A Study on Compressive Strength Attributes of Jute Fiber Reinforced Cement Concrete Composites

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Abstract: The primary objective of this study is to investigate the effect of reinforcing raw jute fibers on the mechanical properties of cement concrete composites. The investigation helps to explore more on the variation of properties of concrete with jute fibers, its effective usage and to reduce the usage of polymer fibers which interns an environmental harm. In the present study, raw jute fibers cut to 10 mm were used with the proportionate mix of cement, coarse aggregate and sand with the water-cement ratio of 0.45. The mixed specimens are casted for different volume content of jute fibers (0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2%, 1.4%, 1.6% and 1.8%) and cured for 3, 7 and 28 days. It is observed that the compressive strength of casted concrete coupon is increased from 8.8 N/mm² to a maximum of 44.44 N/mm² due to the addition of jute fibers. The maximum compressive strength is obtained for a concrete coupon of fiber content 0.4%. As the fiber content increased from 0.4 % the compressive strength get reduced, causing poor workability of concrete.

Keywords: Compressive strength, Jute fibers, Cement concrete composite, Workability

1. Introduction

Composites are fabricated by combining reinforcing material with concrete, which enhances the structural properties of concrete and it is commonly known as fiber reinforced concrete. In this study an effort is made to evaluate the compressive strength characteristics by adding jute fibres in plain cement concrete. As a process of waste management, the jute fibres that are produced in large scale are used as a reinforcing agent with concrete so that there is a significant increase in the structural properties of concrete [1 and 2]. Normally a composite material such as fibre reinforced concrete comprises of a variety of fibres which may be natural or artificial. The addition of these natural fibres is more economical compared with artificial fibres [3].

As India is one of large producers of jute, these fibres can be used in order to overcome the brittle behaviour of concrete. Jute also is one of the most affordable natural fibers and is second only to cotton in amount produced. An attempt to identify the optimum percentage of jute fibres which are to be used with concrete in order to achieve the maximum compressive strength is reported in this article. Different fiber contents were used as reinforcement which is assumed and achieved randomly oriented and uniformly distributed in the matrix. Specimens with varying fiber contents were tested in axial compression.
2. Materials

2.1 Cement:
Portland cement is a part and parcel of building material. It acts as binding material in concrete, mortar matrix and with other constituents [4]. In the current study Ordinary Portland Cement of grade 53 conforming to IS-269:1989, IS-8112: 1989, IS-12269: 1987 is used with an initial setting time of 30 minutes and the final setting time of 600 minutes.

2.2 Jute fibres:
Jute fibres are of silky texture (see figure 1). These are biodegradable and eco-friendly. The common structural properties of the jute fibres are very high tensile strength and low extensibility [5 and 6]. In the present study raw jute fibres cut to a length of 10 mm are used. The content of jute fibres is determined with respect to the weight of cement. The various percentages of jute fibres that used to cast the specimen are 0.2 %, 0.4 %, 0.6 %, 0.8 %, 1 %, 1.2 %, 1.4 %, 1.6 % and 1.8 %.

2.3 Aggregates:
Aggregates used in the concrete matrix increase the soundness and impact absorbing properties of the concrete. Aggregates with same nominal size and grading induce the concrete with satisfactory workability. The fine aggregate used is the M-sand passing 4.75 mm sieve is taken for the mix. The specific gravity of the fine aggregates and coarse aggregates is found to be 2.55 and 2.76 respectively. The Fineness modulus of coarse aggregate and fine aggregate is 3.215 and 4.285 respectively.

3. Fabrication Methodology

3.1 Concrete mix:
Mix design is the process of selection of mix ingredients and their proportions required in a concrete mix. The mix design involves the calculation of amount of cement, fine aggregate, and coarse aggregate and the relation between water/cement ratio and target strength that to be attain. Since, the objective of the study is to investigate the effect of incorporating jute yarn on the mechanical properties of concrete, the mix design with target strength of 26.6 MPa was accomplished and mix ratio of 1 :1.41 : 2.83 and water/cement ratio (by weight) 0.45 were cautiously maintained. The mix design is calculated as per the procedure in IS: 10262- 2009 guidelines.

3.2 Preparation of the test specimen:
The process of mixing is done by hand. Here along with the aggregates and cement, the raw jute fibres are also included in the mix. The jute fibres are distributed randomly resulting in good bonding between the jute fibres and the aggregates. The mixed materials are then casted with a standard cube mould dimension of 150 x 150 x 150 mm (see figure 2). While placing the concrete in the moulds proper vibration is done for the better compaction of concrete and also to reduce the formation of voids that are responsible for the deterioration of the concrete specimen. After that, the casted specimens were left 24 h for de-moulding. After the final setting of concrete the specimens are subjected to the process of curing for 28 days.
Figure 2. Mixing and Casted specimens

After curing these specimens are tested by the compression testing machine for their compression strength values for 3 days curing, 7 days curing and 28 days of curing (see figure 3). During the application of load the load is applied along the fully compacted side of the specimen so that the actual load bearing capacity of the specimen is known. The maximum load that the specimen is applied with before failure of the concrete cube is noted as the maximum compression strength value of the specimen. The figure 3 shows the failed specimen due to the application of compressive load.

Figure 3. Specimen for testing and Failure specimen

4. Results and Discussion
The inclusion of the raw jute fibres provides additional strength and stiffness to the concrete specimen. The compression test carried out for 3, 7 and 28 days of curing shows the increasing concrete strength with the increase in curing period. The maximum compressive strength of the concrete with 0.4 % of jute fibres for a curing period of 3 days is 14.67 N/mm². The maximum compressive strength of the concrete with 0.4% of jute fibres for a curing period of 7 days is 26.88 N/mm². And the maximum compressive strength of the concrete with 0.4 % of jute fibres for a curing period of 28 days is 44.44 N/mm² (refer figure 4). In all cases the concrete compressive strength increases up to a certain dosage of fibres and further goes on decreasing with the increase of fibre content. This is due to the formation of voids or empty spaces, because of the excessive addition of fibres. These voids reduce the internal strength of the concrete. The graphical representation of figure 4 depicts the variation of compressive strength with respect to different fiber percentage.
From the figure 4 it is concluded that as the curing period increases the compressive strength also increases. This is due to the formation of cement gel, which occupies all the voids created around the jute fibres. And also it is further observed that the compressive strength of the concrete cubes goes on decreasing after a certain rise (0.4 %) in the fiber content. It is the result of the excessive fibre content, which may increase the number of voids or empty spaces within the concrete cube. The increase in the fibre content reduces the level of compaction thereby reducing the compressive strength of concrete. Excessive fibres result in balling of fibres and if these are not separated then they result in the increase of water content required for the mixing of concrete and hence reduce the workability of concrete. These unevenly compacted concrete specimens are weak from inside and tend to fail in their weakest plain when the compressive load is applied. Because of this the maximum compressive strength of the specimen is just a false reading that cannot be considered as the cube compressive strength of the concrete specimen.

5. Conclusion
This article helps to have an idea on the influence of volume fraction of jute fibres on compressive strength of the concrete of mix proportion 1:1.41: 2.83 with the water-cement ratio of 0.45. From the results the following conclusions is made,

- Due to the addition of raw jute fibres, there is a predominant increase in the compressive strength of the concrete cube when compared to conventional concrete.
- It is observed that the compressive strength of normal concrete specimen is increased from 8.8 N/mm² to a maximum of 44.44 N/mm², due to the addition of jute fibres.
- The maximum compressive strength is obtained for 28 days curing period and for a fibre content of 0.4%.
- As the fibre content was increased above 0.4% the compressive strength gets reduced. Excessive addition of fibres leads to poor workability and there by proves the inadequacy of proper compaction.
- It is concluded that 0.4 % is the optimum dosage of the fibres in order to achieve the maximum compressive strength of concrete.

The results of this investigation have shown the feasibility of using jute fibers in developing a low cost construction material when jute fibers are readily available.
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