

PROPERTIES OF AGAVE FIBRE REINFORCED CONCRETE

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ABSTRACT

Concrete plays a significant role as a construction material in the world. Concrete is strong in compression and weak in tension. Fibre reinforced concrete is a type of concrete which contains fibrous materials that increase its structural strength and cohesion. Fibre reinforced concrete which contains short discrete fibres that are uniformly distributed and randomly oriented. Many researches are going on the fibres in order to increase its tensile property by using various fibres such as poly propylene, asbestos, steel fibres but they are expensive.

In this present research, Agave fibres along with 25% replacement of fly ash to cement are used in concrete. In this research Compressive strength, Split-tensile strength and Flexural strength of concrete is found. The grade of concrete used is M_{20} and the fibre percentages used are 0%, 0.5%, 1.0%, 1.5%, 2.0% and 2.5%. It is observed that with the addition of 1% of fibres the strength of the concrete is increased when compared to conventional concrete.

Keywords: Fibre reinforced concrete, agave fibres, fly ash.

INTRODUCTION

Fibres are used as reinforcement since ancient times. By the year 1960's, steel, glass and synthetic fibres such as polypropylene fibres were used in concrete and research into new fibre reinforced concretes continues till today. The role of the fibres are essentially to arrest any advancing cracks by applying punching forces at the crack tips and thus delaying their propagation across the matrix. The admixtures like fly ash, silica fume, granulated blast furnace slag and metakolin can be used for such purposes. The reinforcing capacity of fibre is based on the length of the fibre, diameter of the fibre, the percentage of the fibre and condition of mixing, orientation of the fibres and aspect ratio. The amount of fibres which added to a concrete mix is measured as percentage of the total volume of the composite termed as volume fraction. The aspect ratio is calculated by dividing the fibre length by its diameter.

The first use of Natural Fibre Reinforced Concrete fibre in reinforced concrete has been dated since 1870's. The fibre should be embedded in the matrix for a minimum length for an effective strengthening and stiffening of the composite material i.e. NFRC. Natural Fibre Reinforced Concrete consists of cellulose fibres. Natural fibre comes from the nature and which consists of plants and animals fibres. Natural fibres are suitable for reinforcing the concrete. Agave is one of the most important and widely used. Many other fibres were used in the concrete like wood fibres, bamboo fibres, wool fibres, hair fibres etc. From several years, the scientists are doing research on natural fibre reinforced concrete to increase its tensile strength.

AGAVE FIBRE

Agave fibres are extracted from the leaves of certain plants. Agave plant is cellulosic in nature and requires very little water to survive. These agave plants require protection from the frost. Agave plants grow along the railway lines, roadsides and river banks areas throughout many regions of the world. These long technical fibres are generally hard, stiff and coarse in texture. Agave plants are grown naturally, especially in the arid and semi-arid climates. It is also able to grow on dry soils unsuitable for crop cultivation. Each of the agave plant yields 40-50 leaves/year. The life cycle of the agave plant is up to 8-30 years. The colour of the fibre is milky white to golden yellow. These fibres occur after their extraction in bundles constituted of several ultimate fibres held together by waxy and sticky substances.

LITERATURE REVIEW

Asma El Oudiani *et al*

It has been observed that the tensile properties increase with the increase in the weight fraction of fibres to certain extent and then decreases. The hybridization of the reinforcement in the composite shows greater tensile strength when compared to individual type of natural fibres reinforced. For all the composites tested the tensile strength of the composite increased for approximately 25% of weight fraction of the fibres and further for the increase in the weight fraction of fibre the strength decreased, also it is found that for the hybrid combination of ridge guard and sisal fibres there is 65% increase in the tensile strength.

Cesar Juarez *et al*

The main objective of the present research was to provide the housing alternatives to istle zone rural areas in Mexico, which represent about 10% of the national territory. The proposed solution involved a sustainable portland cement-based composite material, reinforced with high tensile strength natural fibres of “Agave lecheguilla”. The results indicated that the “Agave lecheguilla” or simply lechuguilla fibre shows a high tensile capacity, but can be severely deteriorated in the alkaline environment of the composite. However, if the fibre is protected with paraffin and the composite matrix is modified with a pozzolan admixture such as fly ash, the composite performs acceptably well at exposure to aggressive environments and variations in humidity and temperature.

Vinod Goud *et al*

Fly ash a waste generated by thermal power plants is as such a big environmental concern. In modern decades, the industrialization and urbanization are the two phenomena that are spreading all over the world. Apart from the requirement of these phenomena, there should also be investigation into their negative impacts on the worldwide environment and common life. Most important poor effect of these international processes has been the production of large quantities of industrial wastes. Therefore, the problems related with their safe management and dumping has turned into a major test to environmentalists and scientists. Another problem is the stress on land, materials and resources to sustain the developmental activities, including infrastructure. The thermal power plants produce considerably large quantities of solid by product namely fly ash.

Experimental program

The experimental study of the materials is cement, Fine aggregate, Coarse aggregate and water. The properties of these ingredients are given below.

Cement: The ordinary Portland cement which conforms to IS: 8112 – 1989 was used for making concrete.

Physical properties of cement

Properties	Test results
Specific gravity	3.11
Standard consistency	33%
Fineness	6%
Initial setting time	38 min
Final setting time	330 min

Fine aggregate: The river sand was found to be zone – II as per IS: 10262 – 2009, IS: 383-1970.

Physical properties of fine aggregate

Properties	Test Results
Fineness modulus	2.72
Bulk density	1.52 g/cc
Void ratio	0.5
Specific gravity	2.3
Zone	II

Coarse Aggregate: The sieve analysis for coarse aggregates was done as per IS 2386-Part I. The fineness modulus of coarse aggregate (12.5 mm) was given below

Physical properties of coarse aggregate

Properties	Test Results
Fineness modulus	7.32
Bulk density	1.42g/cc
Void ratio	0.75
Specific gravity	2.7

Water: The water which is used is free from oil, acids, vegetable matter, alkalis clay and it satisfy to use in concrete.

Agave fibre extraction and chemical composition:

Agave plants leaves are harvested from the field for the fibre extraction. The lower leaves, which are standing at an angle of more than 45° to the vertical, are cut away from the plant by means of a sharp cutting tool. Before the extraction of the fibre the margins and the spine at the leaf tip are removed. Hand decortication was done by rural folk whereby the leaves were pounded and the pulp was scraped away. Hand decortication is time consuming and requires lot of man power. The operations of the fibre removal, washing and drying must be done promptly done after the leaves are cut, otherwise the gums in the leaves get harden, causing the pulp to adhere with the fibres and making it difficult to clean the fibre properly. Proper drying of the fibres is important as the moisture content in the fibre affects fibre quality. Artificial drying results in the higher grade of the fibres than sun drying.

Chemical composition of Agave fibre

Composition	Amount (%)
Cellulose	68-80
Hemicellulose	15
Lignin	17
Wax	0.26
Moisture	8

Fly ash is a fine- grained material consisting mostly of spherical particles. As per IS 3812:2003, the generic name of the waste product due to burning of coal or lignite in the boiler of a thermal power plant is pulverised fuel ash. Pulverised fuel ash can be fly ash, bottom ash, pond ash or mound ash.

Chemical properties of Fly ash

Loss on ignition	3.72
Alumina as Al ₂ O ₃	19.24
Silica as SiO ₂	63.41
Iron as Fe ₂ O ₃	4.46
Calcium as Cao	2.28
Magnesium as MgO	1.18
Sodium as Na ₂ O	0.20
Potassium as K ₂ O	1.92
Manganese as MnO	0.04
Titanium as TiO ₂	1.06
Phosphorus as P ₂ O ₅	0.08
Vanadium as V ₂ O ₅	0.03
Sulphur as SO ₃	1.44
Zinc as ZnO	0.02

PREPARATION OF SPECIMENS

The research is carried out to study the properties of M₂₀ grade of concrete by adding agave fibre percentages of 0%, 0.5%, 1.0%, 1.5%, 2.0% and 2.5% with replacement of fly ash 25% by volume of cement with fibre length of 20 mm. The mix proportions was 1:1.76:3.49 with water cement ratio 0.55. The compressive strength, split-tensile strength and flexural strength tests are carried out for 7 & 28 days curing. The experimental program is planned to cast around 36 cubes of size 150x150x150 mm, 36 cylinders of size 150x300 mm and 36 prisms of size 500x100x100 mm and they were tested in the laboratory.

Results and Discussions

Compressive Strength

Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during production of concrete etc. Cubes specimens are usually tested under a compression testing machine to obtain the compressive strength. These specimens are tested by compression testing machine after 7 days curing and 28 days curing. Fig.1. and Fig.2. shows the variation of % of agave fibre content Vs Compressive strength of concrete at 7 days and 28 days.

Split-Tensile Strength

Splitting tensile strength test on concrete cylinder is a method to determine the tensile of concrete. The split-tensile strength is tested under a compression testing machine. These specimens are tested by compression testing machine after 7 days curing and 28 days curing. Fig.3. and Fig.4. shows the variation of % of agave fibre content Vs Split tensile strength of concrete at 7 days and 28 days.

Flexural Strength

Flexural strength is also known as modulus of rupture, bond strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. Prisms are tested for flexure in Universal Testing machine. These specimens are tested by compression testing machine after 7 days curing and 28 days curing. Fig.5. and Fig.6. shows the variation of % of agave fibre content Vs flexural strength of concrete at 7 days and 28 days.

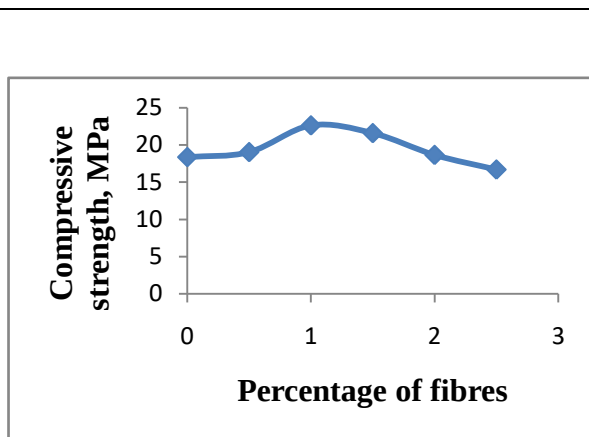


Fig.1. Variation of % of agave fibre content Vs Compressive strength of concrete at 7 days

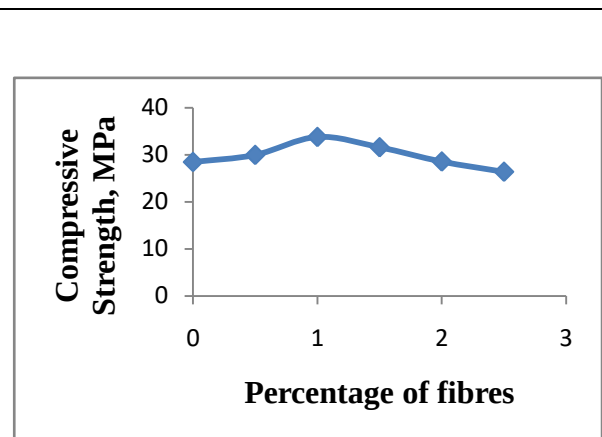


Fig.2. Variation of % of agave fibre content Vs Compressive strength of concrete at 28 days

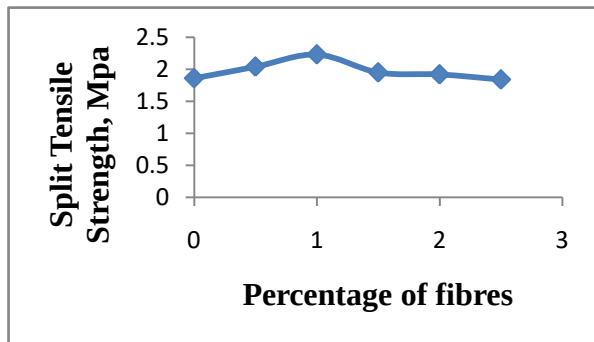


Fig.3. Variation of % of agave fibre content Vs Split Tensile strength of concrete at 7 days

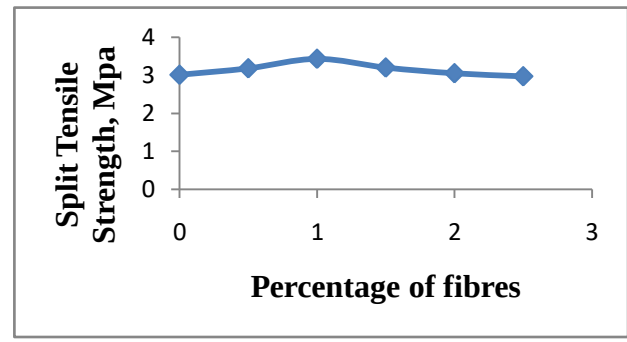


Fig.4. Variation of % of agave fibre content Vs Split Tensile strength of concrete at 28 days

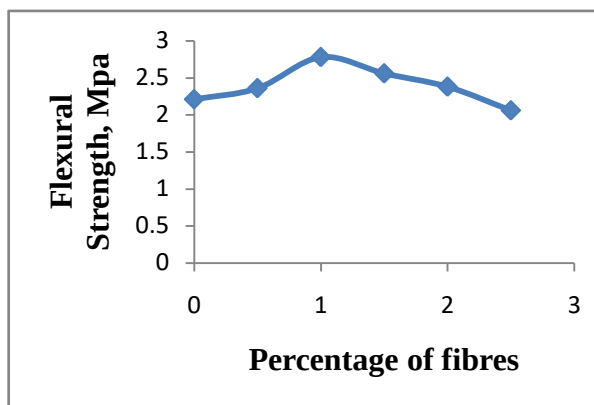


Fig.5. Variation of % of agave fibre content Vs Flexural strength of concrete at 7 days

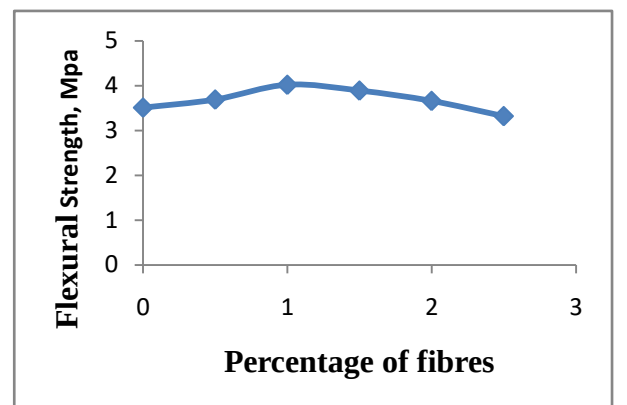


Fig.6. Variation of % of agave fibre content Vs Flexural strength of concrete at 28 days

Conclusion

- With the addition of agave fibres to the concrete, the compressive strength, split tensile strength and flexural strength increases.
- With the partial replacement of 25% of fly ash, a pozzolonic material to the concrete, density of the concrete and strength of concrete increases and as well as to achieve the economy.
- The volume fraction about 0.5% does not affect the compressive strength.
- With the addition of 1.0% of agave fibre in the concrete, there is increase in the compressive strength by 18.69% when compared to conventional concrete and further increase in the percentage of fibres in the concrete there is decrease in the compressive strength.
- With the addition of 1.0% of agave fibres in the concrete, there is increase in split tensile strength by 13.95% when compared to conventional concrete and further increase in the percentage of fibres in the concrete there is decrease in the split tensile strength.
- With the addition of 1.0% of agave fibres in the concrete, there is increase in flexural strength by 14.52% when compared to conventional concrete and further increase in the percentage of fibres in the concrete there is decrease in the flexural strength.
- Hence the optimum percentage of agave fibres to be used in the concrete is 1.0%.

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