THE PROPERTIES OF CONCRETE BYUSING IMPROVEMENT ON FIBERS

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Abstract: The concept of using fibers in concrete to improve resistance to cracking and fragmentation is old and intuitive. During the last 30 years different types of fibers and fiber materials were introduced and are being continuously introduced in the market as new applications. These fibers can be made of metals, natural, glass or organic materials. In the past three decades, extensive research on fiber reinforced concrete has shown that some types of fibers can be added to concrete to improve its durability and physical properties such as cracking induced by plastic shrinkage, drying shrinkage and thermal gradient on the surface of fresh and mature concrete due to the severe environmental conditions of the Saudi Arabia has been marked as one of the several causal factors of deterioration of reinforced concrete in the country.
In this thesis, commercially available synthetic fibers namely, polypropylene, is used to study the effects of polypropylene fiber used for reinforcing concrete mixes and to obtain basic strength. The compressive, splitting tensile strength tests were performed by changing fiber weight content from 0% to 1% of the cement weight content.

I.INTRODUCTION

Concrete:
Concrete is one of the most versatile building materials. It can be cast to fit any structural shape. It is readily available in urban areas at relatively low cost.
Concrete is strong under compression yet weak under tension and a relatively brittle material. As such, a form of reinforcement is needed. The most common type of concrete reinforcement is via steel bars. The advantages to using concrete include high compressive strength, good fire resistance, high water resistance, low maintenance, and long service life. The disadvantages to using concrete include poor tensile strength, and formwork requirement.

Steel Reinforcement Concrete:

Tensile strength of concrete is typically 8% to 15% of its compressive strength. This weakness has been dealt with over many decades by using a system of reinforcing bars (rebars) to create reinforced concrete; so that concrete primarily resists compressive stresses and steel bars resist tensile and shear stresses.
The longitudinal rebar in a beam provide resists flexural (tensile stress) whereas the stirrups, wrapped around the longitudinal bar, resist shear stresses. In a column, vertical bars resist compression and buckling stresses while ties resist shear and confinement to vertical bars.
Use of reinforced concrete makes for a good composite material with extensive applications. Steel bars, however, reinforce concrete against tension only locally. Cracks in reinforced concrete members extend freely .until encountering a rebar. The need for multidirectional and closely spaced reinforcement for concrete arises.

Fiber Reinforced Concrete:
Fiber reinforced concrete is a concrete mix that contains short discrete fibers that are uniformly distributed and randomly oriented. Fiber material can be steel, cellulose, carbon, polypropylene, glass, nylon, and polyester. The amount of fibers added to a concrete mix is measured as a percentage of the total volume of the composite (concrete and fibers) termed Vf. Vf typically ranges from 0.1 to 3%.
Aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). Fibers with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio.

The Problem of Thesis:

Cracking induced by plastic shrinkage, drying shrinkage and thermal gradient on the surface of fresh and mature concrete due to the severe environmental conditions of the Saudi Arabia Country has been marked as one of the several causal factors of deterioration of reinforced concrete in the area. The large fluctuation in the daily temperature in summer months may reach 50°C and seasonal fluctuations may reach 70°C; particularly when heating of concrete surfaces due to direct radiation of the sun is taken into consideration. The combined effect of frequent drying winds, high temperatures and low precipitation result in excessive evaporation of Gulf waters causing high salinities. These climatic characteristics help in the cracking process of concrete.

II.LITERATURE REVIEW

Fiber Reinforcement Concrete
Types of Fibers in Concrete
The concept of using fibers in brittle material to improve resistance to cracking and fragmentation is old and intuitive. For example, straws were used to reinforce sun backed bricks; horse hair was used to reinforce plaster and more recently. When Portland cement concrete started evolving as a building material, attempts were made to add fibers to improve its behavior and to overcome the problem of inherently brittle type of failure that occurs in concrete under tensile stress systems and impact loading. Two periods seem to characterize the development of fiber reinforcement in concrete. The first period, prior to the l970s, corresponds to a slow development, with almost no applications. While the second period, since the early 1970, corresponds to **Plastic Shrinkage Cracking:**

This type of cracking is common on exposed surfaces of freshly placed floors, slabs, and other elements with large surface areas as show in Figure. when subjected to rapid loss of moisture due to low humidity, high temperature, and high wind velocity.When moisture evaporates from the surface of freshly placed concrete faster than it is replaced by bleeding water, the concrete surface shrinks. Tensile stresses develop in plastic concrete, resulting in shallow cracks that are usually short and run in 24 all directions.

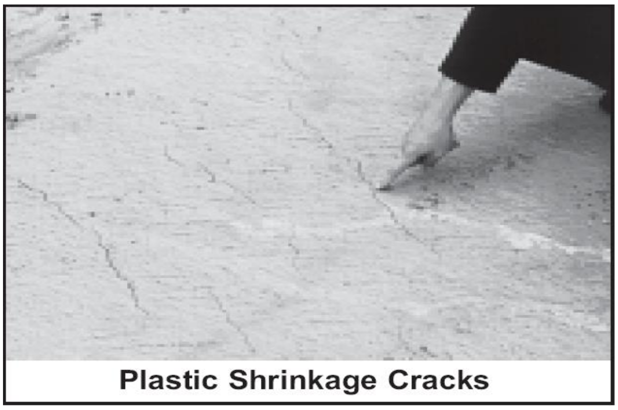


Fig. Plastic Shrinkage Cracking

a phase of more rapid innovative developments with increasing applications.

During this rapid development different types of fibers and fiber materials are introduced and are being continuously introduced to the market for new applications. These fibers can be made of metals, natural, glass or organic materials. Fiber reinforced concrete is concrete made of hydraulic cements containing fine aggregate, or fine and coarse aggregate and discontinuous discrete fibers. These fibers are in various shapes and sizes. A convenient numerical parameter describing a fiber is its aspect ratio defined as the fiber length divided by an equivalent fiber diameter. Typical aspect ratios range from about 30 to 150 for length dimensions of 6.4 mm to 76 mm (0.25 in. to 3.0 in.). Each type of fiber has its own physical properties. Typical ranges of some of the physical properties of the fibers are shown in Table.

Steel Fibers

Steel fibers are the most common fibers used in concrete .They may be produced either by cutting wires, shearing sheets or from a hot melt extract. They may be smooth, or deformed in a variety of ways to improve the mechanical bond with concrete. Steel fibers have high modulus of elasticity which is 10 times that of concrete, reasonably good bond and high elongation at fracture. Steel fibers range in length from 0.25 inches to 3.0 inches. Fiber concentrations in concrete mixes generally range from 0.1 % to 1 % by volume. Present applications of steel fiber reinforced concrete with and without normal reinforcement have been in the areas of refractories, pavements, overlays, patching, hydraulic structures, thin shells, and armour for jetties, rock slope stabilization, mine tunnel linings, and precast products. As Figure shows various shapes of steel fibers.

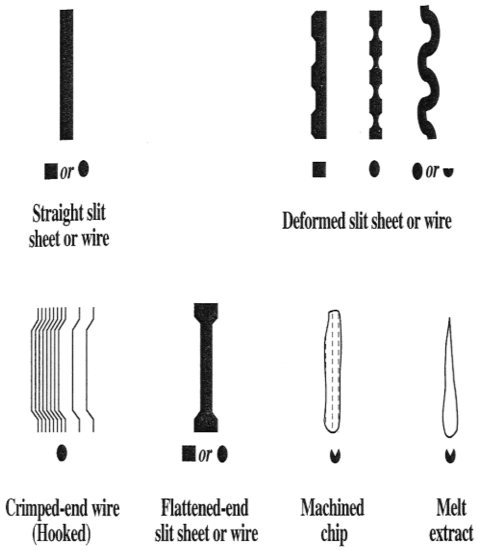


Fig.various shapes of steel fibers used in fiber reinforced concrete, from reference [8]

The effects of steel fibers on mechanical properties of concrete are depicted in Figure. As shown in the Figure, addition of steel fibers does not significantly increase compressive strength, but it increases the tensile toughness, and ductility. It also increases the ability to withstand stresses after significant cracking (damage tolerance) and shear resistance. [9]

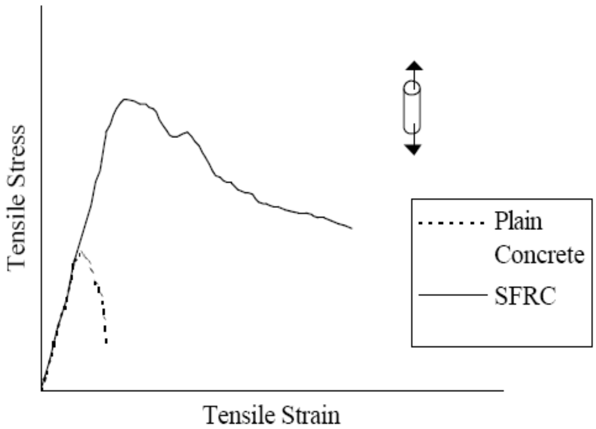


Fig. Properties of SFRC [9]

Synthetic Fibers

The primary synthetic fibers used in concrete slabs on ground are polypropylene and nylon. Nylon fibers are found to be effective in increasing the impact strength of mortar. However, it was generally found that the flexural strength of the composite was reduced by using small volumes of short nylon monofilaments. On the other hand, Walton and Majumdar [1] achieved moduli of rupture of up to 11 MPa using 7% by volume of 25 mm long nylon monofilaments and large increases in impact strength were observed which were not diminished by aging. Synthetic Fiber in concrete mixes generally range from 0.1 % to 0.2 % by volume.

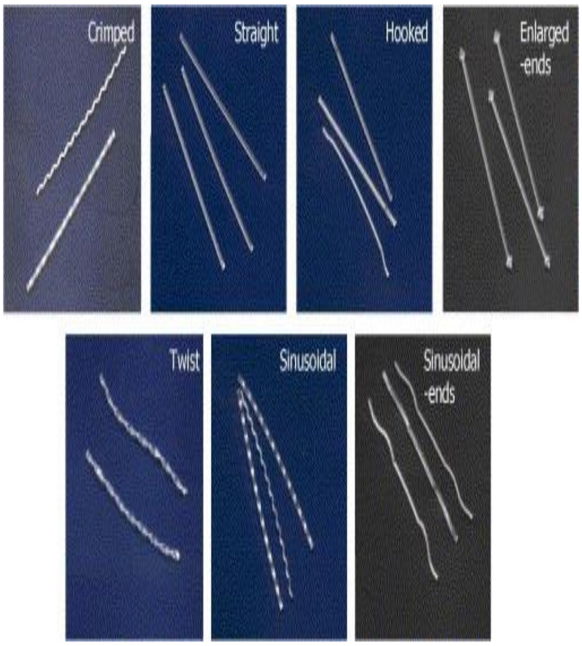


Fig. Various types of synthetic fibers.

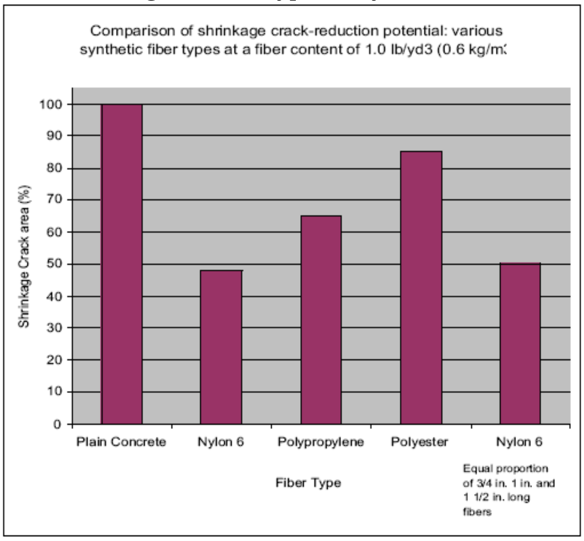


Fig.Comparison of shrinkage crack-reduction potential for various synthetic fiber types and plain concrete

III. CASE STUDY

General:

This case study concerning the status of the selected fiber & explain its specifications, advantages, disadvantages & its applications.

- Name of fiber :- Helix fiber
- Type of fiber :- steel fiber
- Manufactured and sold by Polytorx, LLC Ann Arbor, Michigan (www.helixfiber.com)

What is Helix?

Helix is a revolutionary concrete reinforcing additive which has been thoroughly tested over the past ten years. The patented, toothpick sized, twisted fibers give concrete added strength and reduces cracking.

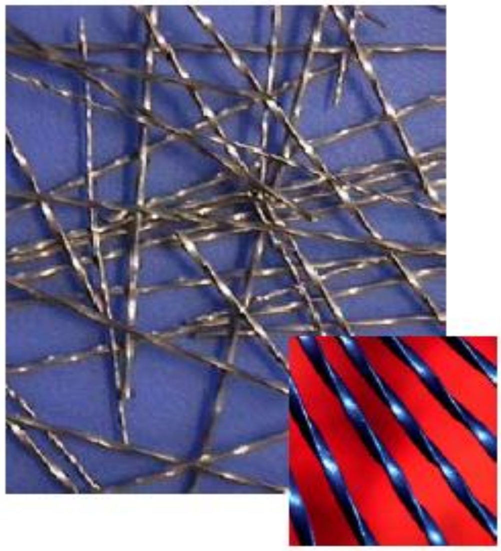


Fig. Shape of Helix fiber

What does Helix do?

Everyone knows that plain concrete is brittle and will crack .Since Helix is added with the other ingredients, it becomes part of the mix and is dispersed throughout the entire matrix of the concrete. Adding Helix directly to the mix allows you to eliminate rebar or wire mesh and maximizes ductility. Helix reinforced concrete continues to carry load with no loss in residual strength.

Fig. Helix is dispersed uniformly in concrete

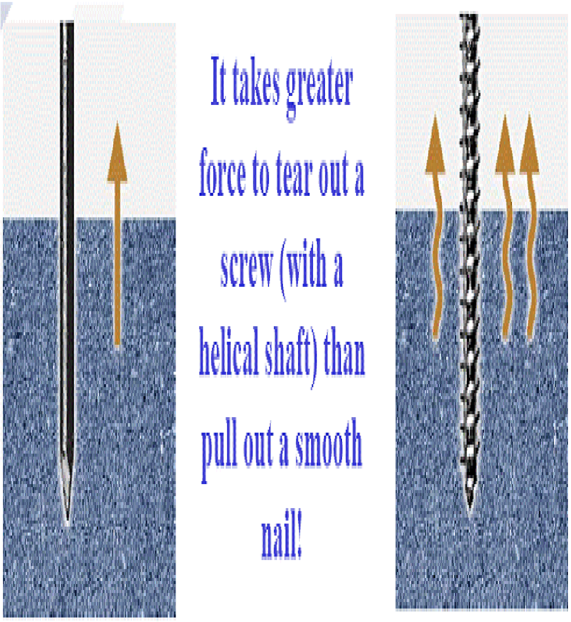
Fig. Helix reinforced concrete bends instead of cracking

Helix puts even reinforcement everywhere - not just a few spots preventing cracking by adding strength and flexibility.

Advantages of Helix Fiber

1- **The Twist**

In simple terms, the twist in Helix maximizes the bond with the concrete that surrounds it. The addition of millions of Helixes into concrete results in a super strong and flexible concrete mix.



2-Easy to use

- The old way… time consuming and labor intensive.

- The new way by use Helix fiber order the truck and forget about it. Helix is completely mixed in the truck along with the other ingredients.

(Easy mixing in the truck)

2- **Easy mixing and placing Mixing**

Mix Design: Slump should be between 3 and 5 inches (7.6-12.7cm) at the time of Helix introduction. Helix will not ball during mixing. Truck Mixer: always add Helix as the last step. Set drum at idle speed Pan Mixer/Drum

Mixer: Helix should be added together with sand and aggregates or to freshly mixed concrete.

Fig.Helix was engineered with ease of use in mind

Placing

Helix fiber reinforced concrete may be placed using conventional methods, no special equipment is needed.

Finishing

- Finishing with Helix reinforced concrete does not require special equipment.
- Finishing can be done by hand using metal tools or using power equipment.

- When finishing using power equipment no changes to procedure are recommended.
- A wet-cut saw may be used to cut joints.

4- Eliminate cracks, add strength with Helix "The strongest Reinforce-ment available for concrete".(www.helixfiber.com)

5- "Stronger and Less Expensive than all other concrete Reinforcing methods". (www.helixfiber.com)

6- Helix meets all the codes**.** It has been subjected to thousands of tests

and is covered under several standards including ASTM A-820**.**

Helix comparing to Synthetic Fibers

- Comparing equal cost dosages, Helix performs four times better than even the best available “Structural” synthetic fiber on the market.
- And typical monofilament fibers, used for plastic shrinkage protection, provide no resistance to loading or cracking after the concrete has cured.

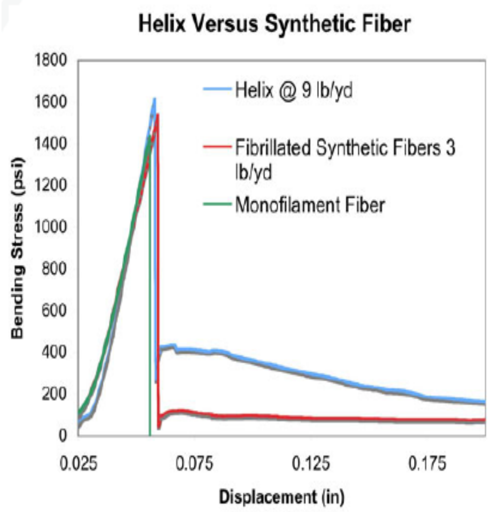


Fig.3.5: Helix Versus Synthetic Fiber

Unlike most synthetics, Helix provides strength throughout the life of the slab, not just during curing .

IV. INVESTIGATION RESULTS AND DISCUSSION

Effect of Polypropylene Fibers on the Properties of Fresh Concrete

Table. The densities of the various mixes

W/C	Fiber Weight Fraction (%)	Unit weight* Kg/m^3	Slump (mm)
0.5	0.0	2350	120
	0.25	2300	105
	0.50	2290	90
	1	2225	80

* Test accordance to ASTM C642-06.

Effect of PF on the Properties of Fresh Concrete

- Reduced rate of bleeding
- Settlement of the coarse aggregate was slower Because Hold the concrete mix together.
- A slower rate of bleeding means a slower rate of drying and thus less plastic shrinkage cracking

Effect of Polypropylene Fibers on the Strength of the Concrete

Table 5.2.Compressive Strength at (7-day and 28-day) curing

Fiber Weight Fraction (%)	Compressive Strength 7-day (MPa)	Compressive Strength 28-day (MPa)	Percentage (%)	
			7-Day	28-Day
0.0	28.7	35.25	100	100
0.25	31.8	37.35	111.8	106
0.50	23.08	31.20	80.5	88.6
1.0	21.1	25.68	73.6	73

* Average of 3 Specimens.

Note: Compressive Strength test according to ASTM C 39

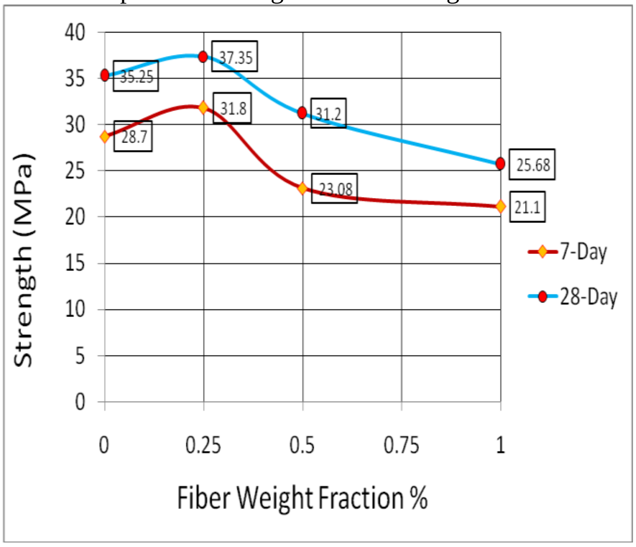


Fig. Compressive strengths of polypropylene fiber concrete.

V. CONCLUSION

In the light of the preceding results and discussion, the following can be concluded:-

1. The addition of polypropylene fibers effect on the compressive strength has increasing by 10% with (0.25%) of fiber than start decreases by with increase the fiber quantities.
2. High quantities of fiber produced concrete with poor workability and segregation, higher entrapped air and lower unit weight.
3. A significant effect on the mode and mechanism of failure of concrete cylinders in a comp. testing with (FRC).The fiber concrete fails in a more ductile mode.
4. The (PC) cylinders typically shatter due to an inability to absorb the energy by the test machine at failure.
5.Fiber concrete cylinders continue to sustain load and large deformations without shattering into pieces.
6.The addition of polypropylene fibers effect on the split tensile strength has increasing by 17%, 18% and 20% with 0.25%, 0.5% and 1.0% of fiber respectively.
7.That improve the tensile and cohesion of concrete.
8.The fiber concrete fails in more ductile mode opposite the plain concrete that shattering into pieces.

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