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Structural Properties of Concrete Using Sisal Fibre

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***Abstract* – Among the various natural fibres, sisal is of particular interest in that its composites have high impact strength besides having moderate tensile and flexural properties compared to other lignocellulosic fibres. Investigations have been carried out in many countries on the various mechanical properties, physical performance and durability of cement based matrices reinforced with naturally occurring sisal fibres. The conventional concrete is strong in compression and weak in tension in order to overcome the steel reinforcement is being provided.**

The sisal fibre with the mechanical properties such as the compressive strength, modulus of rupture and split tensile strength of M40 grade concrete and by varying dosage of fibre content from 0%, 1%, 2%, 3%. The optimum dosage of sisal fibre was found to be 2%.

Keywords: Natural Fibres, Durability, Compressive Strength, Workability.

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1. INTRODUCTION

Fibre is a natural or synthetic string. It is also used as a component of concrete, or when made into sheets. It is used to make products such as paper or felt. Fibres are often used in the manufacture of other materials. The strongest engineering materials often incorporate fibres. Fibres are a class of hair-like material that are continuous filaments or are in discrete elongated pieces, similar to pieces of thread. Concrete made with Portland cement has certain characteristics: it is relatively strong in compression but weak in tension and tends to be brittle.The weakness in tension can be overcome by the use of conventional rod reinforcement and to some extent by the inclusion of a sufficient volume of certain fibres. The use of fibres also alters the behaviour of the fibre-matrix composite after it has cracked, thereby improving its toughness.

Agave sisalana Perrine (Agavaceae), popularly known as sisal is a monocotyledonous plant from Mexico. Sisal represents the first natural fibre in commercial application, in which it is estimated in more than half of the total of all natural fibres used. Sisal can be cultivated in most soil types except clay and has low tolerance to very moist and saline soil conditions. Husbandry is relatively simple as it is resilient to disease and its input requirement is low compared to other crops. These are mainly cultivated for fibres which are highly suited for ropes of all kinds sisal fibres are extracted from an agave plant. Sisal fibres are stiff, straight, smooth and yellow in colour. Strength, durability and ability to stretch are some of the important properties of sisal fibres. Sisal fibre is one of the most widely used natural fibres and it can be easily harvested.

Fig. 1.1Sisal Plant

The inclusion of fibre reinforcement in concrete, mortar and cement paste can enhance many of the engineering properties of the basic materials, such as fracture toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling. In recent years, a great deal of interest has been created worldwide on the potential applications of natural fibre reinforced, cement based composites. 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 cementbased matrices because of their availability, low cost and low consumption of energy. An experimental investigation of mechanical behaviour of sisal fibre reinforced concrete is reported for making a suitable building material in terms of reinforcement. Fibre reinforced Composite is one such material, which has reformed the concept of high strength. Sisal fibres are abundantly available in the hot areas. Sisal fibre has emerged as a reinforcing material for concretes, used in civil structures.

1.1 Aim and Objectives

The project study is aimed towards structural properties of sisal fibre reinforced concrete for various percentages and aspect ratios of sisal fibres. The sample will be tested to study properties of fresh concrete and hard concrete as per IS provisions.

- Study of Natural & Cultivated Sisal Fibre
- Study of Mix Design of Concrete
- To obtain the compressive strength of concrete by testingcube samples.
- To obtain the compressive strength of concrete by testing cylinder samples
- To obtain the flexural strength of concrete by testing beam samples.
- Comparative analysis of test samples for normal concrete and sisal fibre reinforced concrete.

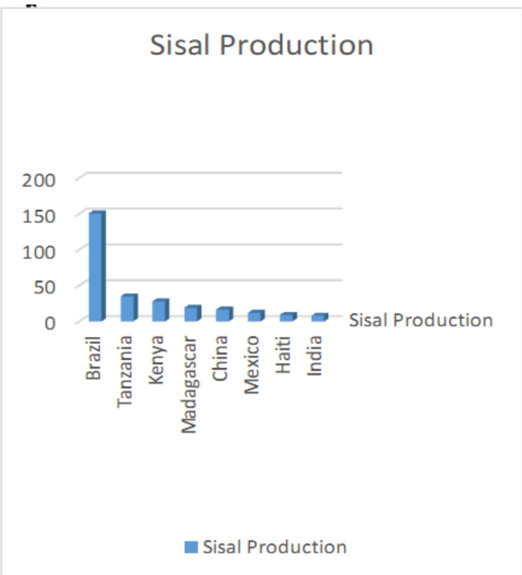

Fig.1.2 Global Sisal Production

2. LITERATURE REVIEW

2.1 Global Scenario

Sisal production is one of the longest surviving agricultural industries. The other leading countries that produce sisal in the world are Madagascar, People's Republic of China, Mexico, and Haiti accounting for 18.9, 16.5, 12.0 and 9.0 thousand tons respectively produced in 2013. The importance of sisal to these countries is that its production not only enhances economic growth but is also a source for employment opportunities.

2.2 Indian Scenario

In some states, cooperative societies and private units are engaged in the fibre supply. Some quantity is locally used for preparation of twines, ordinary ropes. bags, hats and nets. The sisal waste is used in the manufacture of a hard-lustrous wax which Is a good substitute for carnauba wax. Experiments carried out at the National Chemical Laboratory. Pune, have indicated that the yielded of wax is 8-18 percent of the waste materials depending on the quality of the waste. In Andhra Pradesh. fibre is extracted using a manually operated device in which the leaves are bruised and the cuticle and internal sap are removed.

A. Athiappan K., Vijaychandrakanth. S.

Conventional concrete is strong in compression and weak in tension in order to overcome the weakness steel reinforcement is being provided. Researches attempted to inherit thetensile property by introducing synthetic fibres such as poly propylene, asbestos etc., and steel fibres, but they are expensive. Hence, they are attempting to use the natural fibres such as straw, elephant grass, palm leaf, coconut coir etc. to incorporate tensile strength in conventional concrete. So that the traditional steel reinforcement on concrete can be reduced. The use of sisal, a natural fibre with enhanced mechanical performance, as reinforcement in a cement based matrix has shown to be a promising opportunity. The cement matrices can consist of paste, mortar or concrete. Most of the studies on sisal fibre concrete involve the use of ordinary Portland cement. However, high alumina cement, cement with additives such as fly ash, slag, silica fume has also been used to improve the durability of the composites.

B. Suryavanshi Y, Dalvi J

Fibres have been used to toughen bricks and pottery since the very beginning of civilization, but only since last 30 years, the principles of fibre reinforcement of brittle matrices started in practice. The experimental studies showed that the stress at which a brittle matrix will crack can be slightly increased by using high modulus fibres. The fibres bridge across the cracks and so provide post-cracking ductility. The increase in the tensile strain at rupture, resulting in a tough material with high resistance to impact loading is observed. A wide variety of fibres have thus been used with cement based matrices. They include metallic fibres, polymeric fibres, mineral fibres and vegetable fibres. The cement matrices can consist of paste, mortar or concrete. Most of the developments with fibre reinforced concrete involve the use of Ordinary Portland Cement. However, high alumina cement, cement with additives such as fly ash, slag, silica fume, etc. have also been used generally to improve the durability of the composite or to minimize chemical interactions between the fibres and matrix. Fibres can be added to cement based matrices as primary or secondary reinforcement. Fibres work as primary reinforcement in thin products in which conventional reinforcing bars cannot be used. In these applications, the fibres act to increase both the strength and the toughness of the composite. In components such as slabs and pavements, fibres are added to control cracking induced by humidity or temperature variations and in these applications, they work as secondary reinforcement.

C. Romildo D, Kuruvilla J, Khosrow G, George L

The inclusion of fibre reinforcement in concrete, mortar and cement paste can enhance many of the engineering properties of the basic materials, such as fracture toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling. In recent years, a great deal of interest has been created worldwide on the potential applications of natural fibre reinforced, cement based composites. 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 lowconsumption 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 pre-hardened 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 cement based matrices are of 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 serioushazard to human and animal health and is prohibited in industrialized countries.

D. Vajje S, Krishna Murthy N.R.

The Portland cement concrete is a brittle material. It possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are present in concrete and its poor tensile strength is due to propagation of such micro cracks leading to brittle fraction of concrete. In plain concrete and similar brittle materials, structural cracks develop even before loading due to drying shrinkage and other causes. When load is applied the internal cracks propagate and open up due to stress and additional cracks are formed. The development of this crack is the cause of inelastic deformation in concrete. The addition of small closely spaced and uniformly dispersed fibres to concrete can act as a crack arrester and improves its static and dynamic properties. This is known as fibre reinforced concrete, which can also be defined as the concrete containing fibrous materials whichincreases its structural performance. It contains short discrete particles that are uniformly distributed and randomly oriented. Slump is decreasing with the addition of fibres. More the fibre-cement ratio, more is the decrease in slump due to absorbency of water by fibres. Hence the use of proper super plasticizer which does not affect other properties except workability is recommended for higher fibre-cement ratios. Increase in fibre-cement ratio is tending to voids in concrete though thoroughly compacted because of improper bonding of materials in concrete with increase in fibres.

E. Nwankwo P.O, Job F.O.

There is growing trend worldwide in the research and development of sustainable low-cost, non-toxic, renewable and durable construction materials. Sisal fibre (Agave Sisalana) is one of the strongest vegetable fibres with high cellulose content, and elastic modulus, increased impact strength, moderate tensile and flexural strength and inexpensive when compared to other vegetable fibres. However, the main draw back in the use of sisal and other vegetable fibres in the reinforcement of cementitiouscomposites made with ordinary Portland cement (OPC) is the lack of durability of the composites. The key mechanism of deterioration of the fibres is believed to be due to migration of hydration products (mainly, calcium hydroxide (Ca (OH)R 2R)). This is associated with the modification of the reaction and hydration velocity of cement particles to the fibre structure. Consequently, the hydrolysis of the cellulose chain and/or the dissolution of amorphous constituents of the fibre result. Water absorption for locally sourced and processed sisal fibre was observed to be critical for the first 15 minutes; the mean tensile strength was 448kN/mm^2. The use of 3% volume fraction of sisal fibre as reinforcing agent and the optimum ternary blend of Fa and CWCCB in cementitious concrete composites could significantly contribute to sustainable development of low-cost construction materials in the nearest future.

F. Paulo R. L. Lima, Rogério J. Santos, Saulo R. Ferreira, Romildo D. Toledo Filho

Composites made with ordinary Portland cement (OPC) is the lack of durability of the composites. The key mechanism of deterioration of the fibres is believed to be due to migration of hydration products (mainly, calcium hydroxide (Ca (OH)R 2R)). This is associated with the modification of the reaction and hydration velocity of cement particles to the fibre structure. Consequently, the hydrolysis of the cellulose chain and/or the dissolution of amorphous constituents of the fibre result. Water absorption for locally sourced and processed sisal fibre was observed to be critical for the first 15 minutes, the mean tensile strength was 448kN/mm^2.

G. Paulo R. L. Lima, Rogério J. Santos, Saulo R. Ferreira, Romildo D. Toledo Filho

Sisal fibre is an important agricultural product used in the manufacture of ropes, rugs and also as a reinforcement of polymeric or cement-based composites. However, during the fibre production process a large number of residues are generated which currently have a low potential for commercial use. The aim of this study is to characterize the agricultural residues by the production and improvement of sisal fibre, called field bush and refuge and verify the potentiality of their use in the reinforcement of cement-based composites. The residues were treated with wet-dry cycles and evaluated using tensile testing of fibres, scanning electron microscopy (SEM) and Fourier transform infrared (FTIR) spectroscopy. Compatibility with the cement-based matrix was evaluated through the fibre pull-out test and flexural test in composites reinforced with 2 % of sisal residues. The results indicate that the use of treated residue allows the production of composites with good mechanical properties that are superior to the traditional composites reinforced with natural sisal fibres.

H. Sen Tara, Reddy H N J

The materials chosen for structural upgradation must, in addition to functional efficiency and increasing or improving the various properties of the structures, should fulfil some criterion, for the cause of sustainability and a better-quality. Forexample, these materials should not pollute the environment and endanger bio-reserves should be such that they are self-sustaining and promote self-reliance, should help in recycling of polluting waste into usable materials, should make use of locally available materials, utilise local skills, manpower and management systems, should benefit local economy by being income generating, should be accessible to the ordinary people and be low in monetary cost. Besides improving the strength of the structure using FRPs as the raw material, it is also necessary to make use of local materials in construction. So far the work on construction. So far the work on retrofitting of structures is confined to using of carbon, glass or aramid fibres etc, very little work is being imparted in improving structures using naturally available materials, or natural fibres. The application of composites in structural facilities is mostly concentrated on increasing the strength of the structure with the help of artificial fibres and does not address the issue of sustainability of these raw materials used for strengthening purposes. In an expanding world population and with the increase of the purchasing potentials, the need for raw materials required for structuralstrengthening, that would satisfy the demand on world market is rapidly growing. In times when we cannot expect the fibre reinforced polymer prices to come down, with the consumption growing day by day. Also waste disposal has become one of the major problems in modern cities.

3. METHODS OF MIX DESIGN

There are several methods used for carrying out mix design of concrete. However, some of the most commonly used methods are listed below.

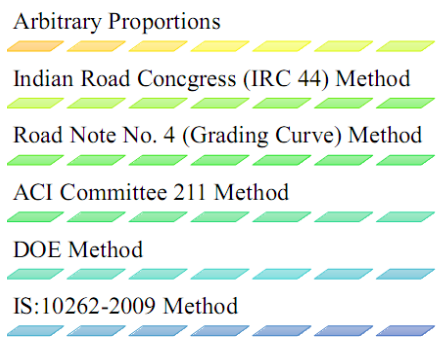

Fig. 3.1 Methods of Mix Design

Table 3.1 Values of Standard Deviation

Grade of Concrete (fck)	Standard Deviation in MPa	Grade of Concrete (fck)	Standard Deviation in MPa
M10	2.3	M30	6.0
M15	3.5	M35	6.3
M20	4.6	M40	6.6
M25	5.3	M45	7.0

3.1 Target Mean Strength

$$Target\ Mean\ Strength\ (\overline{fck}) = fck + 1.65 \times S$$

Where, fck = 28 days compressive strength

S = Standard Deviation

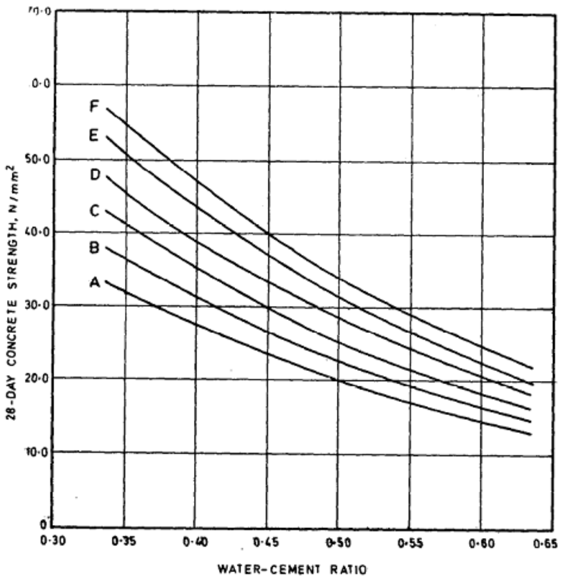

Fig. 3.2 Water Cement Ratio Chart

4 TEST SPECIFICATIONS

✓ All test procedures are as described under IS:516 -1959.

✓ The compressive test has been performed on test specimen after 28 days curing from date of casting on Compression Test Machine.

✓ The split tensile test has been carried out on test specimen after 28 days curing from date of casting on Compression Test Machine.

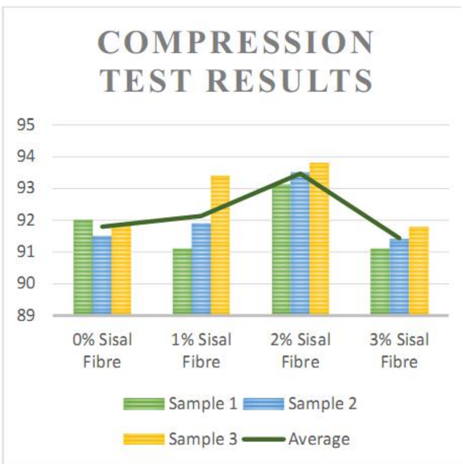

Fig. 3.3 Compression Test Results

5. CONCLUSION

The project aimed towards study of properties of concrete by using sisal fibre as a partial cement replacement. The experimental studies have resulted in following conclusion:

■ The results from compressive test shows that the 28-day characteristic strength of concrete is maximum at 2% Sisal Fibre content and henceforth it keeps on decreasing. The relative analysis of strengths has shown thatCompressive strength of 2% sisal fibre is 1.78% more than conventional concrete.

■ From Split cylinder test the maximum strength is again at 2% sisal fibre and it is more than conventional concrete by 3.131%.

■ Overall, it is observed that 2% sisal fibre has resulted in maximum strength of samples. So the optimum percentage of sisalfibre as a partial cement replacement is 2%.

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