Comparative Study on behaviour of GGBS Incorporated with Sisal Fiber and Geocomposite Reinforced Concrete Beam

Shyam Kumar. M
Assistant Professor
Department of Civil Engineering
Loyola Institute of Technology, Chennai, India

Manikandan. P
UG Student
Department of Civil Engineering
Loyola Institute of Technology, Chennai, India

Alen JD Reno
UG Student
Department of Civil Engineering
Loyola Institute of Technology, Chennai, India

Manikandan. M
UG Student
Department of Civil Engineering
Loyola Institute of Technology, Chennai, India

Jebin. J
UG Student
Department of Civil Engineering
Loyola Institute of Technology, Chennai, India

Abstract

The Concrete structures are the most substantial structures which is traditionally used in the Building Technology. The main aspiration of this study is to evaluate compressive strength and Flexural strength of GGBS along with Sisal fiber Concrete encased with Geocomposite and compared with conventional concrete on the M25 Concrete mix. Sisal fiber is an agricultural product used to intensify the strength of concrete as a result of proficiency to incarcerate cracks and the fibers grips the grid together even after extensive cracking. An attempt has been made to strengthen the concrete by using Geocomposite, it increases Tensile strength, Tear resistance, Puncture resistance, Interface shear strength, Cracking etc. The cement in concrete replaced accordingly with the percentage of 0%, 10%, 20%, 30%, 40% and 50% by weight of GGBS and the sisal fiber added in 1% by weight of cement in M25 grade concrete. For the empirical work of Concrete the Concrete cubes cylinders and beams are casted and tested at 7, 14, and 28 days of curing. Finally, the strength performance of concrete is correlated with the performance of conventional concrete. From the experimental analysis, it has been observed that, the optimum replacement of GGBS to cement is 40 % for M25 grade. The ultimate load has been increased by 1.75 times for GSC, 1.62 times for CGC and 2.6 times for GSGC when compared to CC. GGBS with inclusion of sisal fibre improved compressive strength, flexural strength and shear strength of concrete.

Keywords: Flexural Strength, Geocomposite, Geogrid, GGBS, Sisal fiber

I. INTRODUCTION

The Geomembranes are typically known as the waterproofing material. Geomembranes are absolute formulations of an originator resin and several other additives. Some of the common mechanical properties of Geomembrane are Tensile strength, Tear resistance, Puncture resistance, Interface shear strength, Anchorage strength and Stress Cracking etc. The life period of concrete was very less and the beam was failure because of their shear and flexural strength of the beam has reduced so that the Geomembranes plays a considerable part in resisting the water penetration therefore it is used as a water resisting material. Geogrids are formed from polymeric coated polyester material which has immense tenacity, molecular weight and minor carboxyl end group polyester yarns. It is knitted to form grid like structures.

In monsoon season, the rate of flow of water in Dam is increased. When the water pressure is enforced from one side of the dam, it resists the flow of water to the other side due to the impervious nature of concrete. If the concrete is permeable and allows water into it, the reinforcement present in concrete is prone to corrosion and forms rust (increases volume of reinforcement) which ultimately leads to surface cracking and collapse. To avoid this failure we are using Geomembrane sheet and grid. The fibers used in the Concrete plays an important role in increasing the flexural strength of the Concrete. In this experimental study we used Sisal fiber additionally. The Sisal fiber possess high flexural strength. These fibers are hard fibers which are extracted from Sisal plants. The use of sisal, a natural fibre with enhanced mechanical performance, as reinforcement in a cement based matrix has shown to be a promising convenience. Similar to Sisal fiber the GGBS (Ground granulated blast furnace slag) is also used as the partial replacement of the Cement. The GGBS is also a binding material like Cement, therefore

the GGBS is replaced with Cement in order to provide proper bonding between the Sisal fiber, Geomembrane, Aggregates and the reinforcement. The cement in concrete is replaced accordingly with the percentage of 10 %, 20% , 30%, 40% and 50% by weight and 1% of sisal fiber is added by weight of cement. The Concrete cubes and cylinders are casted and tested at the age of 7, 14, and 28 days of curing. Finally the optimum GGBS Sisal fiber is taken and compared with the Conventional Concrete.

II. OBJECTIVES

- The main objective of this study is to increase the concrete strength by using GGBS, and low cost fibers incorporated with Geomembrane
- To ensure the most optimum proportions of the constituent materials to fulfill the requirement of the structure being built as economically as possible.
- To achieve the desired durability in the given environment conditions.
- To know the Flexural strength variations by comparing conventional concrete with GGBS Sisal fiber Concrete
- To compare the results of Geomembrane concrete, and GGBS Sisal fibre concrete with conventional concrete.
- To obtain the flexural strength by using strengthening techniques using geogrid and geopolymer sheet.

III. MATERIALS USED AND THEIR PROPERTIES

The most common ingredients used in this mix design project are,

- Geomembrane (in the form sheet or grid).
- GGBS (Ground Granulated blast furnace slag).
- Sisal fiber
- Cement
- Coarse aggregate
- Fine aggregate

A. Geomembrane:

Geomembranes are used in vast areas of construction in civil engineering due to their chemical bonding which makes them highly impermeable.Some of the most popular geomembranes are polypropylene, polyvinyl chloride (PVC), medium-density polyethylene (MDPE), and linear low-density polyethylene (LLDPE). Geomembranes can be used as reinforcement, filter and a separator.

Geocomposite sheets can be used as single, double or composite liners. High-density polyethylene (HDPE) geomembranes are mainly used in bottom liners.

Geogrids are made from polymeric coated polyester material, which has high tenacity, molecular weight, and low carboxyl end group polyester yarns. It is knitted to form grid like structures. Its minimum Thickness is 1.5 mm, Sheet Density is 0.94 mm abd Asperity height is 0.250 mm

B. GGBS:

Ground granulated blast furnace slag (GGBS) is obtained by quenching molten iron slag from a blast furnace in water or stream, to produce a glassy, granular product that is then dried and ground into a fine powder. It is highly cementitious and high in CSH which is a strength enhancing compound which increases the strength, durability and appearance of the concrete.

C. Sisal fiber:

Sisal fiber is a hard fiber extracted from the leaves of sisal plants which grow best in hot and dry areas. Sisal is an environmentally friendly fiber as it is bio degradable and almost no pesticides or fertilizers are used in cultivation. Short discrete vegetable fibre (sisal) was examined for its suitability for incorporation in cement concrete.

D. Cement:

The Cement is a binding material which helps to provide bond between the Reinforcement and other ingredient of the Concrete mix. The grade of Cement which we use in this study is 53 grade OPC (Ordinary Portland Cement).

E. Coarse Aggregates:

The Coarse aggregate of the concrete is used to increase the strength and volume of the concrete structures. The coarse aggregates are the aggregates which are having a size greater than 4.75 mm during the Sieve Analysis. The physical properties of coarse aggregate like specific gravity, water absorption and fineness modulus are tested in accordance with IS: 2386.

F. Fine Aggregates:

The Fine Aggregates are the aggregates which having a sieve size less than 4.75mm.The fined aggregates helps to decrease the air voids inside the concrete and helps to increase volume and strength of the Concrete. The fine aggregate used was locally available river sand without any organic impurities and conforming to IS: 383 – 1970.

IV. EXPERIMENTAL INVESTIGATION

A. Mix Proportion:

The minimum strength and durability can be determined only with the help of the Concrete mix design. Proportioning of Concrete mix of M25 grade was carried out as per IS 10262:2009. The Concrete mix design is required to determine the minimum compressive strength required from structural consideration. The mix adopted for the study is given in the table 1.

Table - 1
Mix Proportion

Cement	*Fine Aggregate*	*Coarse Aggregate*	*Water*
1	*1.54*	*2.78*	*0.45*

B. Details of Specimen Preparation:

Table - 2
Specimen Preparation Details

MIX ID	*MATERIAL DESCRIPTION*	*% OF REPLACEMENT*
CC	*CONVENTIONAL CONCRETE*	*0%*
GSC	*GGBS WITH SISALFIBRECONCRETE*	*10% 20% 30% 40% 50% OF CEMENT + ADD 1% SISAL FIBRE*
GSGC	*GGBS + SISAL FIBRE + GEOGRID + GEOMEMBRANE SHEET*	*OPTIMUM %*
CGC	*CC + GEOPOLYMER GRID AS STIRRUPS*	*0%*

C. Casting of Specimens:

Based on the design mix the required quantities of ingredients for the Concrete are taken. Either Hand mix or Machine mix is adopted for mixing the Concrete. After the mixing the Concrete is placed into the Concrete moulds and these Concrete moulds are filled with three layers of the Concrete mix and it is tamped upto 25 times with the help of a tamping rod for Compaction.

1) Cube: The size of the mould used is 150x150x150mm for casting the Concrete Cubes.
2) Cylinder: The moulds used for casting the Concrete cylinders are in the size of 150x300mm.
3) Beam: The Concrete Beam is casted in a mould having a size of 150x150x550mm.

Fig. 1: During Casting of Specimen

D. Curing of Specimens:

After casting the Concrete specimens they are demoulded after 24 hours and then these demoulded specimens are subjected to Curing process in the Curing tank for 7, 14 and 28 days in order to achieve their strength properly.

E. Experimental Setup

Experiments were carried with a loading device UTM as shown in Fig. The device has 2 support points on a cart moving along a rail. The distance between these 2 supports was set to 500 mm. Three-point loading was applied on the top of the beams on 1 points at the center. Steel rod with 20 mm thickness were obtained to be used on the zones where the loading was applied.

V. RESULTS AND DISCUSSION

A. General:

The Tests which are conducted in this research are Compressive test, Split tensile test and Flexural Test of the casted Concrete specimens. These tests are done in order to determine the Ultimate load carrying capacity of the Concrete.

1) Test on Hardened Concrete:

The main purpose of the hardened Concrete test is to ensure that the Concrete used at site has developed the required strength. The hardened Concrete test plays a vital role in controlling the quality of Cement Concrete works by conducting the Compressive test, Split tensile test and Flexural test on Concrete Cubes as well as Concrete Beams for 7, 14 and 28 days in order to determine the Ultimate strength of Casted Concrete Beam.

B. Compressive Strength:

In this experimental investigation totally 72 cubes of 150 mm x 150 mm x 150 mm size were casted and after curing period of 28 days, the cubes were tested in compressive testing apparatus. The cube test was conducted as per IS 516: 1959. The test result are shown graphically in Fig. 5.1. From Compressive strength result, when comparing CC with GSC concrete cubes we came to know that the Optimum value is 40% GGBS and 1% of Sisal fiber Concrete. The Compressive Strength of GSC Concrete is 3 times greater than that of Conventional Concrete as shown in Fig.2.

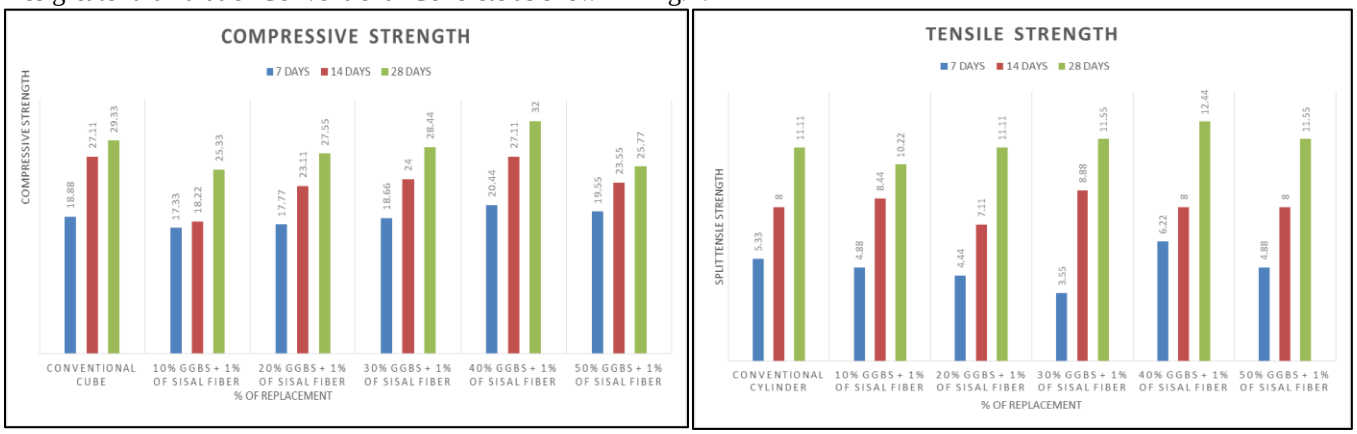

Fig. 2: Compressive strength & Tensile strength of Concrete

C. Tensile Strength:

In this experimental investigation totally 72 cylinders of 150 mm diameter 300 mm length size were casted and after curing period of 28 days, the cylinders were tested under Compression testing machine. The split test was conducted as per IS 516: 1959. The test results are shown graphically in Fig.2.

$$\text{Split Tensile strength} = 2P / \pi DL, \text{ N/mm2}$$

From Split tensile test when comparing CC with GSC concrete cylinders that the Optimum value is 40% GGBS and 1% of Sisal fiber Concrete. The split tensile strength of GSC Concrete is 1.4 times greater than that of Conventional Concrete.

D. Flexural Strength:

RCC beams of size 150x150x550mm were casted and tested under Flexural strength test setup based on the design mix which we have adopted. Totally 4 types of Concrete beams are casted and tested in order to compare the flexural strength results. Under center point loading, the Flexural strength or modulus of rupture is calculated by using the formula

$$\text{Modulus of Rupture} = 3 PL / 2 bd^2, \text{ N/mm}^2$$

The 4 types of Concrete beam design are,

1) Conventional Concrete beam (CC):
2) GGBS along with Sisal fibre Concrete beam (GSC): The GSC Concrete mix consists of optimum 40% of GGBS and 1/% of Sisal fiber provided with reinforcement in the Concrete beam.
3) GGBS along with Sisal fibre & Geomembrane Concrete beam (GSGC): The GSGC Concrete beam mix consists of optimum 40% of GGBS and 1/% of Sisal fiber with longitudinal steel reinforcement and wrapped with geomembrane sheet and transverse reinforcement is provided by Geogrid.
4) Conventional concrete along with Geogrid concrete beam (CGC): The CGC Concrete beam mix consists of Conventional concrete with longitudinal steel reinforcement & wrapped with geomembrane sheet on top and bottom and transverse reinforcement is provided by Geogrid in the form of spiral.

The flexural behavior of RCC beams of above 4 different combinations M25 grade concrete were calculated and compared & results are shown graphically in Fig.3.

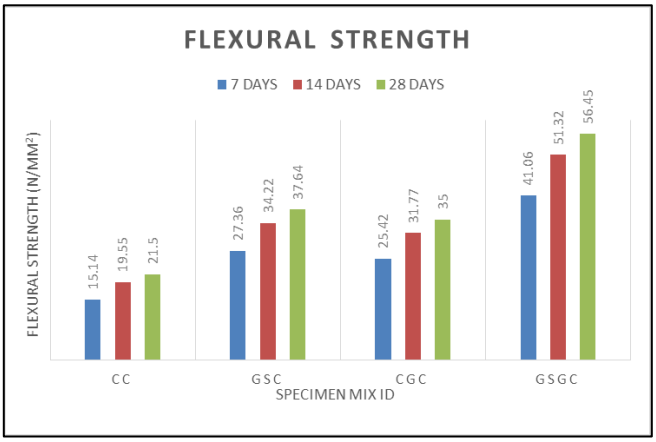

Fig. 3: Flexural Strength of Beam

E. Durability of Concrete (Water Penetration Test (WPT))

Fill the water in the water tube, keep the test specimen in the water penetration cell. After 3 days remove the test specimen and break the specimen perpendicularly. Mark the test specimen with marker how much depth water penetrated. The Maximum depth is called water penetration durability. More the depth of water penetration the less durability of concrete. This can be used for comparing the potential durability of various type of concrete. In the durability study, the conventional and GSGC concrete is tested by conducting water penetration test (WPT). The experimental results revealed that the GSGC concrete have 30 cm penetraton that shows 2 times low penetration when compared with Conventional Concrete (15 cm).

VI. CONCLUSION

On the basis of present experimental study, the following conclusions are drawn:

- Replacement of cement by GGBS is found to increase in the strength of concrete. The optimum dosage for partial replacement of cement by ground granulated blast furnace slag is 40%.
- The sisal fibre makes the concrete stronger in tension. The compressive strength, tensile strength and flexural strength of concrete increases with increase in GGBS, sisal fibre and Geomembrane conten.
- By the addition of 1% sisal fibre and 40% GGBS the compressive strength & split tensile strength of GSC concrete is more (up to 40%) when compared with conventional concrete.
- The ultimate load and flexural strength is increased by 1.75 times for GSC, 1.62 times for CGC and 2.6 times for GSGC when compared to CC.
- While testing a flexural strength, conventional concrete specimen's shows a typical cracking pattern, but GSC and GSGC concrete beam show reduced crack. This shows the ductile behavior due to the presence of sisal fibres and Geomembrane grid.
- CGC concrete beam shows reduced shear cracks because of using geogrid as transverse reinforcement.
- In the durability study, the conventional and GSGC concrete is tested by conducting water penetration test (WPT). The experimental results revealed that the GSGC concrete have 2 times low penetration than CC.
- Using GSGC concrete the penetration is much lower than the conventional concrete, the cover of concrete is provide less it cannot affected the steel or not corrosive in the water retaining concrete structures. Hence we can use GSGC concrete in the construction of water retaining structures.

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