ICC-ES Evaluation Report

ESR-3949

Reissued September 2020

This report is subject to renewal September 2021.

www.icc-es.org | (800) 423-6587 | (562) 699-0543 *A Subsidiary of the International Code Council®*

DIVISION: 03 00 00—CONCRETE
Section: 03 31 00—Structural Concrete

REPORT HOLDER:

HELIX® STEEL

EVALUATION SUBJECT:

HELIX® 5-25 MICRO REBAR™ & HELIX® 5-25U MICRO REBAR™ REINFORCEMENTS

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2018 *International Building Code®* (IBC)
- 2018 *International Residential Code®* (IRC)

Properties evaluated:

- Durability
- Structural
- Crack control

2.0 USES

Helix® Micro Rebar™ reinforcements (Helix® 5-25 Micro Rebar™ and Helix® 5-25U Micro Rebar™) are used as alternatives to the shrinkage and temperature reinforcement specified in Section 24.4 of ACI 318 for plain concrete footings and for plain concrete slabs (as defined by ACI 360) supported directly on the ground.

Helix® Micro Rebar™ reinforcements are also used to increase the modulus of rupture for the design of structural plain concrete using linear elastic design in applications within the scope of ACI 318 Chapter 14, IBC Section 1906 and ACI 332 Section 8.2.1, IRC Sections R404.1.3 and R608.1, or Tables 8.2.1.3a and 8.2.1.3b of ACI 332.

Helix® Micro Rebar™ are also used as an alternative to horizontal temperature and shrinkage reinforcement in structural plain concrete walls as described in IBC Section 1906, IRC Sections R404.1.3 and R608.1, and ACI 332 Sections 8.2.1 and 8.2.7.

Helix® Micro Rebar™ also applies to slabs-on-ground applications that are designed in accordance with Chapter 7 or Chapter 11 of ACI 360.

Under the IRC, an engineered design in accordance with IRC Section R301.1.3 must be submitted to the code official for approval.

3.0 DESCRIPTION

Helix® Micro Rebar™ reinforcements are made from minimum 240 ksi (1650 MPa), 0.020 in +/-0.007 in (0.51 mm +/- 0.02 mm) cold drawn steel wire. Each Helix® Micro Rebar™ has a minimum of one 360-degree twist. Helix® Micro Rebar™ reinforcement is used in dosages between 9 lb/yd^3 and 34.5 lbs/yd^3 (5.4 kg/m^3 and 21 kg/m^3). Helix® 5-25 is electroplated with zinc; whereas, Helix® 5-25U is uncoated.

3.1 Structural Plain Concrete: Structural normal-weight plain concrete must comply with Section 1906 of the IBC. Concrete design must follow ACI 211.1 and ACI 318 Section 26.12.3.1 with specified compressive strength, f'$_c$, between 3000 psi and 5000 psi (21 MPa and 35 MPa).

4.0 DESIGN & INSTALLATION

4.1 Type N (Temperature and Shrinkage): Helix® Micro Rebar™ reinforcements are used as an alternative to shrinkage and temperature reinforcement specified in Section 24.4 of ACI 318 for plain concrete footings and for plain concrete slabs (as defined by ACI 360) supported directly on the ground for dosage rates between 9 lb/yd^3 and 34.5 lbs/yd^3 (5.4 kg/m^3 and 21 kg/m^3).

4.2 Type S (Linear Elastic Design): Type S applications fall within the scope of ACI 318 Chapter 14, IBC Section 1906 and ACI 332 Section 8.2.1, IRC Sections R404.1.3 and R608.1, or Tables 8.2.1.3a and 8.2.1.3b of ACI 332. Design for flexure in accordance with Section 4 of this report must be limited in capacity by the values presented in Table 1 and Equations 1 or 2, and all designs must be verified to meet the criteria of ACI 318 Section 14.1.3 excluding slabs on grade (e.g. slabs designed per ACI 360 Chapter 7.2.1 PCA method where only flexural capacity is required).

a) For pure flexure

$$M_u \leq \lambda_s \varphi L_f \sqrt{f_c'} S_m \qquad \text{(Equation 1)}$$

b) For combined flexure and axial compression

$$\frac{M_u}{S_m} - \frac{P_u}{A_g} \leq \lambda_s \varphi L_f \sqrt{f_c'} \qquad \text{(Equation 2)}$$

Where

$L_f^*\sqrt{f'_c}$ = Maximum limit for flexural capacity.

M_u = Ultimate moment, lb.-in.

P_u = Ultimate axial load, lb.

S_m = Section modulus, in^3.

A_g = Gross section area, in^2.

f_c' = Specified compressive strength as defined in ACI 318-14 26.12.3.1 and ACI 214R.

φ = Strength reduction factor as reported in Table 1 for Type S.

λ_s = Scale-effect adjustment factor per Table 2 of this report, or computed using Equation 3 by a registered design professional (RDP).

$$\lambda_s = \frac{2.5\left(\frac{h_b}{h_o}\right)^{0.7}}{1+1.5\left(\frac{h_b}{h_o}\right)^{0.7}} \quad \text{(Equation 3)}$$

Where:

h_o= depth of member being designed.

h_b= depth of test beam 6.0 in (150 mm).

Axial compression and shear capacity, when required for design, must be based on the requirements of Sections 14.5.3 and 14.5.5 of ACI 318, respectively. Resistance to lateral forces, as part of a lateral force resisting system, must be based on the requirements of ACI 318, Chapter 14. Connections between members must be based on ACI 318, Chapter 16. Provisions of Section 14.6.1 of ACI 318-14, IRC Section R608.8.1, and Section 8.2.7 (g) of ACI 332 must apply.

4.3 Type G (Design Limits for Slabs-on-Ground):

4.3.1 Plain Concrete Method: When the modulus of rupture is required for plain concrete slabs-on-ground design in accordance with ACI 360, Chapter 7, the modulus of rupture (f_r) must be applied using Equation 4 and the values presented in Table 1:

$$f_r = L_f \sqrt{f_c'} \quad \text{(Equation 4)}$$

4.3.2 Fiber Reinforced Concrete Slabs-on-Ground: When the modulus of rupture is required for plain concrete slabs-on-ground design using the Elastic method or Yield Line Method in accordance with ACI 360, Sections 11.3.3.2 and 11.3.3.3, respectively, the modulus of rupture (f_r) must be taken as Equation 4 using the values presented in Table 1.

4.3.3 Factor of Safety: For all plain concrete slabs-on-ground design, a factor of safety must be applied to the loads in accordance with ACI 360 Section 5.9. The resistance factors specified for Type S structures do not apply.

4.4 Installation: Helix® Micro Rebar™ reinforcements may be added to the concrete at the concrete batch plant or to the ready-mix truck at the jobsite. The manufacturer's published installation instructions and this report must be strictly adhered to for adequate dispersal of fibers throughout the batch mixture. A copy of the manufacturer's published installation instructions must be available at all times at the location of the Helix® Micro Rebar™ installation into the concrete.

4.5 Special Inspection: Periodic special inspection is required in accordance with Sections 1705.1.1 and 1705.3 of the IBC.

5.0 CONDITIONS OF USE

The Helix® Micro Rebar™ reinforcements described in this report comply with, 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 Helix® Micro Rebar™ reinforcements must be blended into the concrete mixture in accordance with the installation requirements in the ICC-ES evaluation report and the manufacturers published installation instructions.

5.2 When Helix® 5-25 Micro Rebar™ and Helix® 5-25U Micro Rebar™ reinforcements are added at the ready-mix plant, a batch ticket signed by a ready-mix representative shall be available to the code official upon request.

5.3 Type N applications must comply with Section 4.1 of this report. Joints as specified in Chapter 14.3.4 of ACI 318 (IBC and IRC) are required.

5.4 Design for Type S applications must follow Section 4.2 of this report.

5.5 Design for Type G applications must follow Section 4.3 of this report.

5.6 The fire-resistance rating of constructions with Helix® Micro Rebar™ reinforcements have not been evaluated by ICC-ES and is outside the scope of this report. When requested, evidence of the fire-resistance rating of the construction must be submitted to the code official for their approval.

5.7 Special inspection must comply with Section 4.5 of this report.

5.8 Helix® Micro Rebar™ reinforcements are produced by Helix® Steel under an inspection program with inspections by ICC Evaluation Service, LLC.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Use of Twisted Steel Micro-rebar (TSMR) in Concrete (AC470), approved May 2020.

7.0 IDENTIFICATION

7.1 Each container of Helix® Micro Rebar™ must bear the manufacturer's name, trademark and address; the product name; and the ICC-ES evaluation report number (ESR-3949).

7.2 The report holder's contact information is the following:

HELIX® STEEL
2300 WASHTENAW AVE, SUITE 201
ANN ARBOR, MICHIGAN 48104
(734) 322-2114
www.helixsteel.com

TABLE 1—CALCULATED L_f VALUES[1,2,3]

Dosage rate (lbs/yd³)	Compressive strength (psi)				
	3000	3500	4000	4500	5000
	φ Strength Reduction Factor				
	0.56	0.58	0.59	0.6	0.6
9	8.93	9.25	9.58	9.90	9.90
13.5	9.01	9.43	9.84	10.25	10.25
18.0	9.10	9.60	10.10	10.61	10.61
22.5	9.19	9.78	10.37	10.96	10.96
27.0	9.28	9.96	10.63	11.31	11.31
31.5	9.37	10.13	10.90	11.66	11.66
33.8	9.41	10.22	11.03	11.84	11.84
34.5	9.43	10.25	11.08	11.90	11.90

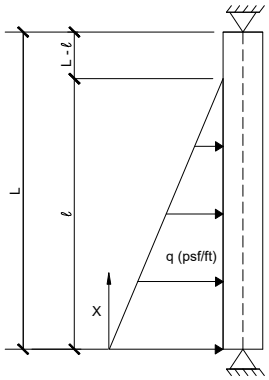
For **SI**: 1 psi = 0.0069 MPa. 1 lb'yd³ = 0.59 kg/m³.

[1]Interpolation between dosage rates and compressive strengths is permitted.
[2]Structures assigned to Seismic Design Category D, E or F must be in compliance with Section 14.1.4 of ACI 318, and combined flexure and axial compression must be considered in accordance with Section 14.5.4 of ACI 318.
[3]RDP must calculate project-specific scale-effect factor (Equation 3) and multiple it with Table 1 values.

TABLE 2—SCALE-EFFECT ADJUSTMENT FACTOR, λ_s

Member Depth, h_o		λ_s
in	mm	6 in (150 mm)
4	100	1.00
6	150	1.00
8	200	0.92
10	250	0.85
12	300	0.80
18	450	0.68
24	600	0.60

Example 1: Basement Wall (Type S Design)

	L=9 ft tall ℓ= 8 ft backfill b=12 in/ft t = 8 in q = 45 lb/ft³ soil pressure f'c = 3000 psi with 9 lb/yd³ Helix® 5-25 Neglect Axial Dead Load Seismic Category A Peak calculated moment: M_u=31,970 in-lb./ft. U = 1.2D +1.6H (governs)
Step 3: Scale Effect Adjustment Factor	$\lambda_s = 0.92$ (Equation 3)
Step 4: Compute Section Modulus	$S_m = \frac{bt^2}{6} = 128\ \frac{in^3}{ft}$
Step 5: Compute Flexural Limit	$f_c' = 3000\ psi \quad \varphi L_f = 0.56 \times 8.93 = 5.0$ (Table 1)
Step 5: Compute M_u and Check Capacity	$M_u \leq 0.92 \times 5.0\sqrt{3000} \times 128 = 32{,}250$ in-lb/ft (Equation 1) 31,970 in-lb/ft < 32,250 in-lb/ft (OK)