EXPERIMENTAL STUDIES ON USE OF HELIX FIBERS IN CONCRETE

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ABSTRACT

This is an experimental investigation focused on the study of the effect of addition of helix fibers in plain concrete to evaluate the compressive strength, tensile strength and the modulus of elasticity when compared to normal concrete. Concrete Mix of M_{25} grade was used and the mix proportions were obtained. The main variable in this study are the different dosages of helix fibers i.e. 0 (Normal concrete), 10, 15 and 25 kg/m^3. The compressive strength and the split tensile strength values for different dosages of helix fibers were plotted for 7, 14 and 28 days. The stress-strain curve was plotted for different dosages of helix fibers at 28 days to determine the modulus of elasticity. The results indicated that the addition of helix fibers in plain concrete increased the compressive strength, tensile strength, modulus of elasticity and the ductility of concrete when compared to normal concrete.

Key Words: Helix fibers, compressive, split tensile, modulus of elasticity.

1.0 INTRODUCTION

Concrete is the most widely used construction material in the world. The use of randomly disbursed fibers steel will reduce cracks and improves its strength, durability, toughness, ductility and post-cracking load resistance. The different types of steel fibers used include straight steel fibers, hooked end steel fibers, flat end steel bars, dumb bell end steel bars, corrugalated steel fibers and helix steel fibers.

The use of helix fibers is a patented technology developed by Anloine Naaman, Professor in Civil Engineering, University of Michigan. Helix fibers are high performance, optimized steel-fibers that act as reinforcement in concrete. These are short, twisted and polygonal in shape. The shape and the twist maximize both the frictional and mechanical bond between the fibers and cement-based matrix. The use of twisted fibers results in a significant increase in the performance of concrete plain concrete at dosages of 0 (Normal concrete), 10, 15 and 25 kg/m^3.

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The tests on compressive strength, tensile strength, and modulus of elasticity were performed and the values were compared with those of normal concrete. This research work is focused on the use of uniformly disbursed steel helix fibers in

2.0 EXPERIMENTAL PROGRAMME
2.1 Materials

Cement: Ordinary Portland Cement (OPC) of 43 Grade was used in the study, and the tests were performed according to IS: 4031-1988 recommendations. The specific gravity of cement used was 2.99.

Aggregate: Locally available river sand was used as fine aggregate. Sand used conformed to the requirements of Zone-III of IS 383-1970. The coarse aggregate used comprised of 20mm downsize granite stones.

The aggregate satisfied graded-size aggregate requirements of IS 383-1970. The physical properties of aggregates are provided in Table 1. Ordinary portable water was used for concreting and curing of specimens.

Table 1 Properties of Aggregates Used

Physical properties	Fine Aggregate	Coarse Aggregate
Specific Gravity	2.49	2.67
Loose Bulk Density	1463 kg/m^3	1360 kg/m^3
Compacted Bulk density	1661 kg/m^3	1527 kg/m^3

Helix fibers: Fig.1 provides a closer view of helix fibers used. The properties of Helix fibers used in this study are as follows:

Specific Gravity: 7.8
Type of material: High Tensile Steel Wire
Length: 25 mm
Diameter: 0.50mm (0.020 in)
Coating: Electroplated Zinc

Fig. 1 Helix Fibres

Superplasticizer: A commercially available sulphonated naphthalene polymer based high range water-reducing admixture was used to improve the workability of concrete mixture. The Superplasticizer added is 0.05%, 0.075% and 0.15% of weight of cement for dosages of 10, 15 and 25 kg/m^3 of helix fibers in concrete respectively in order to maintain the required workability as shown in Table 2. Also see Fig. 2.

Table 2 Slump Value from Tests for Slump

Concrète mix	Slump (mm)
Normal mix	50
Dosage 10 (Kg/m^3)	60
Dosage 15 (Kg/m^3)	60
Dosage 25 (Kg/m^3)	80

Fig. 2 Measurement of Slump using the Slump Cone

2.2 Mix proportions: Concrete satisfying the requirements of M_{25} was developed, and the mix proportion obtained was 1:1.97:3.77:0.4 (cement: sand: coarse aggregate: water). From the mix design, the cement content was arrived at 340 Kg/m^3 of concrete.

2.3 Casting of Specimens: Using the above mix-proportion, 36 numbers of standard cubical concrete specimens of dimension 150mm x 150mm x 150mm and 48 numbers of standard cylindrical specimens of dimension 150mm diameter and 300mm height, were cast.

For the compressive strength test, for the dosage of 0 kg/m^3 (Normal concrete), three cubical specimens each were cast, in order to be tested at end of 7, 14 and 28 days. Similarly specimens were tested for dosages of 10, 15 and 25 kg/m^3.

For the test on split tensile strength, for the dosage of 0 kg/m^3 (for normal concrete), three cylindrical specimens each were cast, in order to be tested at end of 7, 14 and 28 days. Similar specimens were tested for dosages of 10, 15 and 25 kg/m^3. For the test for modulus of elasticity, three cylindrical specimens each were cast for dosages of 0, 10, 15 and 25 kg/m^3 to be tested at the end of 28 days.

To make concrete workable, the above-mentioned super-plasticizer at appropriate optimum dosage by weight of cement was added to the concrete. Concrete was mixed using a laboratory concrete mixer and was checked for slump. Concrete of the same mix was then poured into moulds and compacted using a table vibrator in order to be subjected to other tests. The specimens were cured in water after 24 hours of casting.

2.4 Testing of Specimens

Compressive strength: The test for compressive strength was performed using the universal compression-testing machine. Tests were performed on cube specimens at the ned of 7, 14 and 28 days of curing. See Fig. 3.

Fig. 3 Test for Compressive Strength

Tensile Strength: The direct measurement of tensile strength of concrete is difficult, and an indirect method of testing using the split tensile test was adopted. Here, the load is applied along the vertical diameter on a specimen placed horizontally along the longitudinal axis. The split tensile tests were performed on the cylindrical specimens at the end of 7, 14 and 28 days of curing.

Modulus of elasticity: The ratio of stress to strain within the elastic limit is defined as *modulus of elasticity*. The deformation produced in a cylindrical specimen subjected to uniaxial compression (measured by the compressometer) is divided by the gauge length to obtain the strain. The load applied on the specimen when divided by the cross sectional area provides the stress. The stress-strain graph is drawn and the tangent drawn to the beginning of the stress-strain curve is called *initial tangent modulus.*

3.0 RESULTS AND DISCUSSIONS

The test results are plotted for compressive strength and split tensile strength for dosages of helix fibers at 0 (Normal concrete), 10, 15and 25 kg/m^3 in concrete at 7, 14 and 28 days. The stress-strain curve was plotted and *initial tangent modulus* was determined for the dosages of helix fibers at 0, 10, 15and 25 kg/m^3 in concrete at 28 days.

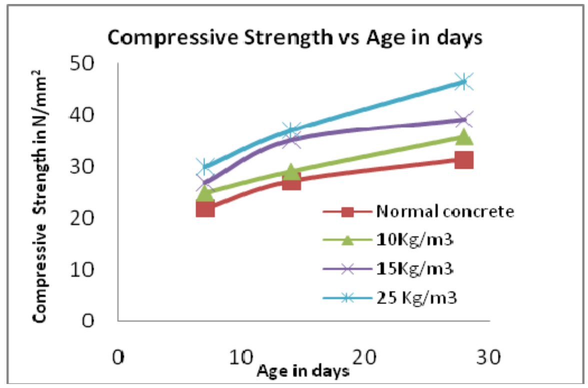

Fig. 4 Compressive Strength Vs Age

With the addition of helix fibers in concrete, it was observed that there is increase in compressive strength of concrete. With addition of dosages of 10, 15 and 25 kg/m^3 of helix fibers to concrete, it was observed that there is increase in compressive strength of about 14%, 25% and 48% respectively compared to normal concrete. (See Fig. 4) .The increased strength of the Helix fiber in concrete is attributed to the shape and the twist, which maximize both the frictional and mechanical bonds between helix and cement based matrix.

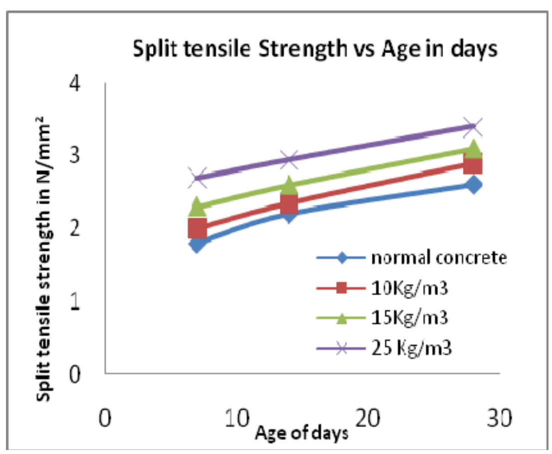

Fig. 5 Split Tensile Strength Vs Age

With the addition of helix fibers in concrete, it was observed that there is an increase in the split tensile strength of concrete. With addition of dosages of 10, 15 and 25 kg/m^3 of helix fibers to concrete, it was observed that there is increase in the split tensile strength of about 10%, 20% and 30% respectively compared to normal concrete (See Fig. 5). The increased split tensile strength of the Helix fiber in concrete may be attributed to failure from a frictional pull out mechanism to a torsional or untwisting mode (See Fig. 6).

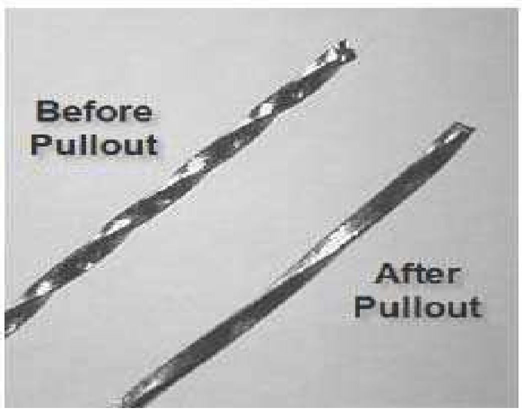

Fig. 6 Helix Fibers Before and after Pullout

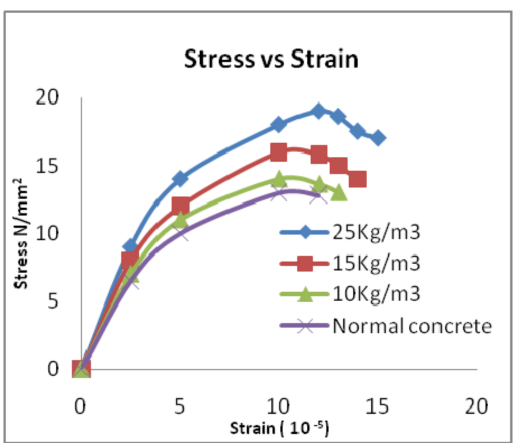

Fig. 7 Plot of Stress-Strain Curve

Initial Tangent modulus

E= 2.6 x 10^5 N/mm^2 for Normal Concrete

E= 2.8 x 10^5 N/mm^2 @ dosage of 10kg/m^3

E= 3.2 x 10^5 N/mm^2 @ dosage of 15 kg/m^3

E= 3.6 x 10^5 N/mm^2 @ dosage of 25 kg/m^3

With the addition of helix fibers in concrete, it was observed that there is an increase in the *initial tangent modulus* of concrete. For dosages of 10, 15 and 25 kg/m^3 of helix fibers added to normal concrete, it was observed that there was an increase in the *initial tangent modulus* by about 7%, 23% and 38% respectively. (See Fig. 7). The increase in helix fibers in concrete has resulted in the increase in strain, resulting in increased ductility. The increase in dosage of steel fibers also resulted in an increase in the *modulus of elasticity* that contributes towards higher resistance to failure due to frictional pull out.

4.0 CONCLUSIONS

The following conclusions can be deduced from the results and observations made from the experimental investigations.

- It is observed that the workability of the mix decreased with increase in the dosage of helix fibers. However, the decease in workability was compensated by the addition of the super plasticizer.

- The addition of helix fibers resulted in increase in compressive strength, tensile strength, modulus-of-elasticity, and ductility.

- The addition of 10kg/m^3 of helix fibers in concrete resulted in a marginal increase in compressive

- strength, tensile strength, modulus-of-elasticity, and ductility by about 7 to 10%.
- The addition of 25kg/m^3 of helix fibers in concrete resulted in a substantial increase in the compressive strength, tensile strength, modulus-of-elasticity, and ductility by about 30% to 40%.

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