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Use of FORTA-FERRO Fiber in Structural Concrete Mix: A Review

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Abstract - *Fibers have played an important role in the design and construction of many different types of projects, from airports and tennis courts to swimming pools and public schools. The purpose of this research is to investigate the use of Forta-Ferro Fibers in structural concrete to enhance the mechanical properties of concrete. The objective of the study is to determine and do the comparative study of the properties of concrete containing no fibers and concrete with fibers, as well as the on the different types of Forta Fibers and advantages of the Forta Fiber over the steel fibers.*

Key Words: **CONCRETE, FIBERS, FORTA-FERRO, POLYMERS, PROPYLENE**

1. INTRODUCTION

The use of fibers to fortify building materials may seem like a new idea, but it's actually been around since ancient Egypt, when crude straw "fibers" were added to clay and mud building blocks and bricks. Though primitive in design, these fibers added a certain amount of cohesiveness and toughness that the Egyptian builders found very valuable. Earlier plasterers achieved similar benefits by adding both horse and pig hair to plaster as a method of reinforcement. Though the design and uniform distribution of these earlier fibers were questionable, the basic theory of adding three-dimensional fibers to increase the toughness and durability of various building materials proved to be a sound one. By combining space-age synthetic materials with unique designs and shapes, it offers the international construction market a valuable fiber reinforcement product that controls cracking and adds long-term durability to a wide variety of concrete applications.

2. POLYMER FIBER REINFORCED CONCRETE

Polymeric fibers are gaining popularity because of its properties like zero risk of corrosion and cost effectiveness. The polymeric fibers commonly used are polyester, Recron 3s, and polypropylene. Various forms of recycled fibers like plastic, disposed tires, carpet waste and wastes from textile industry, can also be used as fiber reinforcements. These fibers act as crack arresters, restricting the development of cracks and thus transforming a brittle material into a strong composite with superior crack resistance, improved ductility and distinctive post cracking behaviour prior to failure.

Concrete may be weak in tension and against impact, but PFRC is a suitable material which may be used for cement concrete as it possesses extra strength in flexural fatigue and impact etc. The usage of fibers in combination with concrete also results in a mix with improved early resistance to plastic shrinkage cracking and thereby protects the concrete from drying shrinkage cracks. It accomplishes improved durability and reduced surface water permeability of concrete. It reduces the risk of plastic settlement cracking over rebar. It enables easier and smoother finishing. It also helps to achieve reduced bleeding of water to surface during concrete placement, which inhibits the migration of cement and sand to the surface and the benefits of the above will be harder, more durable surface with better abrasion resistance. A uniform distribution of fibers throughout the concrete improves the homogeneity of the concrete matrix. It also facilitates reduced water absorption, greater impact resistance, enhanced flexural strength and tensile strength of concrete.

3. POLYPROPYLENE FIBERS

The basic idea behind using fibers is to hold the smaller pieces of concrete together. However, FORTA's blend of polypropylene fibers provides additional benefits such as:

- Non-corrosive and increases cohesiveness
- Non-magnetic
- 100% Alkali Proof
- Increased Impact Resistance
- Reduction in Shrinkage and temperature cracking
- Reduction in slab curling thereby increasing post crack performance
- Increased durability and ductility
- Effective removal of Steel and steel fibers from Slabs on ground.

Forta-Ferro which means "Strong as Steel" is extremely user-friendly, having gained a reputation as the best mixing and finishing fiber of its kind in the industry. Applications of FORTA Fibers include manufacturing commercial and industrial floors, residential slabs and driveways, slabs on deck, parking lots and pavements to name a few.

Fig -1: Forta-Ferro Fiber

3.1 FORTA-FERRO FIBERS (STRUCTURAL FIBERS)

Forta-Ferro is an easy-to-finish, color blended fiber, made of 100% virgin copolymer/ polypropylene consisting of a twisted bundle non-fibrillating monofilament and a fibrillating network fiber, yielding a high-performance concrete reinforcement system. It is used to reduce plastic and hardened concrete shrinkage to improve impact strength, and to increase fatigue resistance and concrete toughness. This extra heavy-duty fiber offers maximum long-term durability, structural enhancements, and effective secondary/temperature crack control by incorporating a truly unique synergistic fiber system of long length design. Forta-Ferro is a non-corrosive, non-magnetic, and 100% alkali proof.

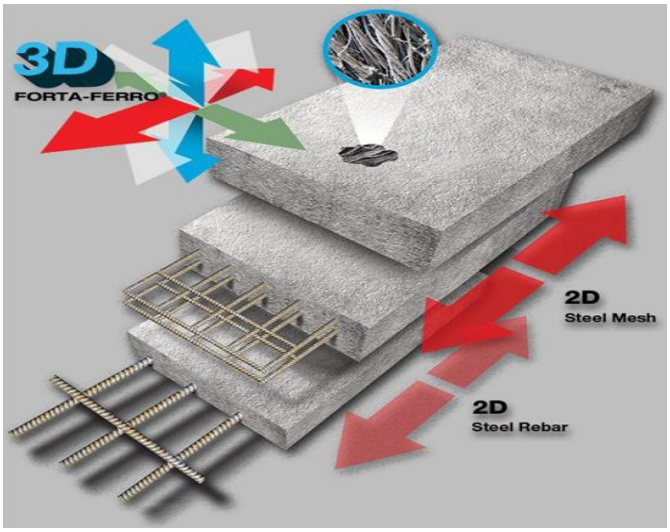

Fig – 2: 3D view of concrete mix with Forta-Ferro

3.2 FORTA ECONO-NET

Forta Econo-Net is an easy to finish, fully oriented, 100% virgin homopolymer polypropylene fibrous reinforcement in a collated fibrillated (network) form. It is used to reduce plastic and hardened concrete shrinkage, improve impact strength, increase fatigue resistance and concrete toughness. This medium-duty fiber offers good-bonding power, long-term durability, and true secondary/temperature control by incorporating a fibrillated pattern and long length option. Non-Corrosive, Non-Magnetic, Chemically Inert, and 100% Alkali Proof.

3.3 FORTA STUCCO BOND

Forta Stucco-Bond is an easy to apply and finish fully oriented, 100% virgin homopolymer polypropylene monofilament fibrous reinforcement. This engineered fiber provides a mini-reinforcing system forming a more cohesive, inner-supported mix that functions as a plastic shrinkage reinforcement intended to reduce the formation of shrinkage cracks prior to initial set. Forta Stucco-Bond is non-corrosive, non-magnetic, chemically inert, and 100% Alkali Proof.

3.4 FORTA FI ASPHALT

FORTA-Fi Asphalt is stronger asphalt, and builds tougher roads that are both safer, and more fiscally responsible. Today, more than ever, using time and material resources responsibly is everyone's goal. Forta-Fi is uniquely capable of reinforcing all asphalt mixtures allowing for either less asphalt or longer life, which translates into reduced processing, reduced labor, reduced time and reduced logistics thereby reducing overall project cost. Its application areas include roadways, streets, pavements, parking lots, residential driveways, and airports.

4. FEATURES AND BENEFITS

4.1 BENEFITS OF FORTA-FERRO FIBRES OVER STEEL FIBRES

Forta-Ferro (which means "Strong as Steel") fibres are non-corrosive, non-magnetic and 100% alkali proof. In comparison testing vs. three types of steel fibres it was

Determined that it requires 1 kg of Forta-Ferro fibre to offer equivalent A.R.S. (Average Residual Strength) values to that of 10 kg of steel fibres. This one-to-ten dosage ratio offers tremendous advantages for Forta-Ferro fibres in the batching, pumping, placing and finishing processes.

4.2 FORTA-FERRO REPLACE WIRE MESH, STEEL MATS OR REBAR IN SLAB-ON-GRADE CONCRETE

In most situations, Forta-Ferro can safely and reliably replace all non-structural steel in slab-on-grade concrete. Factors such as requirements from rack or point load, average daily traffic, slab thickness and sub-base must be considered. As always, it is best to contact Stratmore Construction Solutions Ltd before eliminating steel reinforcement.

4.3 FORTA-FERRO AFFECT PLACEMENT AND FINISHING

Forta-Ferro fibres are added at the concrete batch plant and require 4-5 minutes at normal mixing speed for proper distribution. At low dosages, placement and finishing is similar to finishing normal concrete. They will reduce visual slump approximately 75mm at the 4.5kg/m^3 dosage, and will typically require a super-plasticiser or mid-range water reducer to provide flow ability for placement. Using excessive mix water will naturally reduce concrete strength and create bleed water that will make the surface less durable. Good concrete finishing practices should be exercised. Dosages of 6kg/m3 upwards can be placed with ease (we recommend the use of a bug roller to push the fibres into the concrete paste before final finishing operations). Forta-Ferro fibres can be used in exposed aggregate and ground and polished floors and cannot rust or corrode.

4.4 USING FORTA-FERRO AT 4.5kg PER CUBIC METRE OF CONCRETE

Forta-Ferro used at 4.5kg per cubic metre of concrete can allow for significantly extended joint spacing (or joint less floors), limited visible cracking potential and a reduction or elimination of curling.

4.5 EXTENDED CONTROL JOINT SPACING

With a properly proportioned concrete mix, good placing and finishing techniques and adherence to the techniques described to minimise cracking, floors with extended joint spacing of 120 to even 200 times the thickness of the slab can be achieved (18 to 30 metres for a 150mm thick slab). Good joints are expensive to create and maintain and coupled with a reduction in curling of the slab, significant long-term maintenance costs can be reduced by using Forta-Ferro at 4.5kg/m3 of concrete.

5. DIFFERENT QUANTITY BASED ON PURPOSE OF CONSTRUCTION

2kg/m^3: Temperature and shrinkage reinforcement only. Use for light duty applications including footpaths, cattle races, light-duty driveways, smaller precast items, etc.

3kg/m^3: For moderate benefits to reduce cracking. Use for light commercial applications (including warehouse slab on grade), precast tanks & troughs, driveways, etc. As a superior alternative system to 668/665 wire mesh, dosage of 3.0 to 3.5kg.

4.5kg/m^3: For best benefits and highest probability to reduce cracking from tension, curling and fatigue. Use for applications requiring maximum performance including industrial and commercial warehouse floors with extending joint spacing, applications where curling and joint maintenance are a concern, etc.

For specific applications, including those where steel reinforcement is specified (mesh, rebar or steel fibres), an engineering calculation for FORTA-FERRO dosage can be provided. Typically, for most slab on grade applications demanding the best performance, specify and use 4.5kg of FORTA-FERRO fibres per cubic metre of concrete.

6. ADVANTAGEGS OF FORTA-FERRO FIBER

FORTA-FERRO is unique and offers the following benefits:

- Uniform mixing without balling.
- Better colour blend with cured concrete.
- Excellent finish without fuzzes.
- Improved post-crack performance.
- Easy fibre addition.
- Very high fibre count.
- Superb plastic shrinkage crack reduction.

7. DISADVANTAGES OF FORTA-FERRO FIBER

- The fibres form very small lumps while mixing.
- The fibres appearing on the surface of the concrete and are not recommended from the aesthetic views.

8. CONCLUSIONS

The strength of concrete with the mentioned fiber can be summarized as follow:

- In construction of concrete with FORTA fiber, it is required to take appropriate consideration to prevent the fiber from rolling.
- Concrete without fiber has fragile nature; while reinforced concrete with FORTA fiber prevents the fragility of the concrete due to prevention from dissipation of crack.
- Compressive strength of concrete for ratio of 0.5, 1, 2 and 3 kg fiber has increased up to 6%, 10%, 15% and 19% respectively.
- The tensile strength of concrete for ratio 0.5, 1, 2 and 3 kg fiber has respectively increased by 3.5%, 11%, 14% and 18%.
- The shrinkage of concrete for ratio 0.5, 1, 2 and 3 kg shows 4.3%, 9.3%, 11% and 24% reduction, respectively.

- Fiber, generally and steel fiber, specifically, strongly improves the tensile strength and mechanical properties and strength of concrete and prevents local fracture, crack and crack expansion in concrete.

- The use of fiber in concrete considerably decreases the costs related to maintenance and repair of concrete.

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