the specimen as given below,

$T = 2P / \pi ld$

Where,

P = applied load

T = Splitting tensile strength l = length

d = diameter.

Test results:

Specimen	7 Days	28 Days
M_{25}	5.2 N/mm^2	8 N/mm^2
1%	4.06 N/mm^2	6.24 N/mm^2
2%	5.38 N/mm^2	8.28 N/mm^2
3%	5.15 N/mm^2	7.93 N/mm^2

5.RESULTS AND DISCUSSIONS:

Concrete is a member which is good in compression, moderate in shear and weak in tension. In order to increase the tensile property and other properties like durability, resistance to shrinkage and cracks.Hence replacement of cement with sisal and hemp fiber in 1%, 2% and 3% is done and the results. The concrete specimen which is prepared with the partial replacement of sisal and hemp fiber in 1%, 2% & 3% is casted into cubes beam and cylinder and tested for compressive, flexural and split tensile test and conventional concrete of M25grade is also tested for these strengths. In M25grade concrete the good and reasonable results is obtained in replacement of cement with sisal and hemp fiber in 2%. Thus the compressive strength has been increased 36% than the conventional concrete, 20% increment in flexural strength with centre point loading and 45% increase in split tensile strength.

CONCLUSION:

The material tests, strength test such as compression and split tensile test are had been carried out in the laboratory and as per code provision only. Results of experiments on different properties of different mixes in which fiber is added with different percentages. The following conclusions are drawn from the investigation One day strength results are not to be estimate for the fiber content as the increase in the fiber percentage the setting time of the concrete is delayed.

Freshly prepared Sisal fiber contain some gelatinous chemical reagents which may affect the chemical properties of cement in concrete When the percentage of fiber is increased byore than 1% reduction in mechanical properties is observed. The addition of the fiber in small amounts will increase the tensile strength. Addition of fibers not only increases tensile Strength but also increases bond strength, decreases permeability.

ISSN: 2454-1435 (Print) | 2454-1443 (online)
Volume 4 Issue 2 – www.ijrmmae.in – Pages 29-38

6. REFERENCES

[1] M.A.Aziz , P. Paramasivam and S.L.Lee 1984 – Natural fibers are prospective reinforcing materialand their use.
[2] S.K. Al-Oraimi and A.C.Seibi (1995) – MechanicCharacterization and impeact behavior of concrete reinforced with natural fibers.
[3] Text book on concrete technology by M.S.Shetty
[4] Text book on concrete technology by Ghambhir.
[5] IS383-1970 “Specification for coarse and fine
[6] Aggregates from Natural Sources For concrete”6..IS: 516 – 1959 “Methods of Testing for strength of Concrete”