ISSN 1533-9211

DOI 10.5281/zenodo.6731589

STUDY ON PERFORMANCE OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT BY USING GLASS WASTE POWDER IN ADDITION WITH SISAL FIBRE

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Abstract

In concrete the use of fibres and diverse sort of pozzolanic ingredients are generally used to enhance its mechanical properties. The study focused on utilization of Glass Waste Powder (GWP) as partial replacement of cement, and Sisal fibre to face up to cracking and to help in strengthening of concrete. The custom of GWP and sisal fibre improves the shear strength, tensile strength, impact strength and enhanced fatigue and crack resistance. Study emphases on the compression, split tensile and flexural strength properties of M20 grade concrete. The combination of GWP and Sisal fibre are added to the concrete with variable proportion of 0%, 10%, 20%, 30% and 0%, 0.5%, 1% and 1.5% respectively. Cubes, cylinders, and beams are among the concrete specimens cast. Subsequently success of curing process the concrete specimens are verified at 28 days strengths and the strength achieved due to the addition of GWP and Sisal fibre is related with the conventional concrete. The results of the experiments show that adding 1% Sisal Fibre and 20% GWP to concrete boosts the overall strength of the concrete.

Keywords: Sisal Fibre, Glass Waste Powder, Strength of Concrete

1. Introduction

A. General

Cement is a substantial material that used for civil engineering programs everywhere in the world. Though, the intake of cement brings approximately a few critical ecologic troubles. One of those troubles is the huge quantity of CO_2 emission resultant from the producing system of the cement [1, 2]. In addition to lowering cement intake of the mineral admixture content material additionally improves a few properties of the concrete in ways. First manner is the response takes place among calcium hydroxide and mineral admixture ensuing with the technology of the greater Calcium Silicate Hydrate gel.

Second manner is the filler impact of the mineral admixture because of its fineness [3]. Mineral admixtures also can lessen fabric expenses with the aid of using imparting much less cement intake [4]. Many herbal and synthetic mineral admixtures are used in the field of construction and concrete production for various purposes.

The consumption of the industrial wastes and by-products in concrete industry as mineral admixture provides the industry to be eco-friendlier and sustainable. Industrial by-products and wastes, such as, recycled plastics, silica fume, fly ash and ground granulated blast furnace slag have been successfully used as mineral admixture in concrete technology for decades [4, 6]. The behaviour of these additives in concrete is physico-chemical. The

ISSN 1533-9211

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physical part of this behaviour is originated from the shrinking of the size of the void in the interface between the cement and the aggregate. The main compounds SiO_2, Al_2O_3 and Fe_2O_3 should constitute great rate of the total chemical composition of the mineral admixtures in order to be used in cement and concrete. The activity of these additives is dependent on the presence of oxides and minerals in amorphous or weakly crystalline states [7].

As we all know, the majority of developing countries are currently coping with a scarcity of put up client's disposal garbage, which has become a major issue. As a result, recycling and repurposing waste products as assets can help you save money while also reducing pollution. Currently, glass producers use the majority of recovered waste glass in the production of new glassware such as bottles and other items. However, only a small percentage of the leftover glass collected can be utilised in the manufacture of new glass.

B. Glass Waste Powder

Meanwhile waste glass continues to be a problematic, an attempt was made to incorporate it into the concrete mix and see what the results were. If the results were positive, it would advantage our environment because we would be able to diminish a portion of our waste that cannot be dissolved by natural or conventional reprocessing approaches. The primary goal of this investigation is to produce a healthy environment free of pollution, as well as to find a cutting-edge concrete combination that can provide higher strength to concrete made from waste glass goods.

Even a study might indicate that using those types of additives is less expensive than purchasing pricey admixture to produce better and advanced strength in concrete, as admixture is currently extremely expensive on the marketplace and frequently raises construction costs.

C. Fibre Reinforced Concrete (FRC)

FRC is a type of reinforced concrete; Fibre is a natural or synthetic material that is used to strengthen the flexure of reinforced concrete elements. Short discontinues or distinct fibres are randomly scattered throughout the whole amount of concrete in this composite material. The performance of this composite material outperforms that of standard concrete. Fibre reinforced concretes are now employed in airport and highway pavements, explosive resistance buildings, earthquake resistant structures, mines, tunnels, overlays, and hydraulic structures, among other applications. Various inspections on the creation of FRC with the addition of fibres such as steel, glass, synthetic, and carbon fibres have been undertaken, resulting in greater strength, ductility, and toughness, as well as the avoidance of cracks. The fundamental benefit of employing fibre reinforced concrete is that it reduces microscopic fractures, improves permeability, and increases impact resistance. When fibres remain supplementary toward concrete, the complete strength of the concrete is increased. FRC is a substantial finished up of cement, fine and coarse aggregate, water, and discrete, discontinuous, consistently distributed fibres. The tensile strength of concrete elements strengthened with long reinforcing bars is adequate, but ductility is lacking. In a plane concrete member, shear stresses are also encountered in key points. The use of steel as a

ISSN 1533-9211

DOI 10.5281/zenodo.6731589

reinforcement increases the concrete's strength, but it does not prevent the development of micro fissures. When fibres are added to regular concrete, the total strength, toughness, and tensile strength all improve.

2. Material used

A. Cement

The ordinary Portland cement (OPC) was utilized in this experiment. IS: 12269:1987 was used to evaluate all of OPC's properties. The cement used in the casting was new and as per standards.

B. Aggregate (Fine)

Because natural sand is no longer readily available for construction purposes due to shortage, M-Sand is now employed as a substitute for natural sand. M-sand of good quality, adhering to the IS 383-1970 standards and passing through a 4.75 mm sieve, was employed.

C. Coarse Aggregate

This experiment employed locally available material that passed over a 20mm sieve and was kept on a 4.75 mm sieve. The coarse aggregate utilized was IS: 383-1970 compliant

D. Glass Powder from Waste

Sheet glass, bottles, glassware, and vacuum tubing are just a few examples of how glass is used in our daily life. Due to an ever-increasing use of glass items, the amount of waste glass has significantly increased in recent years. The majority of used glasses have been disposed of in landfills. Landfilling waste glasses is unfavourable since they are not biodegradable, making them unfriendly to the environment. Glass powder has a majority of SiO_2, CaO, and Fe_2O_3 in the powder, whereas Ordinary Portland Cement has about the same content but in different percentages. These findings led us to believe that it could be used as a limited additional for cement material.

E. Fibre

Sisal fibre (Botanical name: Agave sisal; figure 1 is a natural fibre used in concrete reinforcement. It has long been used for rope, twine, and a variety of other traditional applications. The qualities of the sisal fibre employed in this investigation are as follows:

Dimension: 32mm X 0.4mm Fibre

Colour: Creamy white

Aspect ratio: 80mm

ISSN 1533-9211

DOI 10.5281/zenodo.6731589

Figure 1: Sisal fibre

3. Experimental work

A. Mix Design

Proportioning for concrete mix of M20 grade was performed according to IS: 10262-2009 recommendations in this study. In addition to 0 %, 0.5 %, 1 %, and 1.5 % of sisal fibre, GWP is added to the cement in percentages of 0 %, 10 %, 20 %, and 30 % as a partial replacement. The proportional mixtures that were used in the weight batching method are itemized in table 1.

Table 1: Mix proportion for M20 grade concrete

Sl. no	Ingredients	Control mix concrete
1	Cement(kg/m^3)	384
2	Water (liter)	191.58
3	Fine aggregate (kg/m^3)	559.91
4	Coarse aggregate (kg/m^3)	1219.3

B. Slump Test

The concrete slump test determines the consistency of freshly laid concrete before it hardens. It is used to detect the workability of freshly mixed concrete and, as a result, the ease with which it flows. It can also be used to detect a batch that has been poorly mixed. The popularity of the test stems from the ease with which the device is utilized and the procedure is followed. Under field conditions, the slump test is used to assure homogeneity for various concrete loads. The findings of the slump test are depicted graphically in figure 2.

ISSN 1533-9211
DOI 10.5281/zenodo.6731589

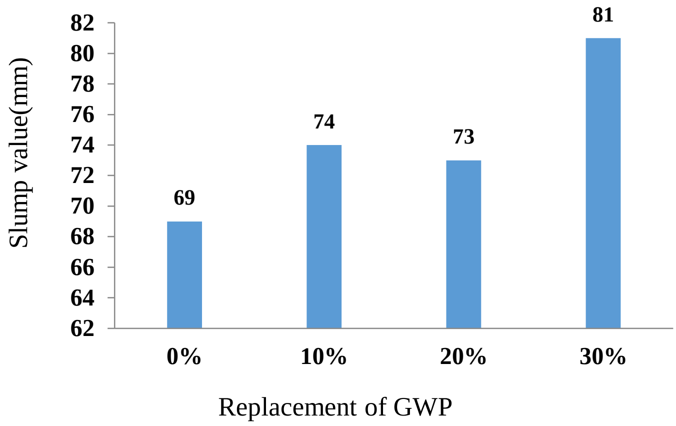

Figure 2: Slump Value with % GWP

C. Compressive Strength

In this experiment, a total of 39 cubes measuring 150mm x 150mm x 150mm were casted and evaluated in a compressive testing device following a 28-day curing period. IS 516: 1959 was used to conduct the cube test. Table 2 contains the test results, which are graphed in figure 3.

Table 2: Compression Strength Result for 28 Days

Descriptions		**Sisal FRC**
% GWP added	% of Fibre added	compressive Strength in N/mm^2
Conventional (0% GWP)	0	21.46
10	0	19.72
	0.5	20.97
	1.0	21.67
	1.5	22.71
20	0	23.07
	0.5	24.21
	1.0	25.37
	1.5	24.62
30	0	25.04
	0.5	24.47
	1.0	24.89
	1.5	23.27

The Seybold Report
ISSN 1533-9211
DOI 10.5281/zenodo.6731589

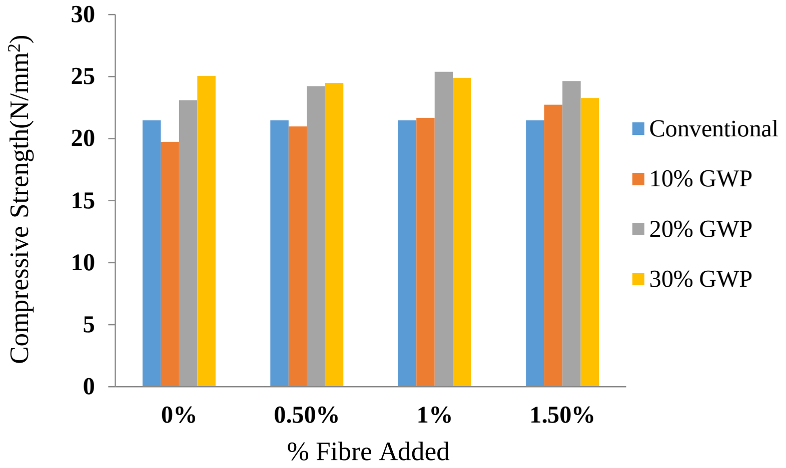

Figure 3: Dissimilarity of Compression strength of Sisal FRC with respect to % of GWP at 28 days

D. Flexural Strength

In this experiment, overall 39 beams with measurements of 500mm x 100mm x 100mm were casted and evaluated in a universal flexural testing machine following a 28-day curing time. The beam test was carried out in accordance with IS 516:1959. Table 3 contains the test findings, which are graphed in figure 4.

Table 3: Flexural Strength Results at 28 Days

Descriptions		**Sisal FRC**
% GWP added	% of Fibre added	Flexural Strength in N/mm^2
Conventional (0% GWP)	0	6.27
10	0	6.38
	0.5	6.29
	1.0	6.51
	1.5	6.40
20	0	6.73
	0.5	6.66
	1.0	6.84
	1.5	6.70
30	0	6.41
	0.5	6.37
	1.0	6.51
	1.5	6.40

ISSN 1533-9211
DOI 10.5281/zenodo.6731589

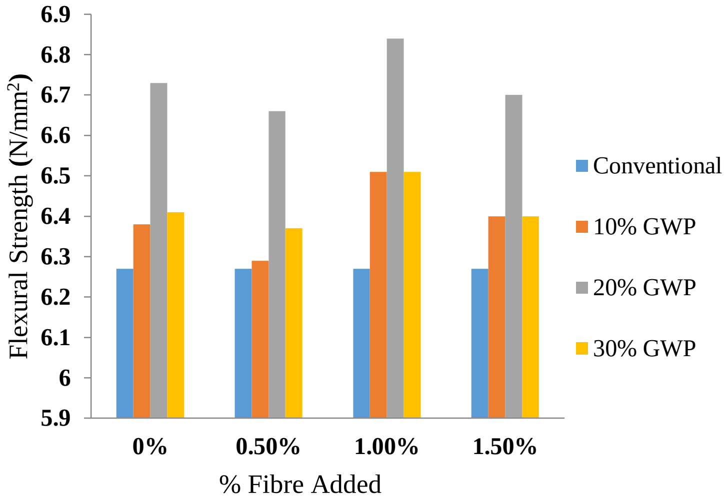

Figure 4: Dissimilarity of Flexural strength of Sisal FRC with respect to % of GWP at 28 days

E. Tensile Split Strength

In this experiment, the dimensions of 150mm diameter and 300mm in length total 39 tubes were casted, and following a 28-day curing time, the cylinders were evaluated using a universal tensile testing machine. IS 516:1959 was used to conduct the split test. Table 4 contains the test findings, which are visually represented in figure 5.

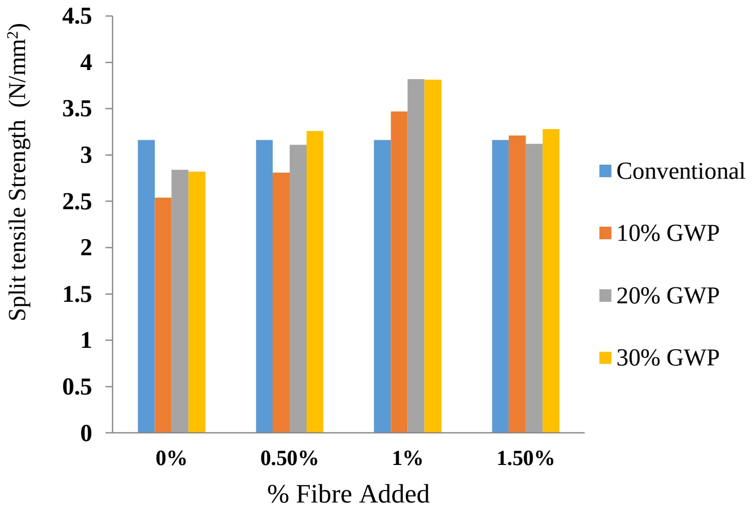

Figure 5: Variation of Split tensile strength of Sisal FRC with respect to % of GWP at 28 days

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ISSN 1533-9211
DOI 10.5281/zenodo.6731589

Table 4: Split tensile Strength Results at 28 Days

Descriptions		Sisal FRC
% GWP added	% of Fibre added	Split tensile Strength in N/mm^2
Conventional (0% GWP)	0	3.16
10	0	2.54
	0.5	2.81
	1.0	3.47
	1.5	3.21
20	0	2.84
	0.5	3.11
	1.0	3.82
	1.5	3.12
30	0	2.82
	0.5	3.26
	1.0	3.81
	1.5	3.28

4. Conclusion

The following conclusions are reached from the current experimental study:

1. Replacement of cement by GWP is found to increase in the strength of concrete.
2. The Sisal fibre makes the concrete stronger in tension and compression.
3. When compared to conventional concrete strength and various percentages GWP and Sisal Fibre in concrete, the compressive strength of sisal FRC (Figure 3) is increased (up to 18.5 %) by adding 1% sisal fibre and 20% GWP.
4. When compared to conventional concrete strength and various percentage GWP in concrete and sisal fibre, the overall strength of sisal FRC improves, particularly the flexure strength and split tensile strength (Figure 4: up to 9.1 % Flexural strength) and (Figure 5: up to 21 % Split tensile strength).
5. During testing, nominal concrete specimens have a conventional cracking pattern, but Sisal FRC specimens exhibit a decreased cracking pattern. This demonstrates the ductile behaviour of concrete due to the presence of fibres.

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