AN EXPERIMENTAL STUDY ON BEHAVIOUR OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT USING GGBS IN ADDITION WITH SISAL FIBRE

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Abstract - *Concrete is probably the most extensively used construction material in the world. The main ingredient in the conventional concrete is Portland cement. The amount of cement production emits approximately equal amount of carbon dioxide into the atmosphere. Cement production is consuming significant amount of natural resources. That has brought pressures to reduce cement consumption by the use of supplementary materials. Availability of mineral admixtures marked opening of a new era for designing concrete mix of higher and higher strength. GROUND GRANULATED BLAST FURNACE SLAG (GGBS) is a new mineral admixture, whose potential is not fully utilized. Moreover only limited studies have been carried out in India on the use of slag for the development of high strength in a concrete with addition of sisal fibres. The study focuses on the compressive strength performance of the concrete containing as a partial replacement of OPC different percentage of slag and addition of sisal fibre. The cement in concrete is replaced accordingly with the percentage of 10 %, 20%, and 30%, by weight of slag and 2% by weight of sisal fibre. Concrete cubes are tested at the age of 3, 14, and 28 days of curing. Finally, the strength performance of slag blended sisal fibre concrete is compared with the performance of conventional concrete. The ultimate compression strength and split tensile strength were obtained at 20% replacement of GGBS with 2% of sisal fibre. The flexural strength of the beam were calculated from the optimum value obtained from compression and split tensile strengths. The various comparison of test results were illustrated graphically.*

Key Words:

Ground Granulated Blast Furnac Slag(GGBS),Sisal Fibre (SF),

1.INTRODUCTION

In the recent years, there is great development in the area of admixtures and now a day, the pozzolanic admixtures like fly ash, micro silica are commonly used to enhance performance characteristics of concrete. It is need of time to design and construct the structures which will have greater durability and strength and which have led to develop concept of high performance concrete. The major intension in developing high performance concrete is to have adequate resistance to aggressive environments and to make the structure impermeable. However, use of pozzolanic admixtures like micro silica adds to the cost of concrete which directly affects the cost of the project.

It is need to find out the substitute to micro silica without sacrificing the quality and performance of High performance concrete. One of the better alternatives to Micro silica is GGBS.Civil structures made of steel reinforced concrete normally suffer from corrosion of the steel by the salt, which results in the failure of those structures. Constant maintenance and repairing is needed to enhance the life cycle of those civil structures. There are many ways to minimize the failure of the concrete structures made of steel reinforce concrete. The custom approach is to adhesively bond fibre polymer composites onto the structure. This also helps to increase the toughness and tensile strength and improve the cracking and deformation characteristics of the resultant composite. But this method adds another layer, which is prone to degradation. These fibre polymer composites have been shown to suffer from degradation when exposed to marine environment due to surface blistering. As a result, the adhesive bond strength is reduced, which results in the de-lamination of the composite. The principal reason for incorporating fibres into a cement matrix is to increase the toughness and tensile strength, and improve the cracking deformation characteristics of the resultant composite. In order for fibre reinforced concrete (FRC) to be a viable construction material, it must be able to compete economically with existing reinforcing systems. As GGBS is good in resisting salt corrosion & chemical reactions it enhances the properties of Sisal fibre.

1.1 MATERIALS USED

Ground Granulated Blast Furnace Slag (GGBS)

Ground Granulated Blast Furnace slag is a bi product obtained from the manufacture of the pig iron. Ground Granulated Blast Furnace slag is manufactured in such a way that the waste slag float over during the manufacture of pig iron is poured directly into the cold water, the process is known as quenching and the clinkers that formed is finely grounded in grinding mills to satisfy the BS standard that is BS 6699 and ASTM standards. So that it satisfies the beneficial properties when compared to the cement.

Sisal fibre

Sisal fibres botanical name Agava sisalana is used as natural fibres in reinforcing concrete. It is traditionally used for rope, twine and has many other uses. Sisal fibres are derived from the leaves of the plant. It is usually obtained by machine decortications in which the leaf is crushed between rollers and then mechanically scraped.

The fibres is then washed and dried by mechanical or natural means. The dried fibres represent only 4% of the total weight of the leaf. Once it is dried the fibres is mechanically double brushed. The lustrous strands, usually creamy white average from 80 to 120 cm in length and 0.2 to 0.4 mm in diameter.

Fig 1 Sisal fibres

Investigations have been carried out in many countries on various mechanical properties, physical performance and durability of cement based matrices reinforced with naturally occurring fibres including sisal, coconut, jute, bamboo and wood fibres. These fibres have always been considered promising as reinforcement of cement based matrices because of their availability, low cost and low consumption of energy. In this review, the general properties of the composites are described in relation to fibre content, length, strength and stiffness. A chronological development of sisal fibre reinforced, cement based matrices is reported and experimental data are provided to illustrate the performance of sisal fibre reinforced cement composites. A brief description on the use of these composite materials as building products has been included.

The influence of sisal fibres on the development of plastic shrinkage in the prehardened state, on tensile, compressive and bending strength in the hardened state of mortar mixes is discussed. Creep and drying shrinkage of the composites and the durability of natural fibres in based matrices are particular interest and are also highlighted. The results show that the composites reinforced with sisal fibres are reliable materials to be used in practice for the production of structural elements to be used in rural and civil construction. This material could be a substitute asbestos-cement composite, which is a serious hazard to human and animal health and is prohibited in industrialized countries. The production of sisal fibres as compared with synthetic fibres or even with mineral asbestos fibres needs much less energy in addition to the ecological, social and economical benefits.

Extraction of sisal fibres

Fibre is extracted by a process known as decortications, where leaves are crushed and beaten by a rotating wheel set with blunt knives, so that only fibres remain. In East Africa, where production is typically on large estates, the leaves are transported to a central decortications plant, where water is used to wash away the waste parts of the leaf. The fibre is then dried, brushed and baled for export. Proper drying is important as fibre quality depends largely on moisture content. Artificial drying has been found to result in generally better grades of fibre than sun drying, but is not feasible in the developing countries where sisal is produced. In the drier climate of north-east Brazil, sisal is mainly grown by small holders and the fibre is extracted by teams using portable raspadors which do not use water.

Fibre is subsequently cleaned by brushing. Dry fibres are machine combed and sorted into various grades, largely on the basis of the previous in-field separation of leaves into size groups is fully biodegradable, green composites were fabricated with soy protein resin modified with gelatine. Sisal fibre, modified soy protein resins, and composites were characterized for their mechanical and thermal properties. It is highly renewable resources of energy. Sisal fibre is exceptionally durable and a low maintenance with minimal wear and tear. Its fibre is too tough for textiles and fabrics. It is not suitable for a smooth wall finish and also recommended for wet areas.

The fine texture of Sisal takes dyes easily and offers the largest range of dyed colours of all natural fibres. Zero pesticides or chemical fertilizers used in sisal agriculture. It is a stiff fibre tradionally used in making twine from the sisal plant (Agava sisalana). It is used in automotive friction parts (brakes, clutches), where it imparts green strength

OTHER MATERIALS USED ARE:
aggregate

1. Cement
2. Fine and coarse aggregates
3. Ground granulated blast furnace slag
4. Sisal fibres

Cement

Ordinary Portland cement was far most important type of cement. The OPC was classified into three grades namely 33 grade, 43 grade and 53 grade depending upon the strength of cement at 28 days when tested as per IS 4031-1988. If the

28 days strength is not less than 33 N/mm² it is called 33 grade cement, if the strength is 43 N/mm², it is called 43 grade and if the strength is not less than 53 N/mm², it is called 53 grade. Ordinary Portland cement of 53 grade was used to conforming a IS Code 8112 – 1989. The physical test was carried out and listed below in Table 1

Table 1 Physical property of 53 Grade Portland cement

S.No	Physical property	Value
1	Specific gravity	3.1
2	Fineness	98
3	Initial setting time	48 minutes
4	Final setting time	320 minutes
5	Standard consistency	31 %

performs, and form enhancing texture in coatings application.

Objectives

- To study the properties of GGBS and sisal fibres.
- Partial replacement of cement by GGBS.
- To reduce the micro cracks and improve the tensile strength of concrete by the use of sisal fibres.
- To find the compressive strength,split tensile strength and flexural strength of concrete specimens by using GGBS and sisal fibres.

To comparing the result of GGBS sisal fibres concrete and conventional concrete in strength aspect an element is casted and tested.

Table 2 Physical property of fine

SI.No	Physical property	Values
1	Specific gravity	2.65
2	Fineness modulus	2.6
3	Bulk density(kg/m³)	1550
4	Water absorption	70%
5	Free moisture content	0.2%

Fine aggregate

Natural river sand was used as fine aggregate. The properties of sand were determined by conducting tests as per IS: 2386 (Part- I). The results are shown in Table 3.2.2. The results obtained from sieve analysis are furnished in Table 2. The results indicate that the sand conforms to Zone II of IS: 383 – 1970

Coarse aggregate

Chemical composition		Physical properties	
Calcium oxide	40%	Colour	Off-white
Silica	35%	Specific gravity	2.9
Alumina	13%	Bulk density	1200 Kg/ m³
Magnesia	8%	Fineness	400 m²/Kg

Coarse aggregate used here is 20 mm aggregate of good quality. The physical properties and the data's is given belowin table 3.

Table 3 Physical property of coarse aggregate

SI.No	Physical property	Values
1	Specific gravity	2.73
2	Water Absorption	1%
3	Bulk density (kg/m3)	1290
4	Free moisture content (%)	0.5%
5	Aggregate Impact value (%)	35.58%

Ground Granulated Blast Furnace Slag (GGBS)

Ground Granulated Blast furnace is a bi-product of the pig iron production. The waste slag formed during the process is poured into the cold water forms the clinkers powdered in the form of fine powder fineness same as that of the cement. The GGBS used here in this project will satisfies ASTM standard ,BS and IS standard. The properties is as shown below.all the properties is performed as per IS 4031 & IS 4032.

Sisal fibre

- Sisal fibre is exceptionally durable with a low maintance with minimal wear and tear.
- Sisal fibres are Anti static, does not attract or trap dust particles and does not absorb moisture or water easily.
- The fine texture takes dyes easily and offers the largest range of dyed colors of all natural fibres
- Its exhibits good sound and impact absorbing properties, It is available as plaid, herringbone and twill.
- Its leaves can be treated with natural borax for fire resistance properties.

Table 4 Physical & chemical properties of sisal fibres

Chemical composition		Physical properties	
Cellulose	65%	Cellulose	65%
Hemicellulose	12%	Hemicellulose	12%
Lignin	9.9%	Lignin	9.9%
Waxes	2%	Waxes	2%

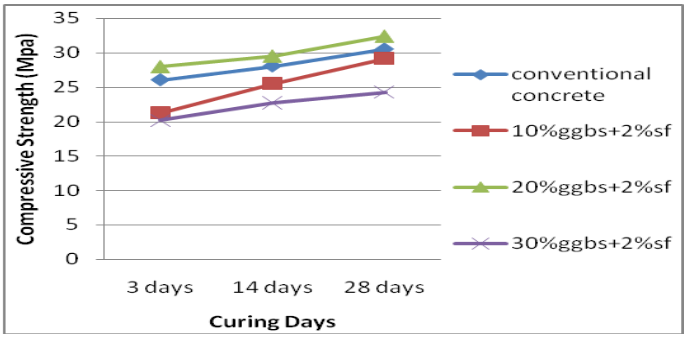
3.RESULTS AND DISCUSSION

Compressive Strength Test

Compressive strength is often measured on a universal testing machine. Measurements of compressive strength are affected by the specific test method and conditions of measurement. Compressive strengths are usually reported in relationship to a specific technical standard. The compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. It can be measured by plotting applied force against deformation in a testing machine. Some material fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures. Concrete cubes of size 150x150mm diameters and height were cast using 1:1.22:2.83 mix with a W/C ratio of 0.45.

Table 5 Compressive strength test results

SI.No	Mix	Strength (N/mm^2)		
		3 days	14 days	28 days
1	Conventional Concrete	26.03	27.07	30.55
2	10%GGBS+2%SF	21.25	25.53	29.15
3	20%GGBS+2%SF	27.95	29.5	32.37
4	30%GGBS+2%SF	20.17	22.73	24.27

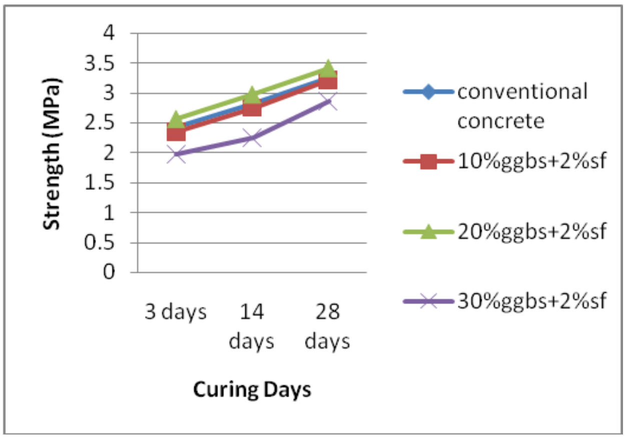


Split tensile Strength Test for cylinder

Direct measurement of tensile strength of concrete is difficult. One of the indirect tension test methods is Split tension test. The Split tensile strength test was carried out on the compression testing machine. The casting and testing of the specimens were done as per IS 5816: 1999. Concrete cylinders of size 150mm diameters and height were cast using 1:1.22:2.83 mix with a W/C ratio of o.45

Table 7 Split tensile strength test results

SI.No	Mix	Strength (N/mm^2)		
		3 days	14 days	28 days
1	Conventional Concrete	2.43	2.87	3.26
2	10%GGBS+2%SF	2.35	2.75	3.21
3	20%GGBS+2%SF	2.57	2.95	3.42
4	30%GGBS+2%SF	1.97	2.25	2.87



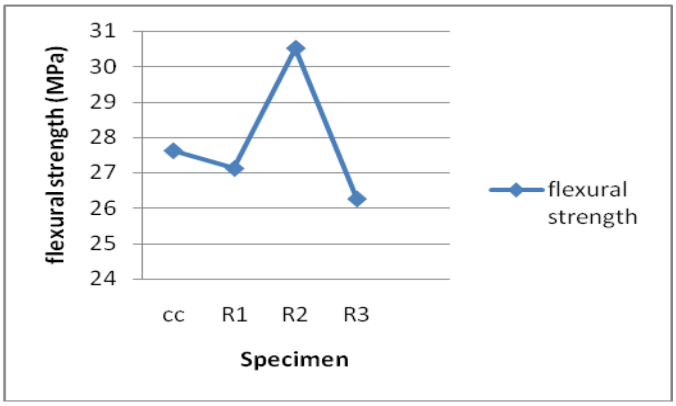
Flexural strength test for Beams

In the second phase flexural test were conducted on beam with the optimum results which is obtained from the compression test of the cubes. A comparative study between the optimum replacements with the conventional was also done. In order to study the performance of the beam with partial replacement of cements and addition of sisal fibre, the experiment is to be carried out as below. The aim of this work is to study the flexural behavior and splitting tensile strength of the beams. All the tests have been carried out in loading frame with a capacity of 800 KN. The beam is simply supported and the two point loading is applied. The mountable mechanical strain gauges are used to measure the strains in the beam specimens. Then LVDT is used to measure deflection of the beams. Also loads are calculated using load cell. The load is to be applied in small increments of 5KN. At each load increment the deflection measured is recorded. All the specimens are loaded up to the failure.

Table 8 Flexural strength test results

M_{25} mix	Specimen No	Load (KN)	Flexural strength (N/mm^2) (Pl/bd^2)
CC	1	49.7	27.61
Replacement mix (20%GGBS+ 2%SF)	1	48.8	27.11
	2	54.9	30.5
	3	47.25	26.25

Fig 4 Flexural strength test



4.CONCLUSION

- From test results it was observed that higher replacement of GGBS makes concrete weaker.
- Lower replacement will acquire almost same result compared to nominal mix.
- The formation of micro-cracks in concrete gets reduced by using sisal fibres.
- Sisal fibres are economical and it is easily available, it can be easily mixed with concrete.
- It will fill the pores of the concrete hence it will increase the impermeability of the concrete.
- Test shows optimum results for 20% GGBS + 2% SF replacement mix.
- Normal concrete is liable to internal cracking due to certain reaction. But this is eliminated as in the case of GGBS.

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