KraTos FIBERS

Application Guide for KraTos Macro Fiber Reinforced Ground Concretes

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1. Introduction

Macro synthetic fiber reinforcements have been used in ground concretes, road concretes, shotcretes and some precast elements since the 1990's. It can be used completely in place of conventional reinforcement in continuous support systems such as shotcrete and ground concretes [1]. Macro synthetic fiber reinforcements increase crack resistance in concrete, provide durability, increase toughness and ductility. It provides increased bending moment capacity on concrete like traditional steel reinforcements. It increases the displacement capacity of concrete under load. KraTos Macro synthetic fiber reinforcements are produced in accordance with EN 14889-2 (Fibers - For use in concrete - Part 2: Polymer fibers - Definitions, properties and conformity) Standard. Fiber types with an equivalent diameter 0.3 mm are called macrofibres.

2. Concrete Mixture

The concrete mix design should be in accordance with TS 13515.

- Min. Concrete Characteristic Compressive Strength: 25 MPa
- Max. Water/Cement Ratio: 0.55
- Min. Cement Content: 300 kg/m^3, Min. Cement Content with mineral additives: 270 kg/m^3
- Max. Methylene Blue Test: %1,5
- Consistency of fresh concrete is recommended as S4 class (Slump: 16-21 cm), if the concrete thickness is more than 10 cm. (The slump value may vary depending on the equipment used and field conditions.)
- If the concrete thickness is lower than 10 cm such as topping concrete, overlay concrete, screed concrete, it is recommended that concrete mixture doesn't have aggregate number 1 and consistency of fresh concrete is recommended as S4 class (Slump: 16-21 cm).

The information about the mixture proportion of the fiber-reinforced concrete is below according to ACI 544.3R-08.

Table 1. Mixture Proportion [2]

ACI 544.3R-08 Guide for Specifying, Proportioning, and Production of Fiber-Reinforced Concrete			
Max. Aggregate Size	(9.5 mm)	(20 mm)	(38 mm)
Mixture Parameters			
Cement/Pozzolana Content, (kg/m^3)	356-593	297-534	279-415
Water/Cement Ratio,	0.35-0.45	0.35-0.50	0.35-0.55
Fine/Coarse Aggregate Ratio	45-60	45-55	40-55
Fiber Dosage, (kg/m^3)	2,7-18	1,8-7,3	1,8-6,3

Coarse Aggregate > 4 mm

4 mm > Fine Aggregate < 4 mm
If the coarse aggregate ratio is more than 55%, fiber clumping might show up. [3].

Important parameters that affect the workability of the fiber-reinforced concrete;

- Fiber Length
- Fiber Aspect Ratio
- Fiber Content
- Aggregate Content
- Aggregate Size and Gradation
- Water/Cement Ratio of the Mixture.

The higher the fiber length with the lowest fiber width, the less workability of the fresh fiber-reinforced concrete. The excessive fiber content in the concrete mixture reduces the workability. Suitable additives, i.e. high range water reducers or superplasticizers, are recommended to improve the workability of fiber concrete.

Highly coarse aggregates do not allow the fibers to settle properly, so they are not effective in fiber bridging for initial cracks. The aggregate ratio is crucial in the concrete mix. Blending and mixing fresh fiber-reinforced concrete is a critical process. It is necessary to obtain a homogeneous fiber distribution in the concrete mixture. Thus, the mixing procedure, cement content, aggregate size, gradation should be closely monitored and designed to ensure adequate workability.

3. Adding and Batching Process of Macrofibers

3.1 Batching on Ready-Mix Power Plant

Follow the following steps:

- Make sure that fiber dosing is correctly calculated for a cubic meter of concrete.
- Add packages to the power plant using the aggregate belt conveyor and mix. Packages are water soluble; it doesn't need to be opened.
- When the truck mixer is delivered to the field, mix the concrete at the highest speed for at least 5 minutes.

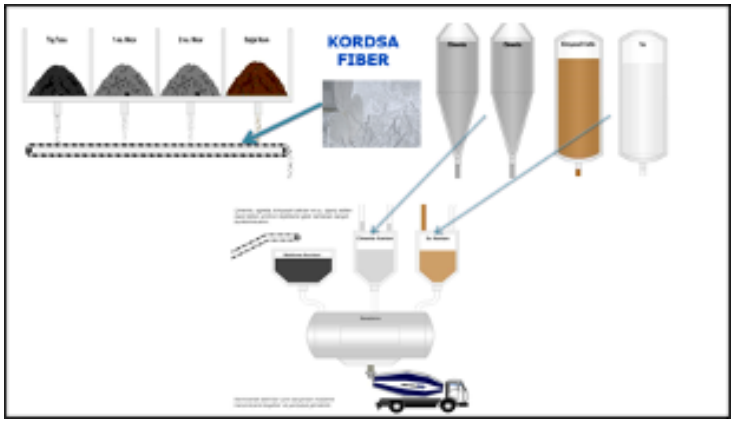

Figure1. Batching Process on Power Plant

3.2 Batching on Truck Mixer

This method is not recommended. Please follow the steps below if the method is required.

- Specify the correct number of packages that suit the volume of concrete.
- Ensure the minimum slump value of the concrete as S4 class before adding the fibers. The slump value may vary depending on the application.
- Make sure that the batching speed of the truck mixer is correct before adding packages.
- Add the KraTos packages on the mixer at the max. speed of 10 kg/min.
- After completing the adding packages, apply high speed batching process for a minute for each cubic meter of concrete. (If the truck mixer has 7 m^3 of concrete in the tank, high speed batching process should be last for 7 minutes.)

When blending KraTos fibers, it should be observed that the fibers are homogeneously distributed by following the steps above. If the mixing process is completed correctly, the KraTos fibers will not clump. KraTos fibers (2-5 kg/m^3) can cause a reduction of slump value as 20-60 mm. Slump correction should be ensured by designing the mixture of concrete using additives. Water should not be added to concrete in the field.

Figure 2. Water Soluble Packages of KraTos Macrofibers and Microfibers and Adding Process on Truck Mixer

Figure3. High Speed Mixing at least for 7 Minutes

4. Finishing

The finishing of KraTos fiber-reinforced concrete has no significant change in standard procedures or techniques for surface treatment. However, the final correction equipment should be kept longer in order to avoid fibers remaining on the surface (trowel, tray etc.). When the polishing machine is used, the blades should be kept straight in the first two layers and the angles of the blades should be perpendicular to each other. Wooden trowels tend to bring the fibers to the surface. Surface finishing operations should be applied in one direction, otherwise the fibers will come to the surface. The

final finishing process provides a sufficient amount of cement paste on the surface. Cement paste constitutes an important parameter for the fibers to remain embedded in the concrete. If tools such as broom are to be used, it should only be applied in one direction on the concrete surface. If applied in both directions the fibers will tend to remain on the surface. Mechanical concrete placement equipment such as laser screed, the finisher is more suitable for placing and finishing fiber reinforced concrete. The mechanical vibration provided by these machines is sufficient to strengthen the fiber-reinforced concrete and ensure that the fibers do not come to the surface.[2]

Figure 4. Concrete Placement (with the Laser Screed)

Figure 5. Floor Hardener, Polishing and Brooming

5. Joint Cutting – Layout & Details

The UK Concrete Society's report TR-34 (2013) [3] provides excellent guidance for the construction and placement of joints in industrial ground concretes. Joint spacing (for cut joints) should not be greater than 6 m x 6 m in order to minimize the risk of cracking as a result of shrinkage and confinement [3]. Joint cut width should be between 3-4 mm [3]. As soon as the concrete reaches the required strength, joint cutting should be done. Usually, it is recommended to cut after 24 hours of pouring. Weather conditions can change this situation [3].

The depth of joint cutting should be one-third of the concrete thickness. [3]. The purpose of having joint cut is to create a weak section on the surface of the poured concrete so that the crack occurs in the sublayer instead of surface. The dimension of joint cutting is recommended as 24-36 (avg. 30) times of the concrete thickness. [4]. In order to reduce the risk of cracking further, proper foundation preparation (nylon, etc. product laying process), concrete mix design and adequate curing are recommended. Cutting joints should be applied practically right after the concrete is poured. This application provides uncontrolled crack formation and reduction of confinement in the concrete slab. Construction joints should be a max 1:1.5 ratio, if possible, this ratio should be 1:1. [5].

Figure 6. Cutting Joint on Concrete and Representation of Cut Joint on Section

Figure 7. Grouting on Concrete

Insulation joints are important in cracking in buildings. Insulation joints should be placed between the ground concrete and building elements (columns, walls, equipment foundations, manholes, stairs, etc.). Isolation joints can be selected from suitable foam materials. To be a full separator, it must be extended under the floor. [5].

Figure 8. Placing Dowel in Cold Joint Areas

6. Curing

Protection of fiber-reinforced concrete in extreme hot or cold weather should be done in the same way as conventional concrete. When fiber reinforced concretes are applied in thin layers (overlay, topping, screed, etc. applications), they may remain vulnerable to plastic shrinkage cracks caused by excessive evaporation [2]. In this case, it is necessary to use microfiber in concrete and protect the surface from wind and sunlight. The curing process is carried out to prevent excessive moisture loss from the concrete surface. If these issues are not taken into account, plastic shrinkage cracks and abrasion/dusting on the concrete surface may occur. The curing can be sprayed onto the concrete surface or alternatively, it should be placed and stored on the concrete surface for at least 24 hours.

7. Crack Formation

Even with the best slab designs and proper construction, it is unrealistic to expect crack-free and curl-free floors. Every owner should be advised by the designer and contractor that it is normal to expect some cracking and curling on every project. This does not necessarily reflect adversely on the adequacy of the floor's design or quality of construction [4].

8. References

[1] «ACI 544.4R-18 Guide to Design with Fiber-Reinforced Concrete».

[2] «TMMOB İMO İSTANBUL ŞUBESİ-THBB, SEM, 19.12.2018, Prof. Dr. Mehmet Ali TAŞDEMİR».

[3] «ACI 544.3R-08, Guide for Specifying, Proportioning, and Production of Fiber-Reinforced Concrete».

[4] «TR 34, Technical Report No .34, A guide to Design and Conctruction, third and fourth editon».

[5] «ACI 360R-10, Guide to Design of Slabs-on Ground».

[6] «ACI 302.1R-15 Guide to Concrete Floor and Slab Construction».

[7] TS 13515: Complementary Turkish standard to TS EN 206-1

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