Engineering Guide To Specifying MaxTen™ High Performance Fibers As An Alternate To Welded Wire Fabric In Precast Concrete Septic Tanks.

The use of High Performance Synthetic Fibers as a reinforcement for welded wire fabric in precast septic tanks is increasing rapidly throughout the Precast Concrete Industry.

The information presented in this document has been provided to determine the minimum volume of synthetic fiber reinforcement required to replace the welded wire fabric typically used in Precast Septic Tanks.

Recommended Specification

Materials

The synthetic fibers used for the manufacture of Precast Septic Tanks shall meet the material specifications described in ASTM C-1116, Type III, Section 4.1.3 "Synthetic Fiber Reinforced Concrete and Shotcrete".

Design

The structural design of the septic tanks shall be by calculation or by performance. When designed by calculations, the Strength Design Method (Ultimate Strength Theory) as outlined in ACI 318-02 Chapter 9 [3] shall be utilized.

When designing by performance, the manufacturer must demonstrate that failure will not occur by physically applying loads to the product. The load applied shall be 1.5 times the anticipated actual loads when in service.

When synthetic fibers are used to replace the steel reinforcement in septic tanks, equivalent performance must be shown based on the engineering calculations.

The ultimate strength of the fiber reinforced wall section must be equal to or greater than the steel reinforced wall section.

The ultimate flexural capacity, M_u in (in-lb) of the steel reinforced concrete wall section is determined as follows:

$$M_u = A_S f_y (0.4h)$$

Where:

A_S = Area of Steel, in^2 / ft
f_y = yield stress of steel, 60,000 psi
h = thickness of wall, in inches

The flexural capacity, M_u in (in/lb) of the fiber reinforced concrete wall section is determined as follows:

$$M_u = f'_t \frac{bh^2}{6}$$

Where:

f'_t = the minimum average residual strength (psi) of the fiber reinforced concrete when tested according to ASTM C-1399 and calculated as specified.
b = unit length of wall section (12 in)
h = thickness of wall, in inches

Equivalent performance between the steel and synthetic fiber reinforcement is demonstrated when the minimum average residual strength of the synthetic fiber reinforced concrete satisfies the following equation:

$$f'_t \geq 2.4 \frac{A_S f_y}{bh}$$

Based on the above referenced engineering analysis, the required residual strength for the synthetic fiber reinforced septic tanks has been calculated for typical welded wire fabric replacement and is presented in Table 1.

The minimum average residual strength, f'_t of the concrete mix designs used to manufacture precast septic tanks with synthetic fibers shall not in any case be less than 150 psi when tested in accordance with ASTM C-1399.

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PSI Packaging, Inc. has developed conversion tables for the MaxTen™ High Performance Fibers. These tables are based on tests, engineering analysis, and calculations.

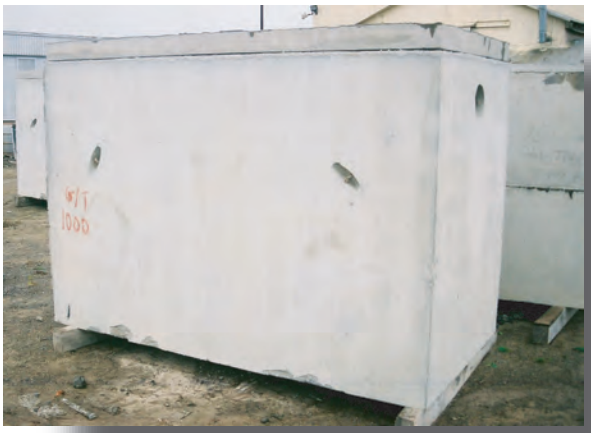
To replace steel reinforcement with MaxTen™ High Performance Fibers, the volume of fibers added must provide equal moment capacities. An example illusrating the calculations is presented herein.

Example:

Given Information

Concrete Strength = 4,000 psi
Wall Thickness (h) = 2.50 in.
Steel Reinforcement = W2 x W2 @ 6 in. x 6 in.
Area of steel, A_s = 0.04 $in.^2$ / ft
Tensile Strength of Steel, f_y = 60,000

What is the fiber application rate required to match this size of steel reinforcement?



The ultimate flexural capacity, M_u in (in-lb) of the steel reinforced wall section is calculated as follows:

$M_u = A_s f_y (0.4h) = .04 \times 60{,}000 \times 0.4 \times 2.50 = 2{,}400$

$M_u = 2{,}400$ in-lb

The required flexural capacity, M_u in (in-lb) for the fiber reinforced wall section is calculated as follows:

$$M_u = f'_t \frac{bh^2}{6} = 2{,}400 = f'_t \frac{bh^2}{6}$$

$f'_t = 2{,}400 / 12.5 = 192$ psi

Equivalent performance between the steel and the synthetic fiber reinforcement is demonstrated if the minimum average residual strength of the synthetic fiber reinforced concrete f'_t satisfies the following equation:

$$f'_t \geq 2.4 \frac{A_s f_y}{bh}$$

$$f'_t \geq \frac{2.4 \times .04 \times 60{,}000}{30}$$

$f'_t \geq 192$

The equivalent flexural strength can be achieved by adding 4.0 lbs/yd^3. This volume is indicated in Table 1

Minimum Residual Strength

The minimum residual strength of 150 psi is equivalent in performance to that of concrete with a steel ratio, P_s of 0.10%, where the steel is located at the mid plane of the wall section. This is the minimum steel ratio recommended by ACI-318-02, Chapter 16 section 16.4.2 for precast nonprestressed walls. The steel ratio,P_s is calculated as follows:

$$P_s = \frac{A_s}{bh} \times 100\%$$

Where:
A_S = Area of Steel ($in.^2$ / ft)
b = unit length of wall section (12 inches)
h = thickness of wall (inches)

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Table 1

MaxTen™ Fiber Reinforcement
Recommended Application Rates

		6 in. x 6 in.											
	Wire Gauge	W 1.4 10/10			W2 8/8			W2.9 6/6			W4 4/4		
	A_s (in.^{2}/ft.)	0.028			0.040			0.058			0.080		
Wall Thickness (in.)		Steel Ratio	f'_t (psi)	MaxTen MT 150 w_f (lb/yd^3)	Steel Ratio	f'_t (psi)	MaxTen MT 150 w_f (lb/yd^3)	Steel Ratio	f'_t (psi)	MaxTen MT 150 w_f (lb/yd^3)	Steel Ratio	f'_t (psi)	MaxTen MT150 w_f (lb/yd^3)
2.00		0.12%	168	4	0.17%	240	5	0.24%	348	8	0.33%	480	10
2.25		0.10%	150	3	0.15%	213	5	0.21%	309	7	0.30%	427	9
2.50		0.09%	150	3	0.13%	192	4	0.19%	278	6	0.27%	384	8
2.75		0.08%	150	3	0.12%	175	4	0.18%	253	6	0.24%	349	8
3.00		0.08%	150	3	0.11%	160	3	0.16%	232	5	0.22%	320	7
3.25		0.07%	150	3	0.10%	150	3	0.15%	214	5	0.21%	295	6
3.50		0.07%	150	3	0.10%	150	3	0.14%	199	4	0.19%	274	6
3.75		0.06%	150	3	0.09%	150	3	0.13%	186	4	0.18%	256	6
4.00		0.06%	150	3	0.09%	150	3	0.12%	174	4	0.17%	240	5

This table addresses the use of high performance synthetic fibers as a replacement for welded wire fabric when used in precast concrete septic tank applications. The information presented recommends a fiber application rate designed to provide equivalent performance characteristics to welded wire fabric.

The structural design of septic tanks can be determined by calculation or by performance.

When designing by calculation, the Strength Design Method (ultimate strength theory) as outlined in ACI-318-02 is typically incorporated.

When designing by performance, the manufacturer must demonstrate that failure will not occur when physically applying loads to the product. The loads applied shall be 1.5 times the anticipated actual loads while in service.

Depending on the required calculated wire reinforcement steel area, this table determines the recommended application rate for the MaxTen™ MT150 Fiber to provide equivilant performance characteristics.

A_s = area of steel, (in.^{2} / ft.)

f'_t = average residual strength (psi) when tested in accordance with ASTM C-1399 to equal the corresponding steel ratio

w_f = weight of MaxTen MT 150 Fiber in (lbs / yd^3) of concrete

To Use This Table:

1. Select the correct wall thickness
2. Select the size of welded wire fabric to be replaced
3. Select the corresponding recommended application rate of MaxTen™ MT 150 Fiber to be used

Note: A minimum average residual strength of 150 psi for the fiber reinforced concrete provides equivalent performance to that of concrete with a steel ratio of 0.10%, where the steel is located at the mid plane of the section. ***This is the minimum steel ratio recommended by ACI-318-02, Chapter 16, Section 16.4.2 for precast non prestressed walls.***

When tested in accordance with ASTM C-1399, the minimum average residual strength, f'_t of the concrete mix desgns used to manufacture septic tanks with MaxTen™ MT150 Fibers shall not in any case be less than 150 psi.

For Steel reinforcement not shown in this table, contact PSI Packaging, Inc. for alternate application rates.

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