Sisal Fiber Reinforced Concrete with Partial Replacement of Cement by Fly Ash And GGBS

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Abstract: This study examines the qualities of freshly-poured and hardened concrete with reinforced sisal fiber, in order to improve the mechanical properties of concrete, steel is replaced by sisal fiber at 0%, 0.5%, 1%, 1.5% and 2% by volume of M-30 design mix. The appearance of concrete is crucial most of the time. So along with sisal fibre reinforcement, partial replacement of cement with mineral admixtures such fly ash and blast furnace slag at 0-20%, 0-6% respectively is done. The concrete specimens will be tested for compressive strength at 7 ,14 and 28 days respectively and Split tensile Strength at 7 ,14 and 28 days and flexural strength, the results obtained will be compared with those of conventional concrete.

Index Terms: Sisal fibre, fly ash powder, blast furnace slag.

I. INTRODUCTION

The building industry is seeing increased demand as the world's population grows. Due to its exceptional inherent features, such as strong compressive capacity, excellent resilience, fire resistance, and low penetrability, the industry significantly depends on concrete, which is the best extensively used building material. Apart from these positive characteristics, there are certain disadvantages, such as less tensile capacity, brittleness, poor fracture resistance, and less impact resistance. The desire to improve the tensile strain of the material's "perceived" fragile qualities was the driving force behind this work.

Natural fibers are an environmentally beneficial alternative to artificial fibers when used as secondary reinforcement in concrete. Fibers are tiny, discrete reinforcement materials created from a variety of materials, natural as well as artificial, and they come in a variety of forms and sizes. Sisal is one of several natural fibers that have proven to show significant promise throughout time, it has several beneficial features, including sustainability, great tensile stain, and cheap cost. Ground Granulated Blast Furnace Slag (GGBS) and Fly Ash are both supplementary cementitious materials that can be used in concrete to enhance its properties and sustainability. GGBS is a by-product of the iron-making industry, produced by rapidly cooling molten iron slag from a blast furnace with water or steam. Fly Ash is a fine, powdery material that is a by-product of burning pulverized coal in electric power generating plants. GGBS and Fly Ash are often used together or in combination with Portland cement to leverage their complementary properties.

The combined use can further enhance concrete performance, such as improving long-term strength, durability, and reducing environmental impact. The aim of this experimental work is to study the effect of adding randomly distributed natural fibers, Sisal Fiber (SF), fly ash and ground granulated blast furnace slag on the properties of plain concrete. in order to improve the mechanical properties of concrete, steel is replaced by sisal fiber at 1%, 1.5% and 2% by volume of M-30 design mix, along with partial replacement of cement with mineral admixtures such fly ash, blast furnace slag and rice husk ash at 0-20%, 0-6% respectively. Many tests are required to be assessed in this experimental work such as, Compressive strength using (150 mm) cubes, flexural strength using (150×150×500 mm) simply supported beams, splitting tensile strength using (150×200 mm) cylinders.

II. OBJECTIVE

The main objective is to study the effect on utilization of sisal fiber in the concrete as the reinforcement and compound replacement of fly ash and GGBS, in this investigation sisal fiber, fly ash and GGBS is mixed in different proportions, sisal fiber is cut into small pieces of size 3 to 5 cm.

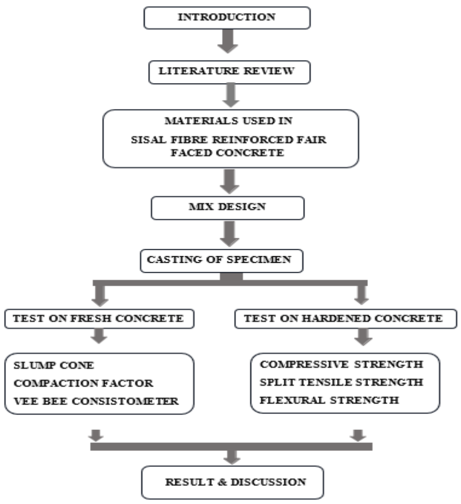
To study the mechanical properties of concrete for

• Compressive test on concrete cubes (150 × 150 ×150 mm)

• Split tensile strength on cylinders (Ø 150 mm & 300 mm long.

• Flexural strength on beams (150mm x 150mm x 500mm long)

III. METHODOLOGY



IV. MATERIALS USED

A. Cement

In this investigation the locally available Portland cement of grade 53 is used. As per IS: 12269- 1987, the cement mix is experienced to determine the physical and chemical requirementsin concurrence with IS: 4032-1977 of 53.

Physical properties of cement:

Specific Gravity	2.95
Standard Consistency	28%
Initial Setting time	30 minutes
Final Setting time	600 minutes
Fineness	2.5%
Grade of cement	OPC 53 grade

B. Fine aggregate

The rock crushed to the required grain size distribution is termed as manufactured sand (M- sand).in order to arrive at the required grain size crushed in a special rock crusher and some of the crushed materials is washed to remove fines.

Physical properties of Fine aggregate:

Specific Gravity	2.7
Fineness modulus	3.1
Bulk density	1.65 kg/m
Water absorption	4.8%

C. Coarse aggregate

Generally, the coarse aggregate will be adopted from any accessible source usually being 20mm in supposed size to be used from the crushed sharp granite metal from the machineries. But as per IS: 383-1970 and IS: 2386-1963 the coarse aggregate will also be experienced to different tests toknow its various properties.

Physical properties of Coarse aggregate:

Specific Gravity	2.76
Fineness modulus	7.10
Density	7.682
Impact value	14.40%
Crushing value	17.50%

D. Sisal fiber

Sisal fiber is species of Agava sisilana. The material is mainly used for applications like rope manufacture in marine and construction industry. As it possesses high strength compared to other fiber materials, this fiber is selected for the present research work. Concrete paste is done with the help of cement, filler materials, aggregates is prepared. Here, Sisal Fibers are used as reinforcing agent for cement.

Physical properties of Sisal fiber:

Sl.No	Property	Value
1	Average length (mm)	300
2	Average diameter (mm)	0.12
3	Density (g/cm^3)	1.45
4	Average Tensile strength (N/mm^2)	1090
5	Elongation (%)	18.2
6	Water absorption (%)	76.7%

E. Fly ash

Fly Ash generated from combustion of Coal in Thermal Power Plants is a major environmental concern. As of now about 25 million tons of fly ash is generated from Thermal Power Plants. Fly ash is a frequently used mineral admixture. Fly ash particles are in the form of microbeads, which can play a lubricating role in the concrete mixing process, effectively improving the compatibility of the mix.

Physical properties of Fly ash:

Specific Gravity	2.07
Fineness	290 kg/m^2
Bulk density	1100 - 1200 kg/m
Colour	Light grey

D. Ground granulated blast furnace slag

Ground granulated furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. Ground granulated blast furnace slag is a latent hydraulic binder forming calcium silicate hydrates (C-S-H) after contact with water. It is a strength-enhancing compound improving the durability of concrete. It is a component of metallurgic cement (CEM III in the European norm EN 197). Its main advantage is its slow release of hydration heat, allowing limitation of the temperature increase in massive concrete components and structures during cement setting and concrete curing, or to cast concrete during hot summer

Physical properties of Coarse aggregate:

Specific Gravity	3.0 – 3.2
Relative Water Requirement	103.00%
Loss on Ignition	0.20%
Relative Strength	100%
Temperature Rise	18.8 °C
Fineness	98.00%

V. MIX PROPORTION

In this study Sisal Fiber Reinforced concrete with partial replacement of fly ash and GGBS mix proportion of M30 grade concrete as per recommended standards are followed. Four types of proportions are available according to the materials used.

Cement	Fine aggregate	Coarse aggregate	W/C ratio
458.2	920.8	1618.8	197
1	2	3.6	0.43

Percentage of replacement proportions:

Proportion – 1

- Fly ash - 5 %
- GGBS – 2%
- Sisal Fiber – 0.5%

Proportion – 2

- Fly ash – 10 %
- GGBS – 3%

- Sisal Fiber – 1%

Proportion – 3
- Fly ash – 215%
- GGBS – 4%
- Sisal Fiber – 1.5%

Proportion – 4
- Fly ash – 20%
- GGBS – 6%
- Sisal Fiber – 1.5%

VI. TESTING OF SPECIMEN

Preparation and testing of specimen:

Based on four different mixes, cube (150mm x 150mm x 150mm) for compression test, cylinder (300mm x 150 mm) for split tensile test and prism (500mm x 100mm x 100mm) for flexure test were casted for each mixes. A set of 3 specimens as average has been prepared for each mix and for each test and cured for 3 different ages 7, 14 and 28 days under water for evaluating hardened characteristics of concrete. For durability test, same set of specimens after attaining 28 days of age under water were taken out and conditioned for another 28 days by immersing under water. After curing the specimens were taken out and tested for evaluating durability in terms of compressive strength, split tensile strength, flexural strength and flexural toughness. The results based on the above tests were discussed under the following section.

I. Specimen Identification

A. Cubes

Table 6.1 shows the five different proportions of cubes were casted for each proportion 3 cubes were casted and their respective specimen identification.

S.No.	MIX ID	Definition
1	CU1	Cubes of Standard mix proportion
2	CU2	5% Fly Ash, 2% of GGBS, 0.5% of Sisal fiber replacement
3	CU3	10% Fly Ash, 3% of GGBS, 1% of Sisal fiber replacement
4	CU4	15% Fly Ash, 4% of GGBS, 1.5% of Sisal fiber replacement
5	CU5	20% Fly Ash, 6% of GGBS, 2% of Sisal fiber replacement

B. Cylinders

Five different mixes (C1-C5) with proportions as mentioned in Table 6.2.

S.No.	MIX ID	Definition
1	C1	Cylinder of Standard mix proportion
2	C2	5% Fly Ash, 2% of GGBS, 0.5% of Sisal fiber replacement
3	C3	10% Fly Ash, 3% of GGBS, 1% of Sisal fiber replacement
4	C4	15% Fly Ash, 4% of GGBS, 1.5% of Sisal fiber replacement
5	C5	20% Fly Ash, 6% of GGBS, 2% of Sisal fiber replacement

C. Beams

Reinforced Concrete beams of 1 per mix as described in Table 6.3 are casted.

S.No.	MIX ID	Definition
1	B1	Cylinder of Standard mix proportion
2	B2	5% Fly Ash, 2% of GGBS, 0.5% of Sisal fiber replacement
3	B3	10% Fly Ash, 2% of GGBS, 1% of Sisal fiber replacement
4	B4	15% Fly Ash, 4% of GGBS, 1.5% of Sisal fiber replacement
5	B5	20% Fly Ash, 6% of GGBS, 2% of Sisal fiber replacement

II. Testing of specimen:

1. Compressive Strength of concrete:

Irrespective of type of mix, all the specimens showed increased compression values as age of concrete increases and maximum values are reported for 28 days aging. In all curing ages, the maximum compressive strength is achieved for CU2 and CU3 specimens are greater than that of reference specimen. Futher increase of sisal fiber and replacement of fly ash and GGBS decreases the compressive strength.

Table 6.1 Mean Compressive Strength of Cubes:

Cube codes	7 Days	14 Days	28 Days
CU 1	29.5	30.2	31.3
CU 2	41.5	45.9	48.7
CU3	27.4	31.5	35.6
CU 4	19.5	25.7	22.4
CU 5	15	22.3	19.3

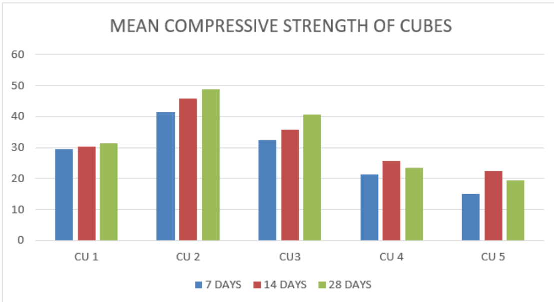


Fig 6.1 Mean Compressive Strength of Cubes

2. Split Tensile strength:

In all curing ages, the maximum compressive strength is achieved for C2 and C3 specimens. Futher increase of sisal fiber and replacement of fly ash and GGBS decreases the compressive strength.

Table 6.2 Mean Split Tensile Strength of Cylinder

MIX ID	7 Days	14 Days	28 Days
C1	3	3.15	3.64
C2	3.2	3.5	4.12
C3	2.11	3.2	3.9
C4	1.2	2.2	3.0
C5	0.9	2	2.4

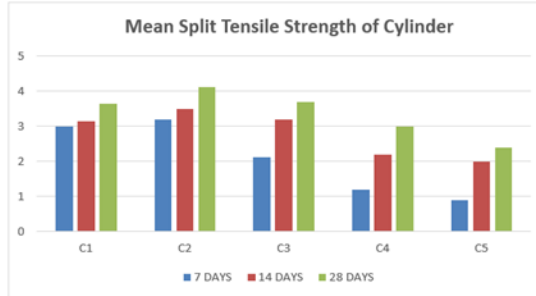


Fig 6.2 Mean Split Tensile Strength of Cylinder

2. Flexural strength:

In all curing ages, the maximum flexural strength is achieved for B2 and B3 with 0.5% sisal fiber 5% fly ash and 2% GGBS, greater than that of reference specimen. Futher increase of sisal fiber and replacement of fly ash and GGBS decreases the flexural strength.

Table 6.3 Mean Flexural Strength of Beams:

MIX ID	7 Days	14 Days	28 Days
B1	3.03	3.12	3.5
B2	3.80	4.34	4.87
B3	3.46	4.08	4.64
B4	1.96	2.78	3.65
B5	0.69	1.65	2.43

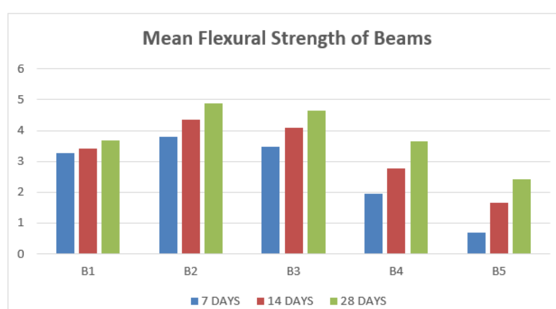


Fig 6.3 Mean Flexural Strength of Beam

- The compressive strength of concrete in which 0% to 20% and 0% to 6% replacing of cement is done by fly ash and ground granulated blast furnace slag (GGBFS) respectively, and 0% to 2% addition of sisal fiber of 28 days has achieved the objective mean strength of about 15.2% that of reference cubes at 5% and 2% of fly ash and GGBFS with 0.5% addition of sisal fiber and further increase in replacing the cement with that of ceramic waste and adding sisal fiber there observed a reduce in strength from Table-4.1.
- The split tensile strength of concrete in which 0% to 20% and 0% to 6% replacing of cement is done by fly ash and ground granulated blast furnace slag (GGBFS) respectively, and 0% to 2% addition of sisal fiber of 28 days has achieved the objective mean strength at 5% and 2% of fly ash and GGBFS with 0.5% addition of sisal fiber. Further increase in replacement there will be reduction in strength observed in Table-4.2.
- The flexural strength of concrete in which 0% to 20% and 0% to 6% replacing of cement is done by fly ash and ground granulated blast furnace slag (GGBFS) respectively, and 0% to 2% addition of sisal fiber of 28 days has achieved the objective mean strength at 5% and 2% of fly ash and GGBFS with 0.5% addition of sisal fiber. Further increase in replacement there will be reduction in strength as observed in Table-4.3.
- This proves that with 5% and 2% replacing of cement with fly ash and GGBFS and 0.5% addition of sisal fiber shows better results.
- Utilization of sisal fibers and its applications are used for the development of the construction industry, material sciences.

VI. CONCLUSION

- The maximum compressive strength is obtained at the curing period of 28 days by 5% and 2% replacing cement with fly ash GGBFS respectively and concurrently 0.5% addition of sisal fiber.
- The split tensile strength of concrete in which 5% and 2% replacing cement with fly ash GGBFS respectively and concurrently 0.5% addition of sisal fiber maximum mean strength at the age of 28 days.
- The flexural strength of concrete in which 5% and 2% replacing cement with fly ash GGBFS respectively and concurrently 0.5% addition of sisal fiber has maximum strength at the age of 28 days.
- Hence the use of compound mix of 5% of fly ash and 2% of GGBFS in concrete along with 0.5% sisal fiber as admixture gives the optimum values of strength.

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