AN EXPERIMENTAL STUDY ON GEOPOLYMER CONCRETE USING SISAL FIBRE

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ABSTRACT
Concrete is the most abundant manmade material in the world. One of the main ingredients in a normal concrete mixture is Portland cement. The production of cement from industries emits greenhouse gases and CO_2. The production of one ton of cement emits approximately one ton of CO_2 and it is responsibility for 65% of global warming. In order to reduce the usage of cement, supplementary cementing materials like fly ash and metakaloin, instead of water alkali solution have been used. Geopolymer concrete is much stronger and durable than ordinary concrete due to its resistance to corrosion. Geopolymer concrete is a revolutionary sustainable building material that will pave the way for green building. Concrete is weak in tension and strong in compression, so in order to increase the tensile strength, sisal fiber are added to the concrete. The sisal fiber can improve the strength properties of hardened Geopolymer concrete. Sodium silicate and sodium hydroxide of 8 molarity solutions were used as alkaline solution. The investigations were carried for the compressive strength, split tensile strength and flexural strength on the concrete specimens. The specimens were cured at ambient temperature and tested at 7th and 28th days.

1. INTRODUCTION

Concrete is one of the most widely used construction material, it is usually associated with Portland cement as the main component for making concrete. Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete.

Production of Portland cement is currently exceeding 2.6 billion tons per year worldwide and growing at 5% annually. Portland cement is a major contributor to carbon-di-oxide emissions as an estimated 5 to 8 percentage of all human-generated atmospheric carbon-di-oxide worldwide comes from the concrete industry. The global warming caused by the emission of greenhouse gases, such as carbon-di-oxide, to atmosphere by human activities. Among the greenhouse gases, carbon-di-oxide contributes about 65% of global warming. The amount of the carbon-di-oxide released during the manufacture of ordinary Portland cement due to the calcinations of limestone combustion of fossil fuel is approximately in the order of one ton for every ton of ordinary Portland cement produced. In terms of reducing the global warming, the Geopolymer technology reduce the carbon-di-oxide emission to the atmosphere caused by cement about 80%.

1.1 OBJECTIVE

1. To make a concrete without using cement (i.e. Geopolymer concrete)
2. To study the different flexural and elastic properties of Geopolymer concrete with percentage replacement of metakaoline.
3. To evaluate the optimum mix proportion of geopolymer concrete with fly ash replaced in various percentage by metakaoline.
4. To compare the cost variation of geopolymer concrete with normal concrete.

1.2 SCOPE OF OUR PROJECT

- Replacement of cement by fly ash and metakaolin can be achieved by utilizing geopolymer matrix which in turn reduces the environmental pollution caused due to emission of green house gases in cement industries.

- The main objectives of this present investigation is to study the possibility of adding metakaolin and fly ash in concrete.
- In order to reduce the cost of construction and make a building free from environment pollution the natural and waste material are to be used in the construction.

2. MATERIALS AND PROPERTIES

2.1 INTRODUCTION

The utilization of waste in the construction industry has two glaring dividends, one, environmental impact is addressed by disposal of the waste and second, the economic impact and this waste has the edge of being available large quantity, everywhere and at low value. The materials used for this investigation were flash, M Sand, Metakaloin, and sisal fibre. In this project is replacement by fly ash in clay soil and its strength is studied. In this chapter the material characteristics, properties used in brick in brick are discussed.

2.2 FLY ASH

Fly ash is a by-product of the combustion of finely ground coal used as fuel in the generation of electric power. Coal with an ash content of around 40% is mostly used in India for thermal power generation. As a consequence, a large amount of fly ash is generated in thermal power plants causing several disposal-related problems. In spite of initiatives taken by the government, several non-governmental organizations and research and development organizations, the total utilization of fly ash is only about 50%. India produces 130 million tons of fly ash annually .This is expected to reach 175 million tons by 2012. Disposal of fly ash is a growing problem as only 15% of fly ash is currently used for applications like concrete, the remaining being used for land filling

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Figure 2.1 Fly ash

Table 2.1 Physical properties of fly ash

S.NO	Properties	Value Obtained
1	Specific gravity	2.44
2	Fineness	2.5

2.3 Fine Aggregate

The fine aggregate used in the project was locally supplied and conformed to grading zone II as per IS 383:1970. It was first sieved through 4.75 mm sieve to remove any particles greater than 4.75mm.

Table 2.2 Physical properties of fine aggregates

S. No	Characteristics	Values
1.	Fineness modulus	2.17
2.	Specific gravity	2.64

2.4 Coarse Aggregate

Locally available coarse aggregate having the maximum size of 10 -20 mm was used in this project. The aggregates were washed to remove dust and dirt and were dried to surface dry condition.

Table 2.3properties of coarse aggregates

S. No	Test for coarse aggregates	Value obtained
1.	Fineness modulus	6.45
2.	Specific gravity	2.70
3.	Maximum size	20mm

2.5 Metakaloin

Metakaloin is a dehydroxide form of the clay mineral kaolinite.

Stone that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of metakaolin is smaller than cement particles, but not as fine as a silica fume. Kaolinite chemical composition is **Al_2O_3.2 SiO_2.2H_2O.**

It is white in color and acts as a pozzolanic material. Kaolin is a flaky, white clay rock, essentially composed of kaolinite. Kaolin is formed by hydrothermal or meteoric degradation of minerals, feldspathoids and other silicates. This kaolin clay is ground and then calculated at 750^0 C, which causes disorganization of the crystalline structure.

Figure 2.2 Metakaolin

Table 2.4 Physical properties of metakaolin

S.No	Characteristics	Experimental value of Metakaolin
1.	Specific gravity	2.5
2.	Bulk density loose (kg/m^3)	$300kg/m^3$
3.	Colour	White
4.	Physical form	Powder

2.6 Sisal fibre

Sisal fiber is one of the most widely used natural fibre and is very easily cultivated. It is obtain from sisal plant. The plant, known formally as Agave sisalana. These plants produce rosettes of sword – shaped leaves which start out toothed, and gradually lose their teeth with maturity. Sisal fiber is fully biodegradable, green composites were fabricated with soy protein resin modified with gelatine.

Figure 2.3 Sisal Fibre

Table 2.5 Chemical composition of sisal fibre

1	Cellulose	65%
2	Hemicelluloses	12%
3	Lignin	9.9%
4	Waxes	2%

3.MIX DESIGN

3.1Geopolymer Concrete mix proportion

The mixes were designated in accordance with IS 10262-2009 mix design method. Based on the results, the mix proportions M_{25} was designed. Concrete mix with w/c ratio of 0.45 was prepared. The details of mix proportions for $1m^3$ of concrete are given in Table below

Table 3.1 Geopolymer concrete mix proportion

Sl.No	Percentage of materials	Sisal fibre (g)	Sodium Hydroxide (kg)	Sodium Silicate (l)
1	75%FA,20%MK,5%SF	0.59	5.14	5.01
2	50%FA,40%MK,10SF	1.17	5.14	5.01
3	25%FA,60%MK,25%SF	1.75	5.14	5.01

Keywords: FA=Fly ash, MK =Metakaloin, SF=Sisal fibre

4. TESTING OF SPECIMEN

4.1 COMPRESSIVE STRENGTH

For cube compressive testing of concrete, 150mm cubes were employed. All the cubes were tested in saturated condition, after wiping out the surface moisture. For each trail mix combination, three cubes were tested at the age of 7, 14and 28days curing using 3000kN capacity compressive testing machine as per BIS: 516-1959

Compressive strength = (P/A) (N/mm^2)

Figure 4.1 Compression testing

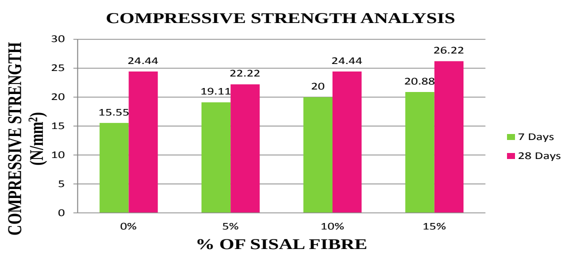
TABLE 4.1RESULT OBTAINED BY COMPRESSIVE STRENGTH AT 7 DAYS

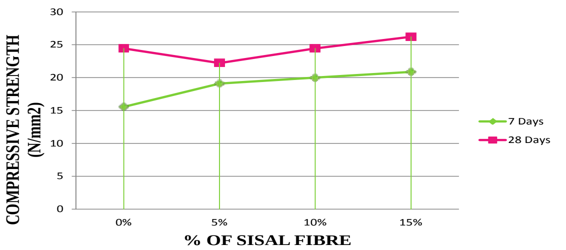
% Of sisal fibre	Specimen	Load (KN)	Comp... F_{ck}...	...e of compressive strength (N/mm²)
5 %	I	430	[illegible]	19.11
10%	I	450	[illegible]	20.00
15%	I	470	20.88	20.88

Figure 4.2 Split tensile test

TABLE 4.2 RESULT OBTAINED BY COMPRESSIVE STRENGTH AT 28 DAYS

% Of sisal fibre	Specimen	Load (KN)	Compressive Strength F_{ck}=P/A (N/mm²)	Average of compressive strength (N/mm²)
5 %	I	500	22.22	22.22
10 %	I	540	24.44	24.44
15 %	I	590	26.22	26.22





4.2SPLIT TENSLIE STRENGTH

This an indirect test to determine the tensile strength of the specimen splitting tensile strength tests were carried out on 150mm x 300mm cylinder specimens at the age of 28 days curing, using 3000kN capacity compressive testing machine as per BIS: 5816 – 1970. The load was applied gradually till the specimen split and reading were noted. The test setup for the spilt tensile strength test on the cylindrical specimen and typical failure pattern. Magnitude of this stress acting in a direction perpendicular to the line of action of applied compressive force is given by,

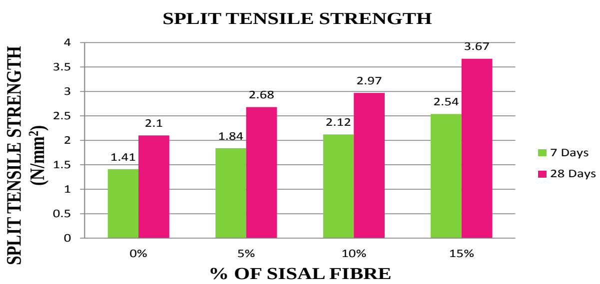
Split tensile strength test = (2xP)/ (πdl) (N/mm²)

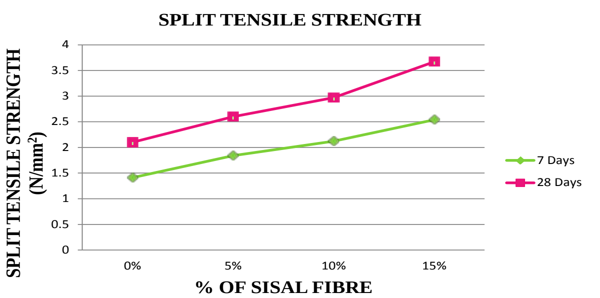
TABLE 4.3 RESULT OBTAINED BY SPLIT TENSILE STRENGTH AT 7 DAYS

% Of sisal fibre	Specimen	Load (KN)	Split tensile strength F_{ck} = 2P/πDL (N/mm²)	Average of split tensile strength(N/mm²)
5 %	I	130	1.84	1.84
10%	I	150	2.12	2.12
15%	I	180	2.54	2.54

TABLE4.4 RESULT OBTAINED BY SPLIT TENSILE STRENGTH AT 28 DAYS

% Of sisal fibre	Specimen	Load (KN)	Split tensile strength F_{ck} = 2P/πDL (N/mm²)	Average split tensile strength(N/mm²)
5 %	I	190	2.68	2.68
10%	I	210	2.97	2.97
15%	I	260	3.67	3.67





3FLEXURAL STRENGTH

Flexural tensile strength test were carried out on prism of size 500mm x 100mm x 100mm specimen at the age of 28days curing, using 400 kN capacity universal testing machine as BIS: 5816 – 1970. The load was applied gradually till the specimen was failed. The test setup for the flexural strength test on the prism specimen and typical failure pattern is shown in figure Magnitude of this tensile stress acting in a direction perpendicular to the line of these line action of applied compressive forces is given by,

Flexural strength = (Pl/bd^2) (N/mm^2)

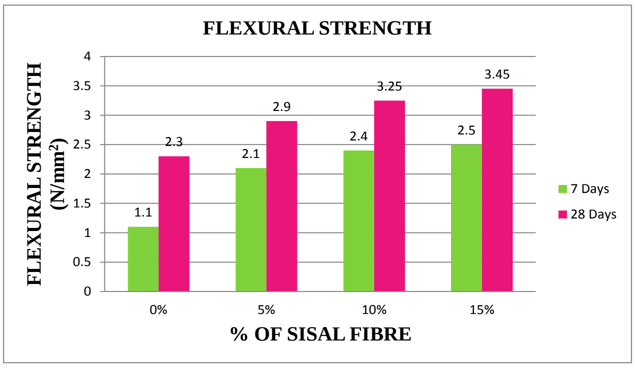
Figure 4.3 Flexural test

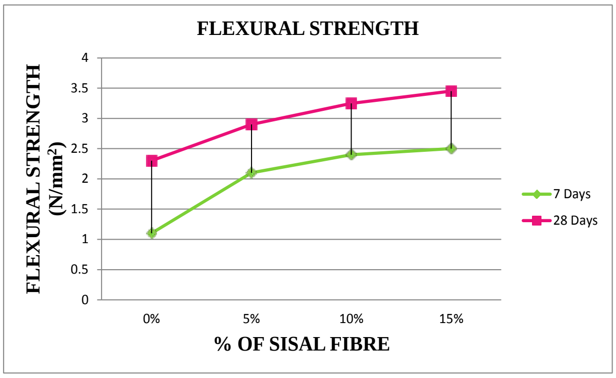
TABLE 4.5 RESULT OBTAINED BY FLEXURAL STRENGTH AT 7 DAYS

% Of sisal fibre	Specimen	Load (KN)	Flexural strength $F_{ck}=PL/bd^2$ (N/mm^2)	Average of flexural strength (N/mm^2)
5 %	I	4.2	2.1	2.1
10%	I	4.8	2.4	2.4
15%	I	5.0	2.5	2.5

TABLE4.6 DAYSRESULT OBTAINED BY FLEXURAL STRENGTH AT 28 DAYS

% Of sisal fibre	Specimen	Load (KN)	Flexural strength $F_{ck}=PL/bd^2$ (N/mm^2)	Average of flexural strength (N/mm^2)
5 %	I	5.8	2.9	2.9
10%	I	6.5	3.25	3.25
15%	I	6.9	3.45	3.45





5. CONCLUSIONS

Portland cement production is a major contributor to carbon di oxide emission as an estimated five to eight percent of all human generated atmosphere carbon- di -oxide worldwide comes from the concrete industry. Here an attempt has been made to investigate the possibility of using metakaolin and fly ash as concrete composites. It increases the properties of concrete such as compressive strength and flexural strength and tensile strength, etc. The strength of metakaolin and Geopolymer concrete increases for 5%, 10% and 15% of sisal fibre for M_{25} grade which is compared with conventional concrete. The strength of the concrete increase for every 5% of Sisal Fiber used for M_{25} grade of concrete which is compared with conventional concrete. Based on strength properties it is concluded that optimum is 10% for M_{25} grade concrete. So finally, it is concluded that metakaolin and Geopolymer concrete is more effective than conventional concrete.

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