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HELIX 5-25 MICRO-REBAR CONCRETE REINFORCEMENT SYSTEM

CSI Division: 03 00 00 - CONCRETE
CSI Section: 03 20 00 - Concrete Reinforcement

1.0 SCOPE OF EVALUATION

1.1 Compliance to the Following Codes & Regulations:

- 2018, 2015, 2012, and 2009 International Building Code® (IBC)
- 2018, 2015, 2012, and 2009 International Residential Code® (IRC)

1.2 Evaluated in Accordance with:

- IAPMO UES EC015-2020, Adopted - November 2013, Revised - January 2020
- ICC-ES AC208, approved October 2005, editorially revised January 2016

1.3 Properties Assessed:

- Shrinkage and temperature crack control in concrete
- Structural tension and shear resistance in concrete
- Fire Resistance

2.0 PRODUCT USE

Helix 5-25 Micro-Rebar functions as tensile reinforcement for concrete.

2.1 Helix Micro-Rebar may be used to reduce shrinkage and temperature cracking of concrete. Helix Micro-Rebar may be used as an alternative to the shrinkage and temperature reinforcement specified in Section 24.4 and Chapter 14 of ACI 318-14 and Section 7.12 and Chapter 22 of ACI 318-11 and ACI 318-08 (as referenced in Section 1901.2 of the IBC and Sections R404.1.2 and R611.1 of the IRC).

2.2 Helix Micro-Rebar may be used as tension and shear reinforcement in other structural concrete as detailed in this report, which satisfies the requirements of ACI 318-14 Section 1.10, ACI 318-11 Section 1.4, and Section 104.11 of the IBC and IRC.

2.3 Use in Seismic Design Categories C, D, E, and F is subject to the restrictions listed in Section 5.2 of this report.

2.4 The Helix 5-25 Micro-Rebar recognized in this report is produced by Pensmore Reinforcement Technologies in Grand Rapids, Michigan**.**

3.0 PRODUCT DESCRIPTION

Helix 5-25 Micro-Rebar reinforced concrete consists of two materials, as described in Sections 3.1 and 3.2 of this report.

3.1 Product Information: Helix 5-25 Micro-Rebar is made from cold-drawn, deformed wire complying with ASTM A 820, Type I. The steel wire has a tensile strength of 268.3 ksi +/- 21.8 ksi (1850 MPa +/- 150 MPa) and a minimum of 3 g/m^2 zinc coating. The length (l) is 1.0 inch +/- 0.1 inch (25 mm +/- 0.004 mm), equivalent diameter is 0.020 inch +/- 0.007 inch (0.5 mm +/- 0.02 mm), and cross-sectional area is 0.0003 square inches (0.196 mm^2). Each Helix Micro-Rebar has a minimum of one 360-degree twist. Helix Micro-Rebars are packaged in 22.5-pound (10.2 kg) boxes, 45-pound (20.4 kg) boxes, or 2450-pound (1111 kg) bags.

3.2 Normalweight Concrete with a minimum 28-day compressive strength of 3,000 psi (20.67 MPa).

4.0 DESIGN AND INSTALLATION

4.1 Design Class Selection: The Helix design class shall be selected based on the application and consequence of failure. The registered design professional shall select the design class based on the criteria in Sections 4.2 through 4.5 of this report. Figure 1 of this report provides guidance in making the design class selection.

4.2 Class A – Shrinkage and Temperature Reinforcement

4.2.1 Helix 5-25 Micro-Rebar replaces deformed reinforcement bars (rebar) or welded wire reinforcement for shrinkage and temperature reinforcement specified in Section 24.4 of ACI 318-14 and Section 7.12 of ACI 318-11 and ACI 318-08 in members complying with the requirements of Section 14.1.3 (a or b) of ACI 318-14 and Section 22.2.1 (a or b) of ACI 318-11 and ACI 318-08.

4.2.2 Helix 5-25 may be used in structures designed in accordance with Chapter 14 of ACI 318-14 or Chapter 22 of ACI 318-11 and ACI 318-08 (as referenced in Section 1901.2

of the IBC and Sections R404.1.3 and R608.1 of the 2018 or 2015 IRC, or Sections R404.1.2 and R611.1 of the 2012 or 2009 IRC). As an alternative and where approved by the building official, ACI 322-72 may be used for the design of structural plain concrete.

4.2.3 Helix 5-25 Micro-Rebar replaces shrinkage and temperature reinforcement in non-composite stay in place form steel deck applications.

4.2.4 Helix 5-25 Micro Rebar may be used in any concrete structure where reinforcement is not required by the IBC or IRC or addition to reinforcement required by the IBC or IRC to reduce shrinkage and temperature cracking of the concrete.

4.3 Class B – Minimum Structural Reinforcement

4.3.1 Helix 5-25 Micro-Rebar replaces structural reinforcement in soil-supported structures including footings and foundations.

4.3.2 Helix 5-25 Micro-Rebar replaces structural reinforcement in arch structure members in which arch action provides compression in the cross-section.

4.3.3 Helix 5-25 Micro-Rebar replaces structural reinforcement in structural concrete slabs supported directly on the ground designed in accordance with ACI 318.

4.3.4 Helix 5-25 Micro-Rebar replaces structural reinforcement in pile-supported slabs on ground designed in accordance with ACI 318, with unoccupied space below not to exceed the slab thickness (so failure will not result in structural collapse endangering occupants).

4.3.5 Helix 5-25 Micro-Rebar replaces reinforcement in above and below grade ordinary structural walls designed in accordance with Chapter 11 of ACI 318-14 and Chapter 14 of ACI 318-11 and ACI 318-08 and conforming to the following criteria:

- Bearing walls support more than 200 pounds per linear foot (2919 N/m) of vertical load in addition to its own weight. Non-bearing walls support no more than 200 pounds per linear foot (2919 N/m) of vertical load in addition to its own weight.
- Minimum wall thickness shall be in accordance with the following:

Wall Type	Minimum Thickness	
Non-bearing	Greater of;	4in. (100 mm)
		1/24 the lesser of unsupported length and height
Bearing	Greater of;	$5\frac{1}{2}$ in. (140 mm)
		1/24 the lesser of unsupported length and height
Exterior basement and foundation	Greater of;	$7\frac{1}{2}$ in. (180 mm)
		1/24 the lesser of unsupported length and height

- Walls shall be braced against lateral translation (walls shall be laterally supported in such a manner as to prohibit relative lateral displacement at top and bottom or on both sides of individual wall elements).
- At least one No. 5 (16 mm) bar shall be provided around all windows, doors, and similar sized openings. The bars shall be anchored to develop f_y in tension at the corners of openings.

  For residential walls designed in accordance with ACI 318 Chapter 14 or the IBC, Section 4.3.6 of this report also applies.

4.3.6 Helix 5-25 Micro-Rebar replaces reinforcement in above grade concrete wall systems and concrete foundation walls designed in accordance with the IRC and conforming to the following criteria:

- Bearing walls support more than 200 pounds per linear foot (2919 N/m) of vertical load in addition to its own weight. Non-bearing walls support no more than 200 pounds per linear foot (2919 N/m) of vertical load in addition to its own weight.
- Walls shall be braced against lateral translation (walls shall be laterally supported in such a manner as to prohibit relative lateral displacement at top and bottom or on both sides of individual wall elements).
- Minimum wall thickness shall be in accordance with the following:

Wall Type	Minimum Thickness	
Bearing and non-bearing	Greater of;	4in. (100 mm)
		1/24 the lesser of unsupported length and height
Exterior basement and foundation	Greater of;	6 in. (150 mm)
		1/24 the lesser of unsupported length and height

- The effective height shall be used to calculate the height to thickness ratio for 4-inch (100 mm) bearing walls when poured monolithic (i.e., wall is rotationally restrained with a moment connection, even if cold joint is present, at the bottom or top). The effective height is determined by the fixity of the wall end conditions. For walls braced top and bottom against lateral translation and restrained against rotation at one or both ends (top, bottom, or both) the effective height shall be 0.8 times the clear height.

- At least one No. 4 (12 mm) bar shall be provided around all window, door, and similar sized openings. The bars shall be anchored to develop f_y in tension at the corners of openings.

4.3.7 Helix 5-25 Micro-Rebar is used to reinforce slabs-on-ground designed using non-linear load analysis provided maximum tensile strains are limited to levels provided in Section 5.7 of this report.

4.4 Class C – Structural Concrete: Helix 5-25 Micro-Rebar replaces structural reinforcement for all other structural concrete including in unsupported horizontal spans.

4.5 Class Cs – Non-Linear Slab Design: Helix 5-25 Micro-Rebar shall be used as reinforcement in slabs on ground designed in accordance with ACI 360-10 Section 11.3.3 Methods 2 and 4 when Yield Line Analysis and Nonlinear finite element analysis show tensile strain limits given in Section 5.7 of this report are exceeded. When the tensile strain limits of Section 5.7 are not exceeded, the design shall comply with this section or with Section 4.3.7 of this report.

For structural concrete slabs supported directly on the ground and designed in accordance with ACI-318, Class C_s may be used with an additional resistance factor applied, which shall be determined by a registered design professional.

4.6 Design: Helix 5-25 Micro-Rebar dosage quantity shall be determined by procedures in this section and Tables 1, 2, and 3 of this report. Figure 2 of this report, the Helix Force Equilibrium and Strain Compatibility Diagram, shall be observed in the structural design.

4.6.1 Required Area of Steel

- **Class A:** The required area of steel, A_s, for shrinkage and temperature reinforcement shall be determined by the design procedures in Section 24.4 of ACI 318-14 or Section 7.12 of ACI 318-11 and 318-08 or other applicable code sections.

- **Class B and C:** The required area of steel reinforcement shall be determined at the centroid of the tension zone (Helix 5-25 Micro-Rebar acts as a rectangular tensile block as shown in Figure 2 of this report) in accordance with standard design procedures in ACI 318 using load and resistance factor design.

- An appropriate strength reduction factor has been applied to the Helix design strength in Tables 1 and 2 of this report.

- For structural concrete slabs supported directly on the ground and using Class C_s design, an additional resistance factor shall be applied to the required area of steel in Table 1 (by dividing the calculated area of steel by selected resistance factor before use in Table 1). The resistance factor shall be determined by the registered design professional.

4.6.2 Required Helix Micro-Rebar Quantity: Table 1 of this report provides the total number of Helix Micro-Rebar required to provide the same tensile resistance as the area of steel computed in Section 4.6.1 of this report. This number shall be divided by the cross-sectional area of the concrete in tension to obtain the number of Helix 5-25 Micro-Rebar required per unit area. This concrete area may result from either direct tension, flexural tension, or shear. Table 1 includes a factor to account for variation on Helix 5-25 Micro-Rebar resistance.

4.6.3 Helix 5-25 Micro-Rebar Dosage: The minimum Helix 5-25 Micro-Rebar dosage required to ensure the number of Helix 5-25 Micro-Rebar per unit area (as determined in Section 4.6.2 of this report) are provided in the tensile region of the concrete shall be selected from Table 2 of this report. This table includes factors to account for variation in orientation and distribution of Helix 5-25 Micro-Rebar.

4.6.4 Strain in the Helix 5-25 Micro-Rebar Concrete: Using the provided Helix unit tensile stress provided in Table 3 of this report, the average strain shall be calculated by (Eq.-1):

$$\varepsilon \cong \frac{\text{Helix tensile stress}}{E_{ct}} \qquad \textbf{(Eq.-1)}$$

where:

E_{ct} = the tensile modulus of elasticity of Helix 5-25 Micro-Rebar concrete, computed from Section 19.2 of ACI 318-14 or Section 8.5 of ACI 318-11 and ACI 318-08, as applicable.

ε = average concrete tensile strain

4.6.5 Pre- or Post-tensioned Concrete: With pre-tensioned concrete, post-tensioned concrete, and/or concrete subject to permanent dead loads from self-weight and axial loading, the initial compressive strain may be subtracted from the average strain calculated in Eq.-1.

4.6.6 Restrained Shrinkage: In cases of restrained shrinkage, the shrinkage strain shall be added to the average strain computed in Eq.-1.

4.6.7 Shear: The same method as provided in Sections 4.6.1 to 4.6.6 of this report shall be used for determining shear and torsion reinforcement. The contribution of plain concrete shall be neglected in shear applications (do not add V_c to the shear resistance computed for Helix Micro-Rebar). The area in tension should be taken as no more than 1.41 x the section width x height minus twice the neutral axis depth. When replacing both bending and shear reinforcement, the higher of the two dosages shall govern the design.

4.7 Hybrid Design: Hybrid design includes a combination of deformed reinforcement (rebar) and Helix 5-25 Micro-Rebar. For Hybrid Design, the area of steel computed in accordance with Section 4.6.1 of this report may be reduced by the cross-sectional area of the rebar that will remain prior to determining the required minimum number of Helix Micro-Rebar in Section 4.6.2 of this report.

4.7.1 Hybrid design for Class A or B structures have no minimum bar reinforcing requirement provided the application requirements in Sections 4.2 and 4.3 are met and strain limits conform to Section 5.7 of this report.

4.7.2 Structures complying with the Class A or B application restrictions in Sections 4.2 and 4.3 of this report but exceeding the strain limits in Section 5.7 may be designed as Class B Hybrid. This process will reduce the strain computed in Section 4.6.5 of this report. The strain limit shall be maintained even if the minimum amount of bar reinforcement as prescribed in 4.7.3 of this report is provided. Alternatively, the registered design professional may elect to use Class C without the need for bar reinforcement.

4.7.3 Structures not complying with Class A and B application limitations listed in Sections 4.2 and 4.3 of this report may be designed as Class C hybrid with a minimum amount of bar reinforcement as prescribed by the following:

Structure	Applicable Sections
Beams	ACI 318-14 Section 9.6 ACI 318-11 Section 10.5.1 ACI-318-08 Section 10.5.1
Slabs and Footings	ACI 318-14 Section 7.6 or 8.6 ACI 318-11 Section 10.5.4 ACI 318-08 Section 10.5.4
Walls	ACI 318-14 Section 11.6.1 ACI 318-11 Section 14.3.1 ACI 318-08 Section 14.3.1

4.7.4 Subject to approval of the building official, the requirement for bar reinforcement in Sections 4.7.2 and 4.7.3 of this report may be waived if registered design professional shows, through supplemental testing and/or analysis, adequate strength for the factored loads and serviceability requirements.

4.7.5 Strength provided by non-composite stay-in-place forms in applications not complying with the Class A and B application limitations may be used to satisfy the minimum reinforcement requirements in Sections 4.7.2 or 4.7.3 provided the registered design professional shows the Helix-reinforced concrete provides resistance equal to or greater than the resistance provided by the required bar reinforcement. The Helix-reinforced design strength, however, shall be adequate to carry the entire load (the contribution of the stay in place forms shall not be added to the capacity).

4.8 Yield Line Methods (ACI 360-10)

The section moment capacity ϕMn shall be calculated using the values in Table 3 of this report. The quantity $\frac{\phi M_n}{S_m \times fr}$ shall replace $\frac{Re,3}{100}$ in ACI 360-10 equations. All other calculations remain the same.

4.9 Fire-Resistance Ratings

4.9.1 For flat walls complying with IBC 722.2.1.1, Helix 5-25 Micro-Rebar are permitted as an alternative to the specified reinforcement according to IBC 722.2.1.1. The maximum dosage is 66 lb/yd^3 (38 kg/m^3).

4.9.2 For slabs on metal deck, Helix 5-25 Micro-Rebar are permitted as an alternative or in addition to the welded wire fabric used in concrete members under Underwriters Laboratories Design Nos. G256 dated January 6, 2014, and G514 dated October 11, 2013. The maximum dosage is 66 lb/yd^3 (38 kg/m^3).

5.0 CONDITIONS OF USE

The Helix 5-25 Micro-Rebar described in this report comply with and/or are suitable alternatives to what is specified in those codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 The concrete with Helix 5-25 Micro-Rebar shall comply with the ASTM C1116, Type I requirements. Substitution of any other steel fiber for Helix 5-25 is not allowed.

5.2 Structures complying with the requirements of Class A, B, and Cs (Section 4.1) are allowed in all seismic design categories permitted by the IBC for these applications. Class C structures in Seismic Design Categories C, D, E, and F are outside of the scope of this report.

5.3 Helix Micro-Rebar shall be blended into the concrete mix in accordance with Section 4.0 of this report, ACI 304R or ACI 318-11 and ACI 318-08 Section 5.8, as applicable, and the manufacturer's published installation instructions. If there is a conflict between the evaluation report and the manufacturer's published installation instructions, the more restrictive governs.

5.4 Concrete used in classes A, B, and Cs shall be normal weight and have a minimum compressive strength of 3,000 psi (20.67 MPa) and a maximum compressive strength of 8,000 psi (55.12 MPa).

5.5 The Helix Micro-Rebar shall not be used to replace any joints specified in ACI 318-14 Section 14.3, and ACI 318-11 and ACI 318-08 Section 22.3, as applicable.

5.6 Concrete used in Class C structures shall be normal-weight and have a minimum compressive strength of 4,000 psi (27.56 MPa) and a maximum compressive strength of 8,000 psi (55.12 MPa) and the mix shall have minimum fine to total aggregate ratio of 0.50 to assure adequate bond with the Helix Micro-Rebar.

5.7 Class A and B Strain Limits: The average tensile strain in the concrete shall not exceed the following:

Number of Helix per area	Tensile Strain, ε^1
Less than 3 Helix/in^2 (4,650 Helix/m^2)	0.000076
3 to 7 Helix/in^2 (4,650 to 10,850 Helix/m^2)	0.000105
Greater than 7 Helix/in^2 (10,850 Helix/m^2)	0.000110

[1]The strain limit in bending for sections deeper than 12 inches is 0.000076.

5.8 Hybrid design in accordance with Section 4.7 of this report is allowed for Class A structures complying with Section 4.2 of this report and B structures complying with Section 4.3 of this report, with no minimum reinforcing bar requirement, provided the strain complies with the limits of Section 5.7 of this report.

In the case of walls designed in accordance with Section 4.3.5 of this report, strain limits in Section 5.7 shall be modified as follows:

Hybrid Strain Limit = Section 5.7 Strain Limit X [1- (Hybrid Rebar Moment Capacity/Total Moment Capacity)]

5.9 Helix 5-25 Micro-Rebar shall be limited to the following dosages:

5.9.1 Class A:
Minimum 9 lb/yd^3 (5.4 kg/m^3)
Maximum 70 lb/yd^3 (42 kg/m^3)
For slabs on ground designed as unreinforced concrete in accordance with ACI 360-10, Chapter 7, slabs on metal deck where the metal deck provides the required tensile reinforcement, or structures designed as structural plain concrete, the minimum dosage shall not apply.

5.9.2 Class B:
Minimum 9 lb/yd^3 (5.4 kg/m^3)
Maximum 70 lb/yd^3 (42 kg/m^3)

5.9.3 Class C:
Minimum 15 lb/yd^3 (9 kg/m^3)
Maximum 70 lb/yd^3 (42 kg/m^3)

5.9.4 Class Cs:
Minimum 20 lb/yd^3 (12 kg/m^3)
Maximum 70 lb/yd^3 (42 kg/m^3)

5.10 For flexure, standard balanced and tension-controlled limits as prescribed in ACI 318-14 Section 21.2, ACI 318-11 and ACI 318-08 Section 10.3 apply.

5.11 A registered design professional shall approve use of Helix 5-25 Micro-Rebar.

5.12 Unsupported horizontal spans (free-spanning beams or slabs) with occupied space above or beneath shall have the minimum amount of bar reinforcement required to carry nominal service loads.

5.13 Helix 5-25 Micro Rebar shall not be used to replace supplemental rebar placed around openings and tied to lifting points in either cast-in-place or precast concrete.

5.14 Helix 5-25 Micro-Rebar shall be added to the concrete either at the ready-mix plant or at the jobsite. The manufacturer's published installation instructions and this report shall be strictly adhered to, and a copy of the manufacturer's published installation instructions shall be available at all times on the jobsite or the batch plant during installation. Installation instructions are available by clicking here.

5.15 When Helix 5-25 Micro-Rebar is added at the ready-mix plant, a batch ticket signed by a ready-mix representative shall be available to the building official upon request. The delivery ticket shall include, in addition to the items noted in ASTM C 94, the type and amount of Helix Micro-Rebar added to the concrete mix.

5.16 Field verification of Helix 5-25 Micro-Rebar dosage not required for Class A, B, and Cs or in applications designed with the minimum quantity of structural reinforcing bars in accordance with ACI 318. When verification is required, such as for Class C structures and as otherwise specified, the procedures in Appendix A shall be observed.

5.17 Helix Micro-Rebar is manufactured under a worldwide exclusive license by Pensmore Reinforcement Technologies, LLC d.b.a Helix Steel.

6.0 SUBSTANTIATING DATA

- Data in accordance with the ICC-ES Acceptance Criteria for Steel Fibers in Concrete (AC208), dated October 2005, editorially revised January 2016.
- Data in accordance with IAPMO UES Acceptance Criteria for Twisted Steel Micro-Rebar (EC 015-2020), Adopted November 2013, Revised January 2020).
- Test results are from laboratories in compliance with ISO/IEC 17025.

7.0 FIGURES, TABLES AND EXAMPLES

Figures (Attached)
- Figure 1: Helix Design Class Selection Flow Chart
- Figure 2: Helix Force Equilibrium and Strain Compatibility Diagram

Tables (Attached)
- Table 1: Helix micro rebar replacement
- Table 2: Helix micro rebar dosage rate
- Table 3: Helix micro rebar tensile force

Examples Calculations (Attached)
- Example 1: Class A Slab on Grade Design Original Rebar Design Given
- Example 2: Class A Slab on Metal Deck - Original Mesh Given
- Example 3: Class B Wall Design - Minimum Reinforcement Ratio Given
- Example 4: Class B Grade Beam Shear Design Only Original Shear Rebar Given
- Example 5: Class B Wall Design – Hybrid

8.0 APPENDICIES

A. Optional Field Dosage Verification Method
B. Minimum Helix Dosage Quick Reference

9.0 IDENTIFICATION

Labels on the boxes or bags bear the name Helix 5-25 and the number of the IAPMO UES evaluation report (ER-279), which identifies the product listed in this report. Either IAPMO Uniform Evaluation Service Mark of Conformity may also be used as shown below:

IAPMO ES or UES

IAPMO UES ER -279

10.0 STATEMENT OF RECOGNITION

This evaluation report describes the results of research completed by IAPMO Uniform Evaluation Service on Pensmore Reinforcement Technologies' Microbar Rebar to assess conformance to the codes shown in Section 1.0 of this report and serves as documentation of the product certification. Products are manufactured at locations noted in Section 2.4 of this report under a quality control program with periodic inspection under the supervision of IAPMO UES.

For additional information about this evaluation report please visit www.uniform-es.org or email us at info@uniform-es.org

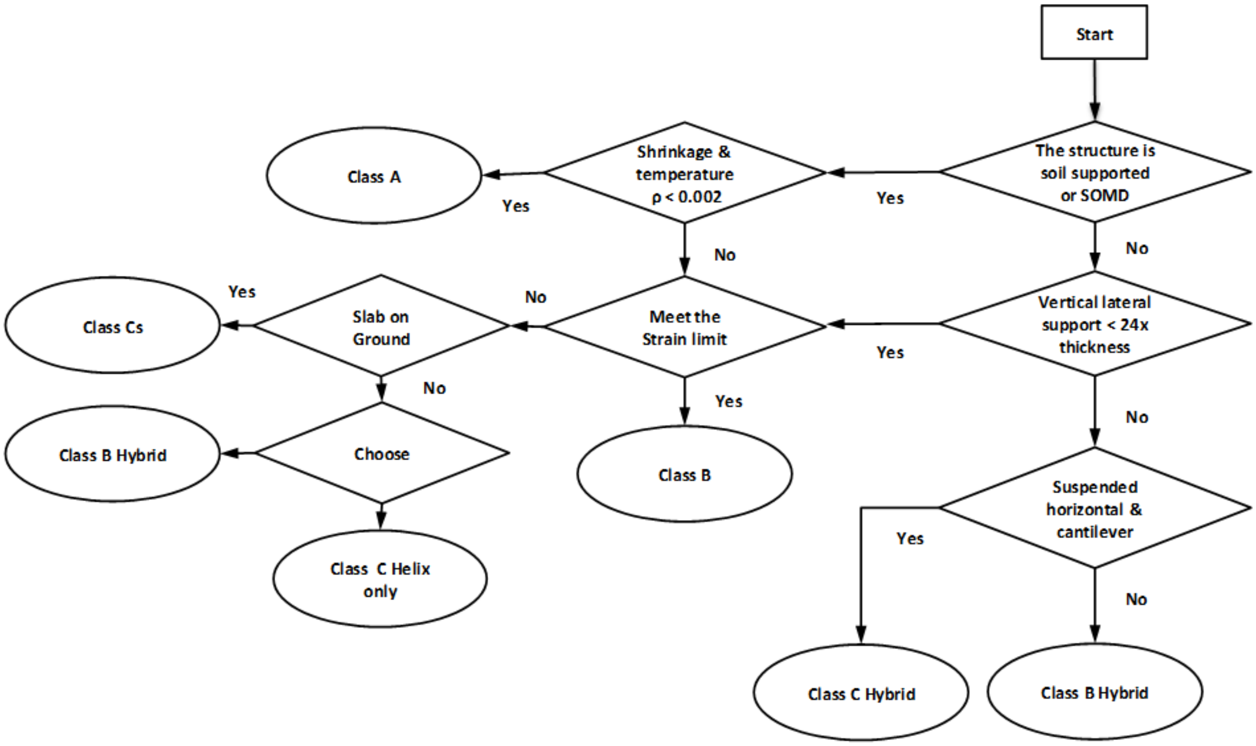
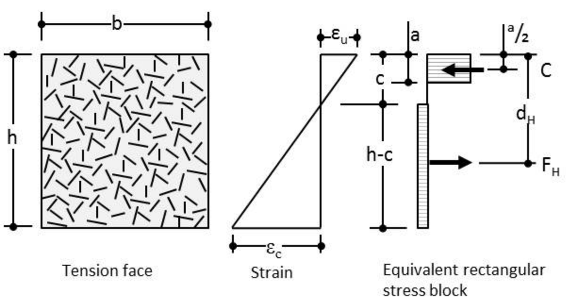


FIGURE 1: Helix Design Class Selection Flow Chart



$$c = \frac{-h+\sqrt{h^2+(1-\beta)\frac{8M}{0.85\Phi f'_c\beta b}}}{2(1-\beta)}$$

$$\Phi A_{s\ req'd\ center\ of\ tension\ zone} = \frac{0.85\Phi f'_c b\beta c}{f_y}$$

Where

M is the required moment capacity of the section calculated per ACI 318. If considering a previously designed section, $M = \phi M_n$. Otherwise, $M = M_u$, where M_u is the factored moment of the section based upon loading.
A_s is the area of steel required at the center of the tension zone (per Section 4.6.1)
$F_H = A_s \times f_y$
f_y is the specified yield strength of the reinforcement
Φ = 1.0 for temperature and shrinkage reinforcement or per applicable code for flexure.

FIGURE 2: Helix Force Equilibrium and Strain Compatibility Diagram

TABLE 1: Helix Micro Rebar Replacement - Imperial

Fy = 60 ksi	Nominal number of Helix Micro Rebar required (Helix/ft)					
Nominal area of steel in tension ΦAs (in²/ft)	3000 psi		4000 psi		5000 psi	
	Class A & B	Class Cs	Class A & B	Class C & Cs	Class A & B	Class C & Cs
0.028	37.8	75.7	37.3	74.6	36.7	73.5
0.040	53.6	107.2	53.1	106.1	52.5	105.0
0.050	66.8	133.5	66.2	132.4	65.7	131.3
0.060	79.9	159.8	79.4	158.7	78.8	157.6
0.080	106.2	212.4	105.7	211.3	105.1	210.2
0.090	119.4	238.7	118.8	237.6	118.3	236.5
0.100	132.5	265.0	132.0	263.9	131.4	262.8
0.110	145.7	291.3	145.1	290.2	144.6	289.1
0.120	158.8	317.6	158.3	316.5	157.7	315.4
0.150	198.2	396.5	197.7	395.4	197.2	394.3
0.160	211.4	422.8	210.9	421.7	210.3	420.6
0.170	224.5	449.1	224.0	448.0	223.5	446.9
0.180	237.7	475.4	237.1	474.3	236.6	473.2
0.200	264.0	528.0	263.4	526.9	262.9	525.8
0.240	316.6	633.2	316.0	632.1	315.5	631.0
0.250	329.7	659.5	329.2	658.4	328.6	657.3
0.300	395.5	791.0	394.9	789.9	394.4	788.8
0.310	408.6	817.3	408.1	816.2	407.5	815.1
0.400	527.0	1054.0	526.4	1052.9	525.9	1051.8
0.440	579.6	1159.2	579.0	1158.1	578.5	1157.0
0.470	619.0	1238.1	618.5	1237.0	617.9	1235.9
0.490	645.3	1290.6	644.8	1289.6	644.2	1288.5
0.500	658.5	1316.9	657.9	1315.8	657.4	1314.8
0.600	790.0	1579.9	789.4	1578.8	788.9	1577.7
0.700	921.5	1842.9	920.9	1841.8	920.4	1840.7
0.760	1000.4	2000.7	999.8	1999.6	999.3	1998.5
0.780	1026.7	2053.3	1026.1	2052.2	1025.6	2051.1
0.790	1039.8	2079.6	1039.3	2078.5	1038.7	2077.4
0.800	1053.0	2105.9	1052.4	2104.8	1051.9	2103.7
0.900	1184.4	2368.9	1183.9	2367.8	1183.3	2366.7
0.950	1250.2	2500.4	1249.6	2499.3	1249.1	2498.2
1.000	1315.9	2631.9	1315.4	2630.8	1314.8	2629.7
1.090	1434.3	2868.6	1433.7	2867.5	1433.2	2866.4
1.250	1644.7	3289.3	1644.1	3288.2	1643.6	3287.1
1.270	1671.0	3341.9	1670.4	3340.8	1669.9	3339.7
1.550	2039.1	4078.3	2038.6	4077.2	2038.0	4076.1
1.950	2565.1	5130.2	2564.6	5129.1	2564.0	5128.0
2.250	2959.6	5919.2	2959.0	5918.1	2958.5	5917.0
2.330	3064.8	6129.6	3064.2	6128.5	3063.7	6127.4
3.040	3998.4	7996.8	3997.8	7995.7	3997.3	7994.6
3.880	5102.9	10205.8	5102.4	10204.7	5101.8	10203.6
4.000	5260.7	10521.4	5260.2	10520.3	5259.6	10519.2
4.500	5918.2	11836.3	5917.6	11835.2	5917.1	11834.1
5.000	6575.6	13151.3	6575.1	13150.2	6574.5	13149.1
5.500	7233.1	14466.2	7232.5	14465.1	7232.0	14464.0
6.000	7890.6	15781.1	7890.0	15780.0	7889.5	15778.9
7.000	9205.5	18411.0	9204.9	18409.9	9204.4	18408.8

TABLE 1: Helix Micro Rebar Replacement- Metric

Fy = 500 Mpa	Nominal number of Helix Micro Rebar required (Helix/m)					
Nominal area of steel in tension ΦAs (mm^2/m)	20 MPa		30 MPa		40 MPa	
	Class A & B	Class Cs	Class A & B	Class C & Cs	Class A & B	Class C & Cs
28	70.0	140.0	69.2	138.5	68.4	136.9
45	111.9	223.8	111.1	222.2	110.3	220.6
50	124.2	248.4	123.4	246.8	122.6	245.2
79	195.6	391.3	194.8	389.7	194.0	388.1
89	220.3	440.5	219.5	438.9	218.7	437.3
90	222.7	445.4	221.9	443.9	221.1	442.3
100	247.3	494.7	246.6	493.1	245.8	491.5
111	274.4	548.9	273.6	547.3	272.9	545.7
113	279.4	558.7	278.6	557.1	277.8	555.6
141	348.3	696.7	347.5	695.1	346.7	693.5
150	370.5	741.0	369.7	739.4	368.9	737.8
154	380.3	760.7	379.5	759.1	378.8	757.5
179	441.9	883.8	441.1	882.2	440.3	880.7
200	493.6	987.3	492.8	985.7	492.0	984.1
201	496.1	992.2	495.3	990.6	494.5	989.0
227	560.1	1120.3	559.3	1118.7	558.5	1117.1
250	616.8	1233.6	616.0	1232.0	615.2	1230.4
290	715.3	1430.6	714.5	1429.0	713.7	1427.4
300	739.9	1479.8	739.1	1478.3	738.3	1476.7
314	774.4	1548.8	773.6	1547.2	772.8	1545.6
350	863.1	1726.1	862.3	1724.5	861.5	1722.9
354	872.9	1745.8	872.1	1744.2	871.3	1742.6
400	986.2	1972.4	985.4	1970.8	984.6	1969.2
450	1109.3	2218.7	1108.6	2217.1	1107.8	2215.5
454	1119.2	2238.4	1118.4	2236.8	1117.6	2235.2
491	1210.3	2420.6	1209.5	2419.1	1208.7	2417.5
500	1232.5	2465.0	1231.7	2463.4	1230.9	2461.8
550	1355.6	2711.3	1354.8	2709.7	1354.0	2708.1
600	1478.8	2957.6	1478.0	2956.0	1477.2	2954.4
616	1518.2	3036.4	1517.4	3034.8	1516.6	3033.2
650	1601.9	3203.8	1601.1	3202.2	1600.3	3200.7
700	1725.1	3450.1	1724.3	3448.5	1723.5	3446.9
750	1848.2	3696.4	1847.4	3694.8	1846.6	3693.2
800	1971.3	3942.7	1970.6	3941.1	1969.8	3939.5
804	1981.2	3962.4	1980.4	3960.8	1979.6	3959.2
850	2094.5	4189.0	2093.7	4187.4	2092.9	4185.8
900	2217.6	4435.3	2216.8	4433.7	2216.0	4432.1
950	2340.8	4681.5	2340.0	4680.0	2339.2	4678.4
1000	2463.9	4927.8	2463.1	4926.2	2462.3	4924.7
1100	2710.2	5420.4	2709.4	5418.8	2708.6	5417.2
1200	2956.5	5913.0	2955.7	5911.4	2954.9	5909.8
1257	3096.9	6193.7	3096.1	6192.1	3095.3	6190.6
1300	3202.8	6405.5	3202.0	6404.0	3201.2	6402.4
1400	3449.1	6898.1	3448.3	6896.5	3447.5	6894.9
1500	3695.3	7390.7	3694.5	7389.1	3693.8	7387.5
1963	4835.6	9671.3	4834.8	9669.7	4834.1	9668.1
2500	6158.2	12316.4	6157.4	12314.8	6156.6	12313.2

TABLE 2: Helix Micro Rebar Dosage Rate - Imperial

Number of Helix per unit area in tension (Helix/in²)	Helix dosage rate, ϕH_d (lb/yd³)										
	3000 psi			4000 psi				5000 psi			
	Class A	Class B	Class C_s	Class A	Class B	Class C	Class C_s	Class A	Class B	Class C	Class C_s
1.18	5.5	7.2	5.5	5.5	7.3	6.6	5.5	5.5	7.5	6.8	5.5
1.25	5.8	7.6	5.8	5.8	7.7	7.0	5.8	5.8	8.0	7.2	5.8
1.43	6.6	8.7	6.6	6.6	8.9	8.0	6.6	6.6	9.1	8.2	6.6
1.50	7.0	9.1	7.0	7.0	9.3	8.4	7.0	7.0	9.6	8.6	7.0
1.53	7.1	9.3	7.1	7.1	9.5	8.5	7.1	7.1	9.7	8.7	7.1
1.75	8.1	10.6	8.1	8.1	10.7	9.7	8.1	8.1	11.0	9.9	8.1
2.00	9.3	12.0	9.3	9.3	12.1	11.0	9.3	9.3	12.4	11.2	9.3
2.25	10.4	13.3	10.4	10.4	13.4	12.3	10.4	10.4	13.7	12.5	10.4
2.50	11.6	14.7	11.6	11.6	14.8	13.6	11.6	11.6	15.1	13.7	11.6
2.75	12.8	16.0	12.8	12.8	16.1	14.9	12.8	12.8	16.6	15.0	12.8
3.00	13.9	17.3	13.9	13.9	17.4	16.1	13.9	13.9	17.9	16.2	13.9
3.25	15.1	18.6	15.1	15.1	18.7	17.4	15.1	15.1	19.1	17.5	15.1
3.50	16.2	19.9	16.2	16.2	20.0	18.6	16.2	16.2	20.6	18.7	16.2
3.75	17.4	21.1	17.4	17.4	21.2	19.8	17.4	17.4	21.8	19.9	17.4
4.00	18.5	22.4	18.5	18.5	22.5	21.1	18.5	18.5	22.9	21.2	18.5
4.25	19.7	23.6	19.7	19.7	23.7	22.3	19.7	19.7	24.3	22.4	19.7
4.50	20.9	24.9	20.9	20.9	25.0	23.5	20.9	20.9	25.5	23.6	20.9
4.75	22.0	26.1	22.0	22.0	26.2	24.7	22.0	22.0	26.9	24.8	22.0
5.00	23.2	27.4	23.2	23.2	27.5	25.9	23.2	23.2	28.3	26.0	23.2
5.25	24.3	28.6	24.3	24.3	28.7	27.1	24.3	24.3	29.3	27.2	24.3
5.50	25.5	29.8	25.5	25.5	29.9	28.3	25.5	25.5	30.7	28.4	25.5
5.75	26.7	31.1	26.7	26.7	31.2	29.5	26.7	26.7	32.1	29.6	26.7
6.00	27.8	32.3	27.8	27.8	32.4	30.8	27.8	27.8	33.1	30.8	27.8
6.25	29.0	33.5	29.0	29.0	33.6	32.0	29.0	29.0	34.5	32.1	29.0
6.50	30.1	34.8	30.1	30.1	34.9	33.2	30.1	30.1	35.9	33.3	30.1
6.75	31.3	36.1	31.3	31.3	36.1	34.4	31.3	31.3	37.3	34.5	31.3
7.00	32.5	37.4	32.5	32.5	37.5	35.7	32.5	32.5	38.7	35.8	32.5
7.25	33.6	38.7	33.6	33.6	38.8	37.0	33.6	33.6	40.0	37.0	33.6
7.50	34.8	40.1	34.8	34.8	40.1	38.2	34.8	34.8	41.4	38.3	34.8
7.75	35.9	41.4	35.9	35.9	41.5	39.5	35.9	35.9	42.8	39.6	35.9
8.00	37.1	42.8	37.1	37.1	42.8	40.8	37.1	37.1	44.2	40.9	37.1
8.25	38.3	44.1	38.3	38.3	44.2	42.1	38.3	38.3	45.6	42.2	38.3
8.50	39.4	45.4	39.4	39.4	45.5	43.3	39.4	39.4	46.9	43.4	39.4
8.75	40.6	46.8	40.6	40.6	46.8	44.6	40.6	40.6	48.3	44.7	40.6
9.00	41.7	48.1	41.7	41.7	48.2	45.9	41.7	41.7	49.7	46.0	41.7
9.25	42.9	49.4	42.9	42.9	49.5	47.2	42.9	42.9	51.1	47.3	42.9
9.50	44.0	50.8	44.0	44.0	50.9	48.4	44.0	44.0	52.5	48.5	44.0
9.75	45.2	52.1	45.2	45.2	52.2	49.7	45.2	45.2	53.8	49.8	45.2
10.00	46.4	53.5	46.4	46.4	53.5	51.0	46.4	46.4	55.2	51.1	46.4
10.25	47.5	54.8	47.5	47.5	54.9	52.3	47.5	47.5	56.6	52.4	47.5
10.50	48.7	56.1	48.7	48.7	56.2	53.6	48.7	48.7	58.0	53.6	48.7
10.75	49.8	57.5	49.8	49.8	57.6	54.8	49.8	49.8	59.4	54.9	49.8
11.00	51.0	58.8	51.0	51.0	58.9	56.1	51.0	51.0	60.7	56.2	51.0
11.25	52.2	60.2	52.2	52.2	60.2	57.4	52.2	52.2	62.1	57.5	52.2
11.50	53.3	61.5	53.3	53.3	61.6	58.7	53.3	53.3	63.5	58.7	53.3
11.75	54.5	62.8	54.5	54.5	62.9	59.9	54.5	54.5	64.9	60.0	54.5
12.00	55.6	64.2	55.6	55.6	64.3	61.2	55.6	55.6	66.3	61.3	55.6

TABLE 2: Helix Micro Rebar Dosage Rate - Metric

Number of Helix per unit area in tension (Helix/m²)	Helix dosage rate, ϕH_d (kg/m³)										
	20 MPa			30 MPa				40 MPa			
	Class A	Class B	Class C_s	Class A	Class B	Class C	Class C_s	Class A	Class B	Class C	Class C_s
2000	3.5	4.6	3.5	3.5	4.8	4.3	3.5	3.5	4.9	4.5	3.5
2500	4.4	5.8	4.4	4.4	5.9	5.3	4.4	4.4	6.0	5.5	4.4
3000	5.3	6.9	5.3	5.3	7.0	6.4	5.3	5.3	7.1	6.5	5.3
3500	6.2	7.9	6.2	6.2	8.0	7.3	6.2	6.2	8.1	7.5	6.2
4000	7.1	8.9	7.1	7.1	9.0	8.3	7.1	7.1	9.1	8.5	7.1
4500	8.0	10.0	8.0	8.0	10.1	9.3	8.0	8.0	10.1	9.4	8.0
5000	8.9	10.9	8.9	8.9	11.0	10.2	8.9	8.9	11.1	10.4	8.9
5500	9.8	11.9	9.8	9.8	12.0	11.2	9.8	9.8	12.1	11.3	9.8
6000	10.6	12.9	10.6	10.6	13.0	12.1	10.6	10.6	13.1	12.2	10.6
6500	11.5	13.9	11.5	11.5	13.9	13.1	11.5	11.5	14.0	13.2	11.5
7000	12.4	14.8	12.4	12.4	14.9	14.0	12.4	12.4	15.0	14.1	12.4
7500	13.3	15.8	13.3	13.3	15.8	14.9	13.3	13.3	15.9	15.0	13.3
8000	14.2	16.7	14.2	14.2	16.8	15.9	14.2	14.2	16.8	15.9	14.2
8500	15.1	17.7	15.1	15.1	17.7	16.8	15.1	15.1	17.8	16.9	15.1
9000	16.0	18.6	16.0	16.0	18.7	17.7	16.0	16.0	18.7	17.8	16.0
9500	16.9	19.5	16.9	16.9	19.6	18.6	16.9	16.9	19.7	18.7	16.9
10000	17.7	20.5	17.7	17.7	20.6	19.6	17.7	17.7	20.6	19.6	17.7
10500	18.6	21.5	18.6	18.6	21.5	20.5	18.6	18.6	21.6	20.6	18.6
11000	19.5	22.5	19.5	19.5	22.6	21.5	19.5	19.5	22.6	21.6	19.5
11500	20.4	23.5	20.4	20.4	23.6	22.5	20.4	20.4	23.6	22.5	20.4
12000	21.3	24.5	21.3	21.3	24.6	23.4	21.3	21.3	24.7	23.5	21.3
12500	22.2	25.6	22.2	22.2	25.6	24.4	22.2	22.2	25.7	24.5	22.2
13000	23.1	26.6	23.1	23.1	26.7	25.4	23.1	23.1	26.7	25.5	23.1
13500	24.0	27.6	24.0	24.0	27.7	26.4	24.0	24.0	27.7	26.4	24.0
14000	24.8	28.6	24.8	24.8	28.7	27.3	24.8	24.8	28.8	27.4	24.8
14500	25.7	29.7	25.7	25.7	29.7	28.3	25.7	25.7	29.8	28.4	25.7
15000	26.6	30.7	26.6	26.6	30.8	29.3	26.6	26.6	30.8	29.4	26.6
15500	27.5	31.7	27.5	27.5	31.8	30.3	27.5	27.5	31.8	30.4	27.5
16000	28.4	32.8	28.4	28.4	32.8	31.3	28.4	28.4	32.9	31.3	28.4
16500	29.3	33.8	29.3	29.3	33.8	32.2	29.3	29.3	33.9	32.3	29.3
17000	30.2	34.8	30.2	30.2	34.9	33.2	30.2	30.2	34.9	33.3	30.2
17500	31.1	35.8	31.1	31.1	35.9	34.2	31.1	31.1	35.9	34.3	31.1
18000	31.9	36.9	31.9	31.9	36.9	35.2	31.9	31.9	37.0	35.2	31.9
18500	32.8	37.9	32.8	32.8	37.9	36.1	32.8	32.8	38.0	36.2	32.8
19000	33.7	38.9	33.7	33.7	39.0	37.1	33.7	33.7	39.0	37.2	33.7
19500	34.6	39.9	34.6	34.6	40.0	38.1	34.6	34.6	40.0	38.2	34.6
20000	35.5	41.0	35.5	35.5	41.0	39.1	35.5	35.5	41.1	39.1	35.5
20500	36.4	42.0	36.4	36.4	42.0	40.1	36.4	36.4	42.1	40.1	36.4
21000	37.3	43.0	37.3	37.3	43.1	41.0	37.3	37.3	43.1	41.1	37.3
21500	38.2	44.0	38.2	38.2	44.1	42.0	38.2	38.2	44.2	42.1	38.2
22000	39.0	45.1	39.0	39.0	45.1	43.0	39.0	39.0	45.2	43.1	39.0
22500	39.9	46.1	39.9	39.9	46.1	44.0	39.9	39.9	46.2	44.0	39.9
23000	40.8	47.1	40.8	40.8	47.2	44.9	40.8	40.8	47.2	45.0	40.8
23500	41.7	48.1	41.7	41.7	48.2	45.9	41.7	41.7	48.3	46.0	41.7
24000	42.6	49.2	42.6	42.6	49.2	46.9	42.6	42.6	49.3	47.0	42.6
24500	43.5	50.2	43.5	43.5	50.2	47.9	43.5	43.5	50.3	47.9	43.5
25000	44.4	51.2	44.4	44.4	51.3	48.8	44.4	44.4	51.3	48.9	44.4

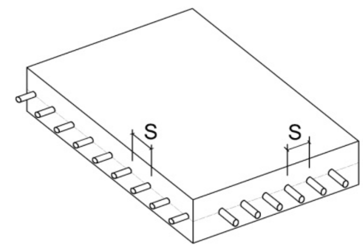
TABLE 3: Helix Micro Rebar Tensile Force - Imperial

Number of Helix per unit area in tension (Helix/in^2)	Provided Helix unit tensile stress, F_{ht} (psi)										
	3000 psi			4000 psi				5000 psi			
	Class A	Class B	Class C_s	Class A	Class B	Class C	Class C_s	Class A	Class B	Class C	Class C_s
1.18	46.2	62.8	19.2	50.3	68.4	28.9	23.4	54.5	74.7	34.0	27.6
1.25	49.4	67.1	20.8	53.5	72.7	30.8	25.0	57.7	79.0	35.9	29.2
1.43	57.6	78.2	24.9	61.7	83.8	35.8	29.1	65.9	90.3	40.9	33.3
1.50	60.8	82.2	26.5	64.9	87.8	37.7	30.7	69.1	94.7	42.7	34.9
1.53	62.1	83.9	27.2	66.3	89.5	38.5	31.4	70.5	96.5	43.5	35.6
1.75	72.2	96.2	32.2	76.4	101.8	44.2	36.4	80.5	108.8	49.2	40.6
2.00	83.6	110.0	38.0	87.8	115.4	50.7	42.1	91.9	122.6	55.7	46.3
2.25	95.0	123.4	43.7	99.2	128.9	57.0	47.8	103.3	136.0	62.0	52.0
2.50	106.4	136.7	49.4	110.6	142.0	63.3	53.5	114.7	149.0	68.2	57.7
2.75	117.8	149.7	55.1	122.0	155.0	69.6	59.2	126.2	163.8	74.5	63.4
3.00	129.2	162.6	60.8	133.4	167.8	75.8	64.9	137.6	176.4	80.6	69.1
3.25	140.6	175.3	66.5	144.8	180.5	81.9	70.6	149.0	188.6	86.7	74.8
3.50	152.1	187.9	72.2	156.2	193.0	88.0	76.4	160.4	203.0	92.8	80.5
3.75	163.5	200.4	77.9	167.6	205.5	94.0	82.1	171.8	214.7	98.8	86.2
4.00	174.9	212.8	83.6	179.0	217.8	100.1	87.8	183.2	226.2	104.8	91.9
4.25	186.3	225.1	89.3	190.5	230.1	106.1	93.5	194.6	240.3	110.8	97.6
4.50	197.7	237.4	95.0	201.9	242.4	112.1	99.2	206.0	251.3	116.8	103.3
4.75	209.1	249.6	100.7	213.3	254.5	118.1	104.9	217.4	265.2	122.7	109.0
5.00	220.5	261.8	106.4	224.7	266.7	124.0	110.6	228.8	279.1	128.7	114.7
5.25	231.9	273.9	112.1	236.1	278.8	130.0	116.3	240.3	289.5	134.6	120.5
5.50	243.3	286.1	117.8	247.5	291.0	135.9	122.0	251.7	303.2	140.6	126.2
5.75	254.7	298.2	123.5	258.9	303.1	141.9	127.7	263.1	317.0	146.5	131.9
6.00	266.2	310.4	129.2	270.3	315.2	147.8	133.4	274.5	326.8	152.5	137.6
6.25	277.6	322.5	134.9	281.7	327.4	153.8	139.1	285.9	340.4	158.4	143.3
6.50	289.0	334.7	140.6	293.1	339.5	159.8	144.8	297.3	353.9	164.4	149.0
6.75	300.4	347.2	146.3	304.6	352.0	165.8	150.5	308.7	367.5	170.4	154.7
7.00	311.8	360.4	152.1	316.0	365.2	172.1	156.2	320.1	381.1	176.7	160.4
7.25	323.2	373.6	157.8	327.4	378.4	178.4	161.9	331.5	394.7	183.0	166.1
7.50	334.6	386.8	163.5	338.8	391.6	184.7	167.6	342.9	408.3	189.3	171.8
7.75	346.0	400.0	169.2	350.2	404.8	190.9	173.3	354.4	421.9	195.5	177.5
8.00	357.4	413.1	174.9	361.6	418.0	197.2	179.0	365.8	435.4	201.8	183.2
8.25	368.8	426.3	180.6	373.0	431.1	203.5	184.7	377.2	449.0	208.1	188.9
8.50	380.3	439.5	186.3	384.4	444.3	209.8	190.5	388.6	462.6	214.4	194.6
8.75	391.7	452.7	192.0	395.8	457.5	216.1	196.2	400.0	476.2	220.7	200.3
9.00	403.1	465.9	197.7	407.2	470.7	222.4	201.9	411.4	489.8	226.9	206.0
9.25	414.5	479.1	203.4	418.7	483.9	228.6	207.6	422.8	503.4	233.2	211.7
9.50	425.9	492.2	209.1	430.1	497.1	234.9	213.3	434.2	516.9	239.5	217.4
9.75	437.3	505.4	214.8	441.5	510.3	241.2	219.0	445.6	530.5	245.8	223.1
10.00	448.7	518.6	220.5	452.9	523.4	247.5	224.7	457.0	544.1	252.1	228.8
10.25	460.1	531.8	226.2	464.3	536.6	253.8	230.4	468.5	557.7	258.4	234.6
10.50	471.5	545.0	231.9	475.7	549.8	260.0	236.1	479.9	571.3	264.6	240.3
10.75	482.9	558.2	237.6	487.1	563.0	266.3	241.8	491.3	584.9	270.9	246.0
11.00	494.4	571.4	243.3	498.5	576.2	272.6	247.5	502.7	598.4	277.2	251.7
11.25	505.8	584.6	249.0	509.9	589.4	278.9	253.2	514.1	612.0	283.5	257.4
11.50	517.2	597.7	254.7	521.3	602.6	285.2	258.9	525.5	625.6	289.8	263.1
11.75	528.6	610.9	260.4	532.8	615.7	291.5	264.6	536.9	639.2	296.0	268.8
12.00	540.0	624.1	266.2	544.2	628.9	297.7	270.3	548.3	652.8	302.3	274.5

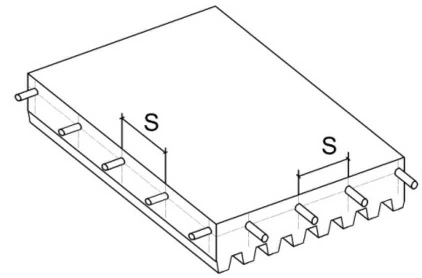
TABLE 3: Helix Micro Rebar Tensile Force - Metric

Number of Helix per unit area in tension (Helix/m²)	Provided Helix unit tensile stress, F_{ht} (MPa)										
	20 MPa			30 MPa				40 MPa			
	Class A	Class B	Class C_S	Class A	Class B	Class C	Class C_S	Class A	Class B	Class C	Class C_S
2000	0.35	0.47	0.15	0.39	0.53	0.23	0.19	0.43	0.59	0.28	0.23
2500	0.45	0.61	0.20	0.49	0.66	0.29	0.24	0.53	0.72	0.34	0.28
3000	0.55	0.73	0.25	0.59	0.78	0.35	0.29	0.64	0.84	0.40	0.33
3500	0.65	0.85	0.30	0.70	0.90	0.41	0.34	0.74	0.96	0.46	0.38
4000	0.76	0.97	0.35	0.80	1.02	0.46	0.39	0.84	1.07	0.51	0.43
4500	0.86	1.08	0.40	0.90	1.14	0.52	0.44	0.94	1.19	0.57	0.48
5000	0.96	1.20	0.45	1.00	1.25	0.57	0.49	1.04	1.30	0.62	0.53
5500	1.06	1.31	0.50	1.10	1.36	0.63	0.54	1.14	1.41	0.67	0.59
6000	1.16	1.42	0.55	1.20	1.47	0.68	0.59	1.25	1.52	0.73	0.64
6500	1.26	1.53	0.60	1.31	1.58	0.73	0.65	1.35	1.63	0.78	0.69
7000	1.37	1.64	0.65	1.41	1.69	0.79	0.70	1.45	1.74	0.83	0.74
7500	1.47	1.75	0.71	1.51	1.80	0.84	0.75	1.55	1.85	0.89	0.79
8000	1.57	1.86	0.76	1.61	1.90	0.89	0.80	1.65	1.95	0.94	0.84
8500	1.67	1.96	0.81	1.71	2.01	0.95	0.85	1.75	2.06	0.99	0.89
9000	1.77	2.07	0.86	1.81	2.12	1.00	0.90	1.85	2.17	1.04	0.94
9500	1.87	2.18	0.91	1.91	2.23	1.05	0.95	1.96	2.28	1.10	0.99
10000	1.97	2.29	0.96	2.02	2.34	1.10	1.00	2.06	2.38	1.15	1.04
10500	2.08	2.40	1.01	2.12	2.45	1.16	1.05	2.16	2.50	1.20	1.09
11000	2.18	2.52	1.06	2.22	2.57	1.21	1.10	2.26	2.61	1.26	1.14
11500	2.28	2.63	1.11	2.32	2.68	1.27	1.15	2.36	2.73	1.32	1.19
12000	2.38	2.75	1.16	2.42	2.80	1.33	1.20	2.46	2.85	1.37	1.25
12500	2.48	2.87	1.21	2.52	2.92	1.38	1.25	2.56	2.97	1.43	1.30
13000	2.58	2.99	1.26	2.62	3.03	1.44	1.31	2.67	3.08	1.48	1.35
13500	2.68	3.10	1.31	2.73	3.15	1.49	1.36	2.77	3.20	1.54	1.40
14000	2.79	3.22	1.37	2.83	3.27	1.55	1.41	2.87	3.32	1.60	1.45
14500	2.89	3.34	1.42	2.93	3.39	1.61	1.46	2.97	3.43	1.65	1.50
15000	2.99	3.46	1.47	3.03	3.50	1.66	1.51	3.07	3.55	1.71	1.55
15500	3.09	3.57	1.52	3.13	3.62	1.72	1.56	3.17	3.67	1.76	1.60
16000	3.19	3.69	1.57	3.23	3.74	1.77	1.61	3.28	3.79	1.82	1.65
16500	3.29	3.81	1.62	3.34	3.86	1.83	1.66	3.38	3.90	1.88	1.70
17000	3.40	3.93	1.67	3.44	3.97	1.89	1.71	3.48	4.02	1.93	1.75
17500	3.50	4.04	1.72	3.54	4.09	1.94	1.76	3.58	4.14	1.99	1.80
18000	3.60	4.16	1.77	3.64	4.21	2.00	1.81	3.68	4.26	2.04	1.85
18500	3.70	4.28	1.82	3.74	4.33	2.05	1.86	3.78	4.37	2.10	1.91
19000	3.80	4.39	1.87	3.84	4.44	2.11	1.91	3.88	4.49	2.15	1.96
19500	3.90	4.51	1.92	3.94	4.56	2.16	1.97	3.99	4.61	2.21	2.01
20000	4.00	4.63	1.97	4.05	4.68	2.22	2.02	4.09	4.73	2.27	2.06
20500	4.11	4.75	2.02	4.15	4.79	2.28	2.07	4.19	4.84	2.32	2.11
21000	4.21	4.86	2.08	4.25	4.91	2.33	2.12	4.29	4.96	2.38	2.16
21500	4.31	4.98	2.13	4.35	5.03	2.39	2.17	4.39	5.08	2.43	2.21
22000	4.41	5.10	2.18	4.45	5.15	2.44	2.22	4.49	5.20	2.49	2.26
22500	4.51	5.22	2.23	4.55	5.26	2.50	2.27	4.59	5.31	2.55	2.31
23000	4.61	5.33	2.28	4.65	5.38	2.56	2.32	4.70	5.43	2.60	2.36
23500	4.71	5.45	2.33	4.76	5.50	2.61	2.37	4.80	5.55	2.66	2.41
24000	4.82	5.57	2.38	4.86	5.62	2.67	2.42	4.90	5.66	2.71	2.46
24500	4.92	5.69	2.43	4.96	5.73	2.72	2.47	5.00	5.78	2.77	2.51
25000	5.02	5.80	2.48	5.06	5.85	2.78	2.52	5.10	5.90	2.83	2.56

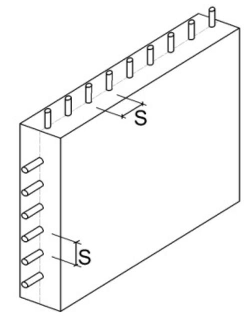
EXAMPLE 1: Class A Slab on Grade Design – Original Rebar Design Given

Imperial Units	**Metric Units**		
Given: **8" slab on ground with** **#4 bars @ 14" OCEW mid depth** f_y **= 60000 psi** f'_c**= 4000 psi** **b =12 in** **ϕ = 1.0**	**Given:** **254 mm slab on ground with** **12mm bars @ 300 mm OCEW mid depth** **fy = 500 MPa** f'_c**= 30 MPa** **b =1000 mm** **ϕ = 1.0**	 	
Calculation in accordance with ACI 318 and this report		**Code Reference**	**Report Reference**
Step 1. Class Selection 1 - Slab on ground (Soil supported) 2 - Shrinkage & temperature reinforcement less than ρ = 0.0020 ⇨ Class A	Step 1. Class Selection 1 - Slab on ground (Soil supported), 2 - Shrinkage & temperature reinforcement less than ρ=0.0020 ⇨ Class A		**4.1**
Step 2. Compute area of steel required at the center of the section, ΦAs = 1.0 x 0.2 x 12/14 in = 0.17 in^2 /ft ρ = 0.0018 (The rebar configuration is given, but if it were not given, it would be computed based on the loads using standard ACI 318 methods)	Step 2. Compute area of steel required at the center of the section ΦAs = 1.0 x 116 x 1000 / 300mm = 377 mm^2 /m ρ = 0.0015 (The rebar configuration is given, but if it were not given, it would be computed based on the loads using standard ACI 318 methods)	ACI 318-14 24.4 ACI 318-11 7.12 ACI 318-08 7.12	**4.6.1**
Step 3. Use Table 1, find the nearest area of steel in column 1 and read the required number of Helix for the appropriate compressive strength: = 224 pieces of Helix Micro Rebar	Step 3. Use Table 1, find the nearest area of steel in column 1 and read the required number of Helix for the appropriate compressive strength: = 985.4 pieces of Helix Micro Rebar		**4.6.2** **Table 1**
Step 4. Divide number of Helix required by the area in tension, A_g = 224/(8x 12 in) = 2.33 Helix per square inch	Step 4. Divide number of Helix required by the area in tension, $A_{g:}$ = 985.4 x 1000^2/(254*1000 mm) = 3880 Helix per square meter		**4.6.2**
Step 5. Use Table 2, find the nearest number of Helix per unit area in column 1 and read the required Helix dosage for the appropriate class and compressive strength: **Required Helix Dosage 10.9 lb/yd³**	Step 5. Use Table 2, find the nearest number of Helix per unit area in column 1 and read the required Helix dosage for the appropriate class and compressive strength: **Required Helix Dosage 7.1 kg/m³**		**4.6.3** **Table 2**

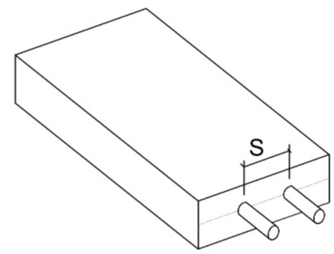
EXAMPLE 2: Class A Slab on Metal Deck – Original Mesh Given

Imperial Units	**Metric Units**		
Given: **Slab on non-composite metal deck 5” total thickness, 2” metal deck with 6”x 6”- W2.9 x W2.9 welded wire mesh** **f_y = 60000 psi** **f'_c= 4000 psi** **b =12 in** **ϕ = 1.0**	**Given:** **Slab on non-composite metal deck 125 mm total thickness, 50 mm metal deck with welded wire mesh 6mm dia x 200mm spacing** **f_y = 500 MPa** **f'_c= 30 MPa** **b =1000 mm** **ϕ = 1.0**		
Calculation in accordance with ACI 318 and this report		**Code Reference**	**Report Reference**
Step 1. Class Selection 1 - Slab on non-composite metal deck 2 - Shrinkage and temperature reinforcement less than ρ=0.0020 ⇨ Class A	Step 1. Class Selection 1 - Slab on non-composite metal deck 2 - Shrinkage and temperature reinforcement less than ρ=0.0020 ⇨ Class A		**4.1**
Step 2. Compute area of steel required at the center of the section ΦA_s =0.058in^2 /ft ρ=0.0016	Step 2. Compute area of steel required at the center of the section ΦA_s =141 mm^2 /m ρ=0.0019	ACI 318-14 24.4 ACI 318-11 7.12 ACI 318-08 7.12	**4.6.1**
Step 3. Use Table 1, find the nearest area of steel in column 1 and read the required number of Helix for the appropriate compressive strength: = 79.4 pieces of Helix Micro Rebar	Step 3. Use Table 1, find the nearest area of steel in column 1 and read the required number of Helix for the appropriate compressive strength: = 347.5 pieces of Helix Micro Rebar		**4.6.2** **Table 1**
Step 4. Divide required number of Helix by the gross section area in tension, A_g: = 79.4/(3x12 in) = 2.2 Helix per square inch. Note: the 5” thickness is reduced to 3 inches due to the 2” deep corrugated metal deck.	Step 4. Divide number of Helix required by the gross section area in tension, A_g: = 347.5 x 1000^2/(75 x 1000mm) =4633 Helix per square meter. Note: the 125 mm thickness is reduced to 75 mm due to the 50 mm deep corrugated metal deck.		**4.6.2**
Step 5. Use Table 2, find the nearest number of Helix per unit area in column 1 and read the required Helix dosage for the appropriate compressive strength: **Required Helix Dosage 10.4 lb/yd^3**	Step 5. Use Table 2, find the nearest number of Helix per unit area in column 1 and read the required Helix dosage for the appropriate compressive strength: **Required Helix Dosage 8.9 kg/m^3.**		**4.6.3** **Table 2**

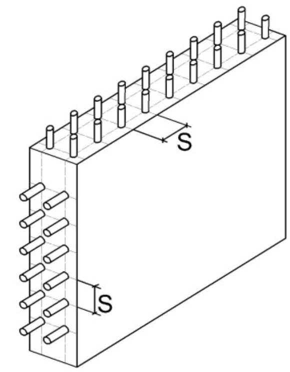
EXAMPLE 3: Class B Wall Design –Minimum Reinforcement Ratio Given

English/Imperial Units	**Metric Units**		
Given: **Wall 12' high x 6" thick with (ρ_{min}=0.0025) #4 bars @ 12" OCEW -at mid-depth** **f_y = 60000 psi** **f'_c= 4000 psi** **b =12 in** **ϕ = 0.9** ϕMn = 31 kip-in/ft = 31,000 lb-in/ft	**Given:** **Wall 3.6m high x 150 mm thick with (ρ_{min}=0.0025) 12mm bar @300 mm OCEW at mid-depth** **fy = 500 MPa** **f'_c= 30 MPa** **b =1000 mm** **ϕ = 0.8** ϕMn = 10.8 kN-m/m	 	
Calculation in accordance with ACI 318 and this report		**Code Reference**	**Report Reference**
Step 1. Class Selection • Vertical structural support • Slenderness check, h/24 =12' x 12"/24 = 6" OK ⇨ Class B	Step 1. Class Selection • Vertical structural support • Slenderness check, h/24 = 3.6m x 1000mm/24 = 150 OK ⇨ Class B	ACI 318-14 Section 14.3.1.1 ACI 318-11 Section 22.6.6.2 ACI 318-08 Section 22.6.6.2	**4.1**
Step 2. Compute required area of steel at the center of the tension zone using equations in Figure 2: Calculate the neutral axis depth, "c". c = 0. 0.328" Required area of steel = 0.17 in^2/ft at tension zone center	Step 2. Compute required area of steel at the center of the tension zone using equations in Figure 2: Calculate the neutral axis depth, "c". c = 8.33 mm Required area of steel= 286 mm^2/m	ACI 318-14 Cpt. 9 ACI 318-11 Cpt. 10 ACI 318-08 Cpt. 10 (Rebar given, but if it were not given it would be computed based on the loads using standard ACI 318 methods)	**4.6.1 Figure 2**
Step 3. Use Table 1, find the nearest area of steel in column 1 and read the required number of Helix for the appropriate compressive strength: = 224 pieces of Helix Micro Rebar	Step 3. Use Table 1, find the nearest area of steel in column 1 and read the required number of Helix for the appropriate compressive strength: = 715 pieces of Helix Micro Rebar.		**4.6.2** **Table 1**
Step 4. Divide number of Helix required by the area in tension, A_T A_T = b x (h-c) = 12 x 5.7 = 68.4 in^2 = 224/ (68.4 in^2) = 3.27 Helix per square inch	Step 4. Divide number of Helix required by the area in tension, A_T A_T = b x (h-c) = 1000mm x (150mm - 8.33 mm) x $(1m/1000mm)^2$ = 0.142 m^2 = 715/ 0.142 = 5035 Helix per square meter		**4.6.2** **4.6.1 Figure 2**
Step 5. Use Table 2, find the nearest number of Helix per unit area in column 1 and read the required Helix dosage for the appropriate class and compressive strength: **Required Helix Dosage 18.7 lb/yd³**	Step 5. Use Table 2, find the nearest number of Helix per unit area in column 1 and read the required Helix dosage for the appropriate class and compressive strength: **Required Helix Dosage 11.1 kg/m³**		**4.6.3** **Table 2**
Step 6. Use Table 3 & result of step 4 to find Helix tensile stress, = 181 psi = $181 \times 10^6 / (57000\sqrt{4000})$ = 50 micro strain	Step 6. Use Table 3 & result of step 4 to find Helix tensile stress: =1.25 MPa Strain = $1.25 \times 10^6 / (4700\sqrt{30})$ = 49 micro strain		**4.6.4** **Table 3**
Step 7. Use result of step 4 to find allowable strain = 105 > 50 OK	Step 7. Use result of step 4 to find allowable strain = 105 > 49 OK		**5.7**

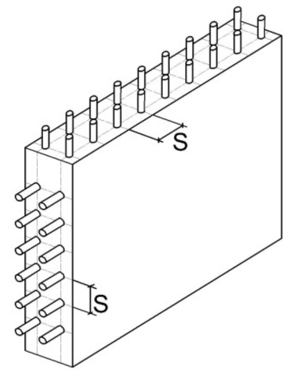
EXAMPLE 4: Class B Grade Beam Shear Design Only – Original Shear Rebar Given

English/Imperial Units	**Metric Units**		
Given: **Grade beam 8” thick with #4 bars @12” shear ties.** **f_y = 60000 psi** **f'_c= 4000 psi** **b =12 in** **ϕ = 0.75**	**Given:** **Grade Beam 200 mm thick with 12mm bars @ 300 mm shear ties.** **fy = 500 MPa** **f'_c= 40 MPa** **b =1000 mm** **ϕ = 0.75**		
Calculation in accordance with ACI 318 and this report		**Code Reference**	**Report Reference**
Step 1. Class Selection ⇨ Class B	Step 1. Class Selection ⇨ Class B		**4.1**
Step 2. Compute Required Area of Steel for shear resistance, #4@12” (Given).	Step 2. Compute Required Area of Steel for shear resistance, N 12 @300 (Given).		
Step 3. Compute required area of steel assuming rebar inclined at 45 degrees, ϕAs = ϕA_v x sin(45) x b/s = 0.75 x 0.2 x .707 x 12”/12” = 0.106 in^2/ft	Step 3. Compute required area of steel assuming rebar inclined at 45 degrees, ϕAs= ϕA_v x sin(45) x b/s = 0.75 x 113 x 0.707 x1000/300 mm = 200 mm^2/m	ACI 318-14 Section 22.5.10.6.2 ACI 318-11 Section 11.4.7.5 ACI 318-08 Section 11.4.7.5	**4.6.1**
Step 4. Use Table 1, find the nearest area of steel in column 1 and read the required number of Helix for the appropriate compressive strength: = 145.1 pieces of Helix Micro Rebar	Step 4. Use Table 1, find the nearest area of steel in column 1 and read the required number of Helix for the appropriate compressive strength: = 492 pieces of Helix Micro Rebar		**4.6.2** **Table 1**
Step 5. Compute shear area based on diagonal tension plane = h x 1.41 x b = 8 x 1.41 x 12 = 135 in^2/ft	Step 5. Compute shear area based on diagonal tension plane = h x 1.41 x b = 200 x 1.41 x 1000 mm/1000^2 = 0.282 m^2/m		
Step 6. Divide number of Helix required by the shear area, =145.1/135 =1.07 Helix per square inch	Step 6. Divide Number of Helix Required Area, = 492/0.282 = 1745 Helix per square meter		**4.6.8**
Step 7. Use Table 2, find the nearest number of Helix per unit area in column 1 and read the required Helix dosage for the appropriate class and compressive strength: **Required Helix dosage 7.3 lb/yd^3** **Less than minimum, use 9 lb/yd^3**	Step 7. Use Table 2, find the nearest number of Helix per unit area in column 1 and read the required Helix dosage for the appropriate class and compressive strength: **Required Helix dosage 4.9kg/m^3** **Less than minimum, use 5 kg/m^3**		**4.6.3** **Table 2**

EXAMPLE 5: Class B Wall Design – Hybrid

English/Imperial Units	**Metric Units**		
Given: **Wall 20' high x 10" thick with** **2- Layers #6 bars @ 10" OCEW** **As = 0.53 in^2/ft** **(ρ = 0.0088)** **ϕM = 220 k-in/ft** **C_c = 1.5 in** **f_y = 60000 psi** **f'_c = 4000 psi** **b =12 in** **ϕ = 0.9**	**Given:** **Wall 6m high x 254 mm thick with** **2 -Layers 16mm bars @200 mm OCEW** **As = 1000 mm^2/m** **(ρ =0.0079)** **ϕM = 83 kN-m/m** **C_c = 40 mm** **fy = 500 MPa** **f'_c = 30 MPa** **b =1000 mm** **ϕ = 0.8**	 	
Calculation in accordance with ACI 318 and this report		**Code Reference**	**Report Reference**
Step 1. Class Selection Vertical structural support • Slenderness check, h/24 =20 x12/24 =10" OK • Strain check Rebar Tension= As Fy = 31,800 lb Helix tensile stress= = T [(h-C_c)/(h/2)]/(bh)= = 31,800[1.7]/(10x12) = = 450 psi = 450x10^6/(57000$\sqrt{4000}$) = 125 micro strain • Allowable strain Number of Helix/in^2= 8.0 110 micro strain < 125 Not OK ⇨Class B Hybrid	Step 1. Class Selection Vertical structural support • Slenderness check, h/24 =6 x 1000/24 =250mm OK • Strain check Rebar Tension= As Fy =500000 N Helix tensile stress= = T [(h-C_c)/(h/2)]/(bh)= = 500000[1.7]/(254x1000) = = 3.36 MPa = 3.36 x10^6/(4700$\sqrt{30}$) = 130 micro strain • Allowable strain Number of Helix/in^2= 8.0 110 micro strain < 130 Not OK ⇨Class B Hybrid		**4.1** **4.6.5** **5.7**
Step 2. Calculate minimum As As = $3\sqrt{f'c}$ bd/fy = 3$\sqrt{4000}$ x 12 x 8.2 / 60000 = 0.31 in^2/ft Use #5 at 12 in = 0.31 in^2/ft	Step 2. Calculate minimum As As=$0.25\sqrt{f'c}$ bd/fy = 0.25$\sqrt{30}$ x 1000 x 206 / 500 = 564 mm^2 /m use 12mm at 200mm = 550 mm^2/m	ACI 318-14 Chapter 9 ACI 318-11 Chapter 10 ACI 318-08 Chapter 10	**4.7.2**
Step 3. Calculate the moment for the Hybrid rebar ϕM= ϕAs x fy x(h/2)=84 k-in/ft	Step 3. Calculate the moment for the Hybrid rebar ϕM= ϕAs x fy x(h/2)= 28 KN-m/m		
Step 4. Calculate Helix required bending moment ϕM= 220-84= 136 k-in/ft	Step 4. Calculate Helix required bending moment ϕM=83-28 = 55 KN-m/m		
Step 5. Calculate the equivalent area of steel for the bending moment that Helix requires Using equation in Figure 2, calculate the neutral axis depth, "c" c = 0.86" As at tension zone center = 0.448 in^2/ft	Step 5. Calculate the equivalent area of steel for the bending moment that Helix requires Using equation in Figure 2, calculate the neutral axis depth, "c" c = 24.9 mm As at tension zone center = 846 mm^2/m	ACI 318-14 Chapter 9 ACI 318-11 and ACI 318-08 Chapter 10	**4.6.1** **Figure 2**

EXAMPLE 5: Class B Wall Design – Hybrid

English/Imperial Units	Metric Units	
Given: **Wall 20' high x 10" thick with** **2- Layers #6 bars @ 10" OCEW** **As = 0.53 in²/ft** **(ρ = 0.0088)** **ϕM = 220 k-in/ft** **C_c = 1.5 in** **f_y = 60000 psi** **f'_c = 4000 psi** **b =12 in** **ϕ = 0.9**	**Given:** **Wall 6m high x 254 mm thick with** **2 -Layers 16mm bars @200 mm OCEW** **As = 1000 mm²/m** **(ρ =0.0079)** **ϕM = 83 kN-m/m** **C_c = 40 mm** **fy = 500 MPa** **f'_c = 30 MPa** **b =1000 mm** **ϕ = 0.8**	

Calculation in accordance with ACI 318 and this report		Code Reference	Report Reference
Step 6. Use Table 1, find the nearest area of steel in column 1 and read the required number of Helix for the appropriate compressive strength: = 590 pieces of Helix Micro Rebar	Step 6. Use Table 1, find the nearest area of steel in column 1 and read the required number of Helix for the appropriate compressive strength: = 2093 pieces of Helix Micro Rebar.		**4.6.2** **Table 1**
Step 7. Divide number of Helix required by the area in tension, A_T A_T = b x (h-c) = 12 x 9.1 = 109 in^2 = 590/109 in^2 = 5.41 Helix per square inch	Step 7. Divide number of Helix required by the area in tension, A_T A_T = b x (h-c) =1000mm x (254mm – 24.9mm) x $(1m/1000mm)^2$ = 0.229 m^2 = 2093/ 0.229 = 9140 Helix per square meter		**4.6.2**
Step 8. Use Table 2, find the nearest number of Helix per unit area in column 1 and read the required Helix dosage for the appropriate class and compressive strength: **Required Helix Dosage 29.9 lb/yd³ plus one layer of #5 bars at 12 in on center at mid depth**	Step 8. Use Table 2, find the nearest number of Helix per unit area in column 1 and read the required Helix dosage for the appropriate class and compressive strength: **Required Helix Dosage 19.0 kg/m³ plus one layer of 12 mm bars at 200 mm on center at mid depth**		**4.6.3** **Table 2**
Step 9. Strain check Use Table 3 & result of step 7 to find Helix tensile stress, ϕF_{ht} = 291 psi strain = $291 \times 10^6/(57000\sqrt{4000})$ = 81 micro strain	Step 9. Strain check Use Table 3 & result of step 7 to find Helix tensile stress: ϕF_{ht} = 2.23 MPa Strain = $2.23 \times 10^6/(4700\sqrt{30})$ = 87 micro strain		**4.6.4** **Table 3** **4.6.5**
Step 10. Use result of step 7 to find allowable strain = 110 > 81 OK	Step 10. Use result of step 7 to find allowable strain = 105 > 87 OK		**5.7**

Appendix A: Field Verification of Helix Dosage by Washout Test

Procedure
Helix content (dosage) verification testing, when required, shall be conducted in accordance with CSA A23.2-16C "Standard Test Method for Determination of Steel or Synthetic Fibre Content in Plastic Concrete". Available for download at http://shop.csa.ca/

Criteria
The average Helix content (CSA A23.2-16C section 9g) shall exceed specified minimum dosages in Tables 1 or 2 below. If dosage verification is required in accordance with Section 5.16 and two consecutive tests fail, corrective action is required prior to continuing the pour.

Conversions
Multiply lb/yd^3 by 0.59 to obtain oz/ ft^3
Grams per liter is equal to kg/m^3

TABLE 1 - Imperial Unit Limits (9 and 10 yd^3 Trucks)

Boxes Of Helix Added to 9 yd^3 Truck	Specified Helix Dosage (lb/yd^3)	Minimum Average Helix Dosage (lb/yd^3)
1	5	3.6
2	10	7.9
3	15	12.5
4	20	17.4
5	25	22.4
6	30	27.6
7	35	32.8
8	40	38.0
9	45	43.3
10	50	48.5
11	55	53.7
12	60	58.9
13	65	64.0

Boxes Of Helix Added to 10 yd^3 Truck	Specified Helix Dosage (lb/yd^3)	Minimum Average Helix Dosage (lb/yd^3)
1	4.5	3.3
2	9	7.0
3	13.5	11.1
4	18	15.4
5	22.5	19.9
6	27	24.5
7	31.5	29.1
8	36	33.8
9	40.5	38.5
10	45	43.3
11	49.5	48.0
12	54	52.6
13	58.5	57.3

TABLE 2 -Metric Unit Limits (7 and 8 m^3 Trucks)

Boxes Of Helix Added to 7 m^3 Truck	Specified Helix Dosage (kg/m^3)	Minimum Average Helix Dosage (kg/m^3)
1	2.9	2.1
2	5.8	4.5
3	8.8	7.2
4	11.7	10.0
5	14.6	12.9
6	17.5	15.9
7	20.5	18.9
8	23.4	22.0
9	26.3	25.0
10	29.2	28.1
11	32.1	31.1
12	35.1	34.2
13	38.0	37.2
14	40.9	40.2

Boxes Of Helix Added to 8 m^3 Truck	Specified Helix Dosage (5g/m^3)	Minimum Average Helix Dosage (kg/m^3)
1	2.6	1.8
2	5.1	4.0
3	7.7	6.3
4	10.2	8.8
5	12.8	11.3
6	15.3	13.9
7	17.9	16.6
8	20.5	19.2
9	23.0	21.9
10	25.6	24.6
11	28.1	27.2
12	30.7	29.9
13	33.2	32.6
14	35.8	35.2

Appendix B: Helix 5-25 Micro Rebar Quick Reference Class A and B Dosages

The tables include common welded wire mesh and rebar configurations in concrete 4 - 10 inch (100 – 250 mm) thicknesses along with Helix alternative designs computed in accordance with this report. Class A (Section 4.2) is assumed when reinforcement ratio is less than 0.002, (just above the limit for temperature and shrinkage reinforcement in ACI 318 Section 7.12), otherwise Class B (Section 4.3) is assumed (shaded cells). This table shall not be used for Class C or Cs design (Section 4.4 and 4.5). The rebar and mesh in these tables is assumed to specified at mid depth and concrete has a 3000 psi (20 MPa) compressive strength. To use the table, find the reinforcement specified in the left-hand column and follow to the right until you reach the column corresponding to the specified thickness of the concrete. The number in the cell is the Helix dosage required to replace the mesh or rebar. The tables may be used for design provided a written submittal referencing this report is provided to the building official indicating that the original specifications match the table assumptions, the design class is either A or B and restrictions in Section 5 are satisfied.

Common Mesh Arrangements Imperial Units

3000 psi Concrete		4 inch	5 inch	6 inch	7 inch	8 inch	10 inch
Grade 60 WWF		Minimum Helix 5-25 Micro Rebar Dosage (lb/yd^3)					
6x6	W1.4XW1.4	4.5	4.5	4.5	4.5	4.5	4.5
6X6	W2.0XW2.0	5.2	4.5	4.5	4.5	4.5	4.5
6X6	W2.9XW2.9	7.5	6.0	5.0	4.5	4.5	4.5
6X6	W4XW4	10.3	8.2	6.9	5.9	5.2	4.5
4X4	W2.9XW2.9	11.2	9.0	7.5	6.4	5.6	4.5
6X6	W5.5XW5.5	15.7	11.3	9.4	8.1	7.1	5.7
4X4	W4XW4	16.9	13.9	10.3	8.8	7.7	6.2
4X4	W5.5XW5.5	22.3	18.3	15.7	12.0	10.6	8.5

Common Mesh Arrangements Metric Units

20 MPa Concrete		100 mm	150 mm	200 mm	250 mm
Grade 500 WWF		Helix Micro Rebar Dose (kg/m^3)			
200mm	4.75mm	4.0	3.0	3.0	3.0
200mm	6mm	6.4	4.3	3.2	3.0
200mm	6.75mm	8.0	5.4	4.0	3.2
200mm	7.6mm	11.5	6.8	5.1	4.1
200mm	8.6mm	14.2	8.6	6.5	5.2
200mm	9.5mm		11.9	7.9	6.3
100mm	7.6mm		14.7	11.5	8.1

Single Layer Rebar Imperial Units

3000 psi Concrete		4 inch	5 inch	6 inch	7 inch	8 inch	10 inch
Grade 60 Rebar		Minimum Helix 5-25 Micro Rebar Dosage (lb/yd^3)					
#3	24" OC	7.1	5.7	4.8	4.5	4.5	4.5
#3	18" OC	9.4	7.6	6.3	5.4	4.8	4.5
#3	16" OC	10.6	8.5	7.1	6.1	5.3	4.5
#3	12" OC	15.7	11.3	9.4	8.1	7.1	5.7
#4	24" OC	14.4	10.3	8.6	7.4	6.4	5.2
#4	18" OC	18.5	15.2	11.4	9.8	8.6	6.9
#4	16" OC	20.5	16.9	14.4	11.0	9.6	7.7
#4	12" OC	35.0	21.7	18.5	16.7	14.3	10.2
#5	12" OC		47.2	27.2	23.7	21.1	17.3

Single Layer Rebar Metric Units

20 MPa Concrete		100 mm	150 mm	200 mm	250 mm
Grade 500 Rebar		Helix Micro Rebar Dose (kg/m^3)			
10mm	400 mm	8.6	5.8	4.4	3.5
10mm	300 mm	12.8	7.7	5.8	4.6
10mm	200 mm	18.2	12.8	8.6	6.9
12mm	400 mm	13.5	8.1	6.1	4.9
12mm	300 mm		12.2	8.1	6.5
12mm	200 mm			13.5	11.1
16mm	400 mm			12.4	10.2
16mm	300 mm				13.2

NOTE: If the original design configuration is not listed, the dosage cell is blank or if there is ANY deviation from the assumptions (original bar depth, grade listed in table, thickness, or concrete compressive strength) listed above, doubt about the design class (Section 4.2-4.3), or doubt about compliance with the conditions of use (Section 5), please contact the manufacturer (Pensmore Reinforcement Technologies) or a professional registered design professional and ask for a detailed design in accordance with this report based on your exact specification.