PROFIS ENGINEERING DIAPHRAGM

Design Guide

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1.0 OVERVIEW PROFIS ENGINEERING DIAPHRAGM DESIGN MODULE

PROFIS Engineering Diaphragm Design Module is a new design module introduced in PROFIS Engineering in 2023 for the design of steel deck diaphragms and concrete filled deck attached to steel structures to transfer lateral loads and uplift loads into the main structural systems. The PROFIS Engineering Diaphragm Design Module has been designed to provide a productive solution for structural engineers to perform code compliant designs.

This design guide is intended to supplement the North American Product Technical Guide Volume 1: Direct Fastening Technical Guide. To see the complete information for Steel Deck products and design information, view the complete Technical Guide at www.hilti.com.

2.0 CODES AND APPROVALS

The Diaphragm Design module is based on the following documents and approvals to perform the engineering calculations for the deck diaphragm designs in the software. Engineering calculations can be displayed in the long report documents that are generated in the software.

Standard	Title
AISI S100	North American Specification for the Design of Cold-Formed Steel Structural Members
AISI S310	North American Standard for the Design of Profiled Steel Diaphragm Panels
SDI DDM04	Steel Deck Institute Diaphragm Design Manual Edition 4
ESR-2776	Steel Deck Diaphragms attached with Hilti Powder-Actuated Fasteners and Hilti SLC Sidelap Connectors
ESR-3693	Steel Deck Diaphragms attached with S-MD 12x24 x 1 5/8 M or S-RT5+ Frame Fasteners
ESR-2197	Steel Deck and Concrete Filled Diaphragms Attached with Hilti Fasteners

3.0 STEEL DECK DIAPHRAGM DESIGN AND THEORY

This design guide is intended to supplement the North American Product Technical Guide Volume 1: Direct Fastening Technical Guide. To see the complete information for Steel Deck products and design information, view the complete Technical Guide at www.hilti.com.

3.1 GENERAL DISCUSSION

A steel deck diaphragm is a horizontal assembly that transfers in-plane forces to the lateral force resisting system of a structure. This includes roof, floors, and other membrane systems. A diaphragm can be modeled as a horizontal beam with interconnected floor and roof deck units that act as the beam web. Intermediate joists or beams act as web stiffeners and perimeter beams or reinforcement on the diaphragm perimeter act as the beam flanges. Figure 1, based on graphics from the Steel Deck Institute (SDI) Diaphragm Design Manual (DDM), depicts a roof deck diaphragm model.

Design of steel deck diaphragms can be done using the Steel Deck Institute (SDI) Diaphragm Design Manual (DDM) or American Iron and Steel Institute (AISI) S310. These methods provide the basic equations for determining the strength and stiffness of the diaphragm considering the following parameters:

1. Steel Deck Profile Type and Thickness
2. Supporting Steel Frame Spacing or Deck Span
3. Frame Fastener Type and Spacing (connector for steel deck to steel frame)
4. Sidelap Fastener Type and Spacing (connector for steel deck panel edge to edge)
5. Safety Factors (ASD) or Resistance Factors (LRFD/LSD) based on load type (wind, seismic, other) and fastening type (mechanical, weld)

ICC Evaluation Services (ICC-ES) recognizes the AISI S310 design methods as acceptable in AC43, “Acceptance Criteria for Steel Deck Roof and Floor Systems”. An ICC Evaluation Service Report (ESR) for a product based on ICC-ES AC43 provides recognition for use with the International Building Code (IBC). Hilti deck fasteners are currently listed in the SDI Deck Design Manual Version 04 (DDM04) and were evaluated in ICC-ES ESR-3693, ESR- 2776 and ESR-2197. Hilti deck fastener performance with decking systems is also documented in ICC-ES ESR-1169, ESR-2635, ESR-2657 and IAPMO ER-0217, ER-2018, and ER-0329. Additional industry research has shown that metal deck systems, bare and filled, provide a high level of ductility and over strength, when tested as part of a horizontal diaphragm. Metal deck fastened to the structure using specially designed Power-actuated fasteners perform especially well in absorbing excess energy in the inelastic range. The Steel Diaphragm Innovation Initiative, www.steeli.org, has compiled a comprehensive report containing a database of small element and full scale static and cyclic tests.

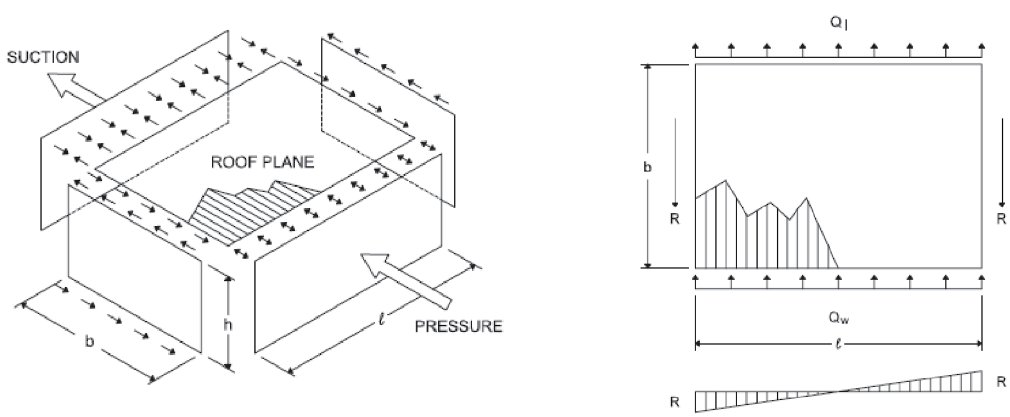


Figure 1 — Diaphragm model

3.0 STEEL DECK DIAPHRAGM DESIGN AND THEORY

3.2 FASTENER TEST PROGRAMS

Many small element and full scale test programs have been conducted using Hilti deck fasteners to evaluate their performance.

1. Small element connection tests

Small element connection tests are used to determine fastener pullout, pullover and lap-joint shear strength and stiffness with sheet steel and base steel representative of typical construction. The data is analyzed and used in a predictive model to calculate the performance of the larger steel deck diaphragm assembly or system. These tests are conducted in accordance with the following standards, and shown in Figure 2.

- AISI S905 Test Methods for Mechanically Fastened Cold-Formed Steel Connections
- ASTM E1190 Standard Test Methods for Strength of Power-Actuated Fasteners Installed In Structural Members
- ICC-ES AC70 Acceptance Criteria for Fasteners Power Driven Into Concrete, Steel and Masonry Elements
- ICC-ES AC118 Acceptance Criteria for Tapping Screw Fasteners

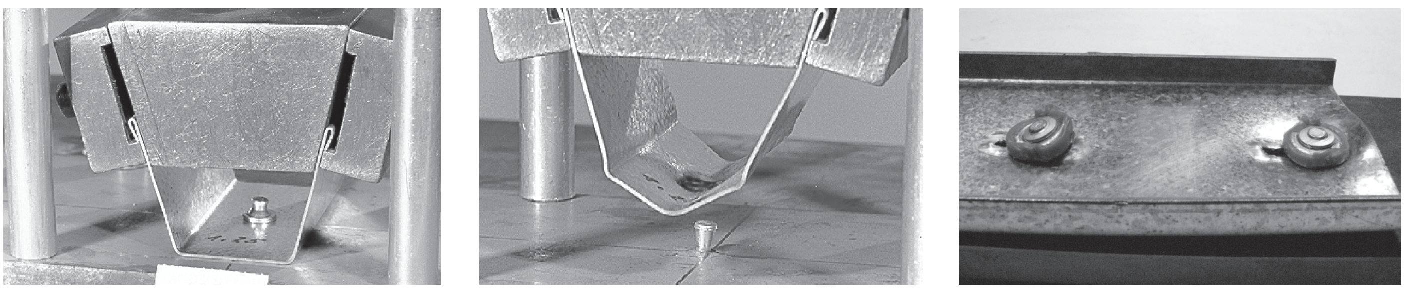


Figure 2 — Small element connection tests

2. Full scale diaphragm system tests (cantilever tests)

Full scale diaphragm system tests are used to determine the strength and stiffness of a larger steel deck diaphragm assembly directly. The data is analyzed and fit in a predictive model to address varying configurations of base steel, steel deck, specific fastener combinations and spans. These tests are conducted in accordance with the following standards and shown in Figures 3, 4 and 5.

- ICC-ES AC43 Acceptance Criteria for Steel Deck Roof and Floor Systems
- AISI S907 Cantilever Test Method for Cold-Formed Steel Diaphragms
- ASTM E455 Standard Test Method for Static Load Testing of Framed Floor or Roof Diaphragm Constructions for Buildings

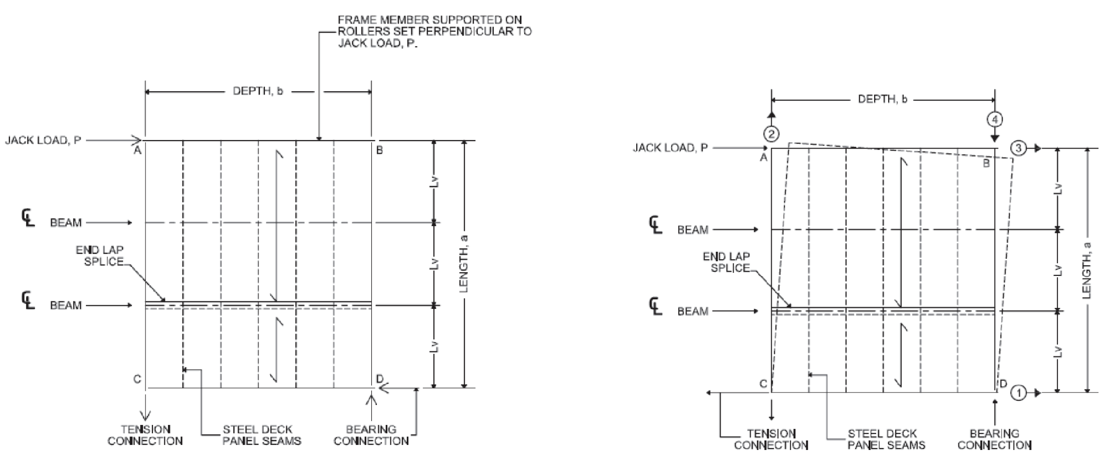


Figure 3 — ICC-ES AC43 diaphragm test frame schematics

3.0 STEEL DECK DIAPHRAGM DESIGN AND THEORY

3.2 FASTENER TEST PROGRAMS

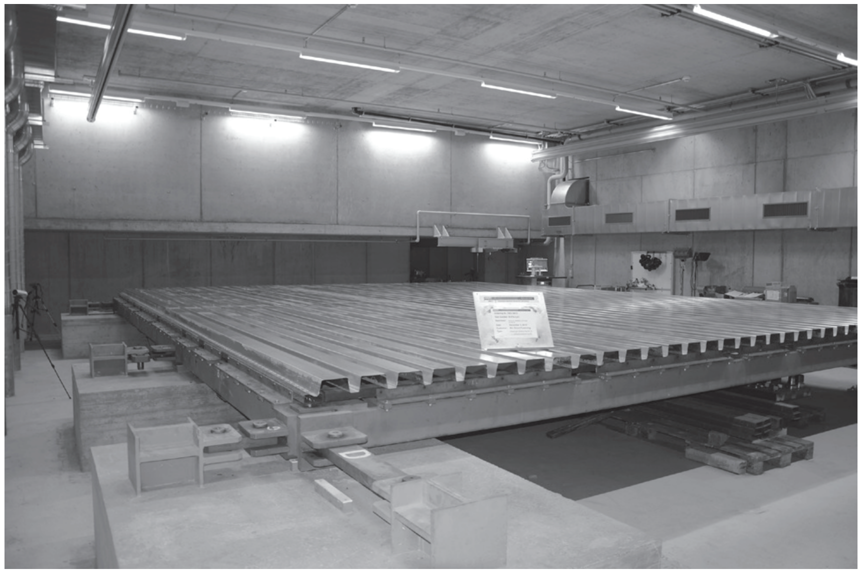


Figure 4 — AC43 diaphragm test frame Fastening Systems Research Laboratory (FSRL), Schaan, Liechtenstein

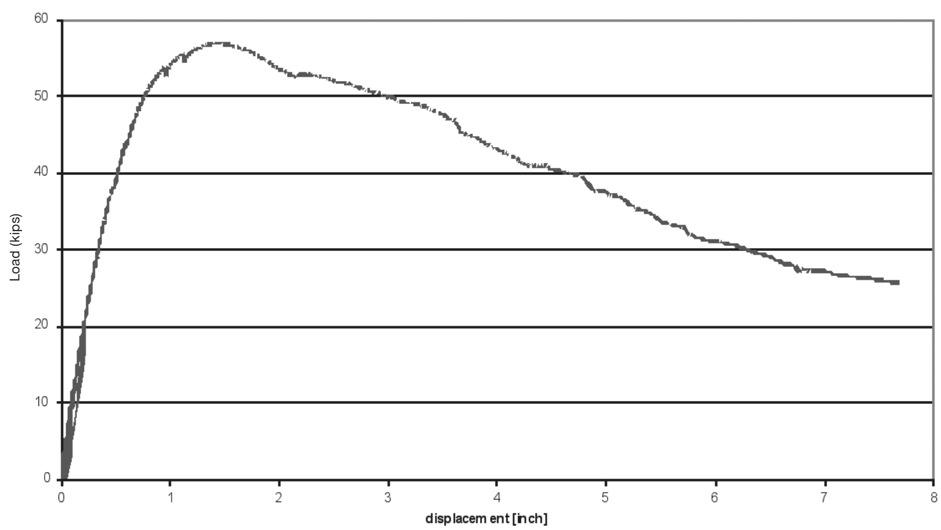


Figure 5 — AC43 deck diaphragm load displacement curve

Displacement (inch)

3.0 STEEL DECK DIAPHRAGM DESIGN AND THEORY

3.3 DIAPHRAGM SHEAR AND STIFFNESS CALCULATIONS

Background: An extensive independent laboratory test program was conducted investigating the performance of steel deck diaphragms attached with Hilti fasteners. The program test scope consisted of full scale diaphragm system tests conducted in accordance with ICC-ES AC43 and AISI S907, as well as comparative small element lap-joint shear tests conducted in accordance with AISI S905 Test Methods for Mechanically Fastened Cold-Formed Steel Connections. The resulting full scale and small element test data was analyzed and predictive equations were developed for the steel deck diaphragm system strength and stiffness using specific combinations of Hilti fasteners.

The American Iron and Steel Institute (AISI) Standard for the Design of Profiled Steel Diaphragm Panels (S310) method equations are used as the basis for determining the steel deck diaphragm strength and stiffness. Specific Hilti fastener strength and stiffness values and test data correlation adjustment factors were developed to provide 95% or greater accuracy with test results per ICC-ES AC43 requirements.

The resulting design information is documented in The North American Product Technical Guide Volume 1: Direct Fastening Technical Guide and in ICC-ES ESR-2776, ESR-2197, and ESR-3693.

Design: The data in the aforementioned ICC-ES Reports are then used with the equations found in AISI S310 Section D to calculate diaphragm strength (S) and stiffness (G') or flexibility factor (F) for Hilti X-HSN 24, X-ENP-19 L15, S-RT5+, or S-MD 12-14x1-5/8 M HWH5 (RT5) frame fasteners and Hilti Sidelap Connectors (SLC). The PROFIS Engineering Diaphragm module is also capable of performing AISI S310 calculations for fastening methods not specific to Hilti such as welding, non-proprietary screws, and button punching of deck.

Uplift and combined loading: The nominal uplift resistance for a given frame fastener and fastening pattern is calculated using methods found in the SDI DDM04 and verified against the uplift demand on the system.

For combined loading, when a uplift load is specified by the user, equations are applied from AISI S310 Section D to find the tension effect on shear frame fastener strength. This will result on a reduced diaphragm shear capacity based on the tensile uplift effect.

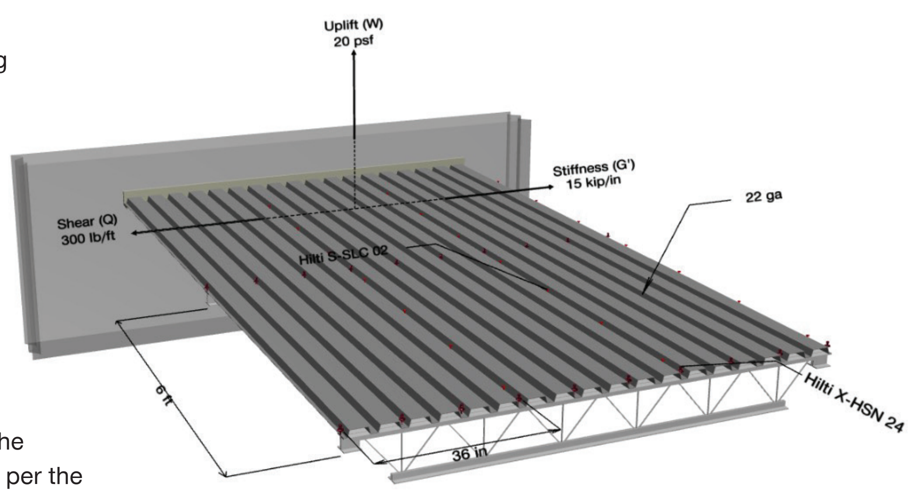
3.4 DESIGN EXAMPLES

This side-by-side comparison is intended to highlight the benefits of the Hilti full scale test approvals versus the use of standard equations in SDI. The first case uses the Hilti X-HSN 24 and S-SLC 02 Sidelap Fasteners combined in a system as approved under ICC-ES ESR-2776. The second features a similar system using the X-HSN 24 and a #12 drill screw with calculations based on the information found in SDI DDM04. You can see in the Diaphragm shear calculations that the ICC-ESR 2776 values are used with the Hilti Proprietary system rather than the calculated values from SDI DDM 4th Edition for the Frame Fastener and Sidelap Fastener calculations.

Design Example #1:
Steel Roof Deck
1 1/2" B-Deck 50 ksi with bar joists at 6' spacing
Nestable deck – 36" panel width
Minimum joist thickness – 0.25"
Design Method – ASD
Wind Loads

System Demands:
Diaphragm Shear: Q = 300 plf
Uplift: W = 20 psf
Stiffness G' = 15 k/in

Compare the Hilti full scale tested system with the Hilti X-HSN-24 and S-SLC 02 Sidelap Fasteners per the ICC ESR-2776 to the Hilti X-HSN24 with the #12 Drill Screw using the calculated values per SDI DDM04.

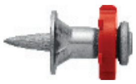


3.0 STEEL DECK DIAPHRAGM DESIGN AND THEORY

3.4 DESIGN EXAMPLES

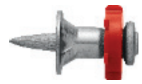
Design Example #1: Steel Roof Deck (continued)

System:
22-gauge deck
36/4 pattern with Hilti X-HSN 24 Fasteners



Hilti S-SLC02 Sidelap Fasteners at 24" o.c.

System:
22-gauge deck
36/4 pattern with Hilti X-HSN 24 Fasteners



Hilti #12 Drill Screw Sidelap Fasteners at 24" o.c.

Area 1

Zone	Deck gauge	Frame fastener pattern	Framer fastener	Sidelap connector	Sidelap connector spacing	Diaphragm shear, Q	Uplift, W	Stiffness, G'	Status
1 Full Scale Testing	22 ga	36/4	Hilti X-HSN 24	S-SLC 02 M HWH Sidelap Connector	24 in o.c.	355.49 plf	83.33 psf	16.59 kip/in	OK
2 SDI Equations	22 ga	36/4	Hilti X-HSN 24	Hilti #12 Drill Screw	24 in o.c.	264.06 plf	83.33 psf	16.59 kip/in	Not Recommended

One or more zones do not meet the design requirements

Design Checks:
Design Shear = 355.49 plf >= Q = 300.00 plf => OK
Design Uplift = 83.33 psf >= T = 20.00 psf => OK
Shear Stiffness G = 16.59 kip/in >= G' = 15.00 kip/in => OK

Design OK

Design Uplift and Shear-Tension Interaction Calculation for Zone A-1

Nominal uplift resistance:

$T_{n,F}$ = Hilti ESR — ICC ESR-2776, Table 10 and 11, Roof Deck Construction Handbook

$$T_n = \frac{K \cdot T_{n,F}}{C \cdot l_v}$$

C (ft)	K	l_v (ft)	$T_{n,F}$ (lb)	T_n (psf)
3.00	3.00	6.00	1,500	250

Design uplift resistance:

$$T_{n,allow} = \frac{T_n}{\Omega} >= T$$

T_n (psf)	Ω	$T_{n,allow}$ (psf)	T (psf)
250	3.00	83	20

Tension force per fastener: — Roof Deck Construction Handbook

$$T_{FF} = \frac{C \cdot l_v \cdot T}{K}$$

C (ft)	K	l_v (ft)	T (psf)	T_{FF} (lb)
3.00	3.00	6.00	20	120

Tension effect on shear frame fastener strength:

$$\frac{P_{nft}}{P_{nf}} + \frac{T}{\min\left(\frac{P_{nov}}{\Omega_{tov}}, \frac{P_{not}}{\Omega_{tot}}\right)} = 1.0 \rightarrow \frac{Q_{F,red}}{Q_F} + \frac{\Omega_{up} \cdot T_{FF}}{T_{n,F}} = 1.0$$

AISI S310 Eq. D3.1.3-1a

$$Q_{F,red} = \left(1 - \frac{\Omega_{up} \cdot T_{FF}}{T_{n,F}}\right) \cdot Q_F$$

Q_F (lb)	T_{FF} (lb)	$T_{n,F}$ (lb)	Ω_{up}	$Q_{F,red}$ (lb)
1,590	120	1,500	3.00	1,208

Design Checks:
Design Shear = 264.06 plf >= Q = 300.00 plf => Not Recommended
Design Uplift = 83.33 psf >= T = 20.00 psf => OK
Shear Stiffness G = 16.59 kip/in >= G' = 15.00 kip/in => OK

Design Not Recommended

Design Uplift and Shear-Tension Interaction Calculation for Zone A-1

Nominal uplift resistance:

$T_{n,F}$ = Hilti ESR — ICC ESR-2776, Table 10 and 11, Roof Deck Construction Handbook

$$T_n = \frac{K \cdot T_{n,F}}{C \cdot l_v}$$

C (ft)	K	l_v (ft)	$T_{n,F}$ (lb)	T_n (psf)
3.00	3.00	6.00	1,500	250

Design uplift resistance:

$$T_{n,allow} = \frac{T_n}{\Omega} >= T$$

T_n (psf)	Ω	$T_{n,allow}$ (psf)	T (psf)
250	3.00	83	20

Tension force per fastener: — Roof Deck Construction Handbook

$$T_{FF} = \frac{C \cdot l_v \cdot T}{K}$$

C (ft)	K	l_v (ft)	T (psf)	T_{FF} (lb)
3.00	3.00	6.00	20	120

Tension effect on shear frame fastener strength:

$$\frac{P_{nft}}{P_{nf}} + \frac{T}{\min\left(\frac{P_{nov}}{\Omega_{tov}}, \frac{P_{not}}{\Omega_{tot}}\right)} = 1.0 \rightarrow \frac{Q_{F,red}}{Q_F} + \frac{\Omega_{up} \cdot T_{FF}}{T_{n,F}} = 1.0$$

AISI S310 Eq. D3.1.3-1a

$$Q_{F,red} = \left(1 - \frac{\Omega_{up} \cdot T_{FF}}{T_{n,F}}\right) \cdot Q_F$$

Q_F (lb)	T_{FF} (lb)	$T_{n,F}$ (lb)	Ω_{up}	$Q_{F,red}$ (lb)
1,489	120	1,500	3.00	1,131

3.0 STEEL DECK DIAPHRAGM DESIGN AND THEORY

3.4 DESIGN EXAMPLES

Design Example #1: Steel Roof Deck (continued)

Design OK

Design Shear / Stiffness Calculation for Zone A-1

Frame fastener strength:

Q_F = Hilti ESR — ICC ESR-2776, Table 5

Q_F (lb)	$Q_{F,red}$ (lb)
1,590	1,208

Sidelap connector strength:

Q_S = Hilti ESR — ICC ESR-2776, Table 5

Q_S (lb)
844

Shear strength calculation:

$S_{ne} = (2 \cdot \alpha_1 + n_p \cdot \alpha_2 + n_e) \cdot \frac{Q_F}{l}$ — AISI S310-20 Eq. D1-3

$S_{ni} = (2 \cdot A \cdot (\lambda - 1) + B) \cdot \frac{Q_F}{l}$ — AISI S310-20 Eq. D1-1

$\lambda = 1 \frac{D \cdot l_v}{240 \cdot \sqrt{t}} \geq 0.7$ — -

$B = n_s \cdot \alpha_s + \left[2 \cdot n_p \cdot \frac{\Sigma (x_p)^2}{w^2} + 4 \cdot \frac{\Sigma (x_e)^2}{w^2}\right]$ — AISI S310-20 Eq. D1-6

$\alpha_s = \frac{Q_S}{Q_F}$ — -

$S_{nc} = Q_F \cdot \sqrt{\frac{N^2 \cdot B^2}{l^2 \cdot N^2 + B^2}}$ — AISI S310-20 Eq. D1-2

$S_{np} = n_d \cdot Q_F \cdot \frac{1}{wt}$ — AISI S310-20 Eq. D1-4a

$S_n = Min(S_{ne}; S_{ni}; S_{nc}; S_{np})$ — -

$S_n = S_n \cdot c$ — -

A	c	D (in)	l (ft)	l_v (ft)	N (ft^{-1})	n_d
1	1.149	1.470	18.00	6.00	1.000	1.000

n_e	n_p	n_s	Q_F (lb)	t (in)	W (in)	w_t(in)
9.000	2	9.000	1,208	0.0295	36.000	6.000

α_1	α_2	$\Sigma(x_e)^2/W^2$	$\Sigma(x_p)^2/W^2$	B	α_s	λ
1.333	1.333	0.556	0.556	10.731	0.698	0.786

S_{nc} (plf)	S_{ne} (plf)	S_{ni} (plf)	S_{np} (plf)	S_n (plf)
619	962	692	2,417	711

Design shear strength:

$S_{n,allow} = \frac{S_n}{\Omega}$

S_n(plf)	Ω	$S_{n,allow}$(plf)
711	2.00	355

Check for buckling:

$S_{nb} = \frac{7890}{l_v^2} \cdot \left(\frac{l^3 \cdot t^3 \cdot d}{s}\right)^{0.25}$

$S_{nb,allow} = \frac{S_{nb}}{\Omega}$

d (in)	I (in^4/ft)	l_v (ft)	s (in)	t (in)	S_{nb} (plf)	Ω
3.000	0.178	6.00	8.189	0.0295	3,955	2.00

$S_{nb,allow}$
1,978

Design Not Recommended

Design Shear / Stiffness Calculation for Zone A-1

Frame fastener strength:

$Q_F = 52 \cdot t \cdot (1 - t)$ — SDI DDM, Fourth Edition

t (in)	Q_F (lb)	$Q_{F,red}$ (lb)
0.0295	1,489	1,131

Sidelap connector strength:

$Q_S = 4.2 \cdot (t^3 \cdot d)^{1/2} \cdot F_u$ — AISI S100 Eq. J4.3.1-1

d (in)	F_u (ksi)	t (in)	Q_s (lb)
0.211	65	0.0295	636

Shear strength calculation:

$S_{ne} = (2 \cdot \alpha_1 + n_p \cdot \alpha_2 + n_e) \cdot \frac{Q_F}{l}$ — AISI S310-20 Eq. D1-3

$S_{ni} = (2 \cdot A \cdot (\lambda - 1) + B) \cdot \frac{Q_F}{l}$ — AISI S310-20 Eq. D1-1

$\lambda = 1 \frac{D \cdot l_v}{240 \cdot \sqrt{t}} \geq 0.7$ — -

$B = n_s \cdot \alpha_s + \left[2 \cdot n_p \cdot \frac{\Sigma (x_p)^2}{w^2} + 4 \cdot \frac{\Sigma (x_e)^2}{w^2}\right]$ — AISI S310-20 Eq. D1-6

$\alpha_s = \frac{Q_S}{Q_F}$ — -

$S_{nc} = Q_F \cdot \sqrt{\frac{N^2 \cdot B^2}{l^2 \cdot N^2 + B^2}}$ — AISI S310-20 Eq. D1-2

$S_{np} = n_d \cdot Q_F \cdot \frac{1}{wt}$ — AISI S310-20 Eq. D1-4a

$S_n = Min(S_{ne}; S_{ni}; S_{nc}; S_{np})$ — -

$S_n = S_n \cdot c$ — -

A	D (in)	l (ft)	l_v (ft)	N (ft^{-1})	n_d
1	1.470	18.00	6.00	1.000	1.000

n_e	n_p	n_s	Q_F (lb)	t (in)	W (in)	w_t(in)
9.000	2	9.000	1,131	0.0295	36.000	6.000

α_1	α_2	$\Sigma(x_e)^2/W^2$	$\Sigma(x_p)^2/W^2$	B	α_s	λ
1.333	1.333	0.556	0.556	9.500	0.562	0.786

S_{nc} (plf)	S_{ne} (plf)	S_{ni} (plf)	S_{np} (plf)	S_n (plf)
528	901	570	2,263	528

Design shear strength:

$S_{n,allow} = \frac{S_n}{\Omega}$

S_n(plf)	Ω	$S_{n,allow}$(plf)
528	2.00	264

Check for buckling:

$S_{nb} = \frac{7890}{l_v^2} \cdot \left(\frac{l^3 \cdot t^3 \cdot d}{s}\right)^{0.25}$

$S_{nb,allow} = \frac{S_{nb}}{\Omega}$

d (in)	I (in^4/ft)	l_v (ft)	s (in)	t (in)	S_{nb} (plf)	Ω
6.000	0.178	6.00	8.189	0.0295	3,955	2.00

$S_{nb,allow}$
1,978

3.0 STEEL DECK DIAPHRAGM DESIGN AND THEORY

3.4 DESIGN EXAMPLES

Design Example #1: Steel Roof Deck (continued)

Design OK

Design Shear / Stiffness Calculation for Zone A-1

Governing:

$S_{n,gov} = \text{Min}\,(S_{n,allow} \cdot S_{nb,allow}) \geq Q$

$S_{n,allow}$ (plf)	$S_{nb,allow}$ (plf)	$S_{n,gov}$ (plf)	Q (plf)
355	1,978	355	300

Frame fastener flexibility:

S_F = Hilti ESR — ICC ESR-2776, Table 6

S_F (in/kip)
0.0073

Sidelap connector flexibility:

S_S = Hilti ESR — ICC ESR-2776, Table 6

S_S (in/kip)
0.0175

Shear Stiffness / Flexibility Factor Calculation:

$$G' = \frac{E \cdot t}{2.6 \cdot \frac{s}{d} + {}_{p}D_{n} + C}$$ AISI S310-20 Eq. D5.1.1-1

$$G' = \frac{E \cdot t}{2.6 \cdot \frac{s}{d} + 0.9 \cdot \frac{D}{I} + K1 \cdot I}$$ -

$$K1 = E \cdot t \cdot \frac{S_F}{W} \cdot \frac{2}{2 \cdot \alpha_1 + n_p \cdot \alpha_2 + 2 \cdot n_s \cdot \frac{S_F}{S_S}}$$ -

$$F = \frac{1000}{G'}$$ -

D (in)	d (in)	E (ksi)	I (in)	s (in)	t (in)	W (in)
10,314.600	6.000	29,500.000	216.000	8.189	0.0295	36.000

K1 (in^{-1})	G' (kip/in)	F (in/kip)
0.0274	16.5924	0.0603

Design Not Recommended

Design Shear / Stiffness Calculation for Zone A-1

Governing:

$S_{n,gov} = \text{Min}\,(S_{n,allow} \cdot S_{nb,allow}) \geq Q$

$S_{n,allow}$ (plf)	$S_{nb,allow}$ (plf)	$S_{n,gov}$ (plf)	Q (plf)
264	1,978	264	300

Frame fastener flexibility:

$$S_F = \frac{1.25}{1000 \cdot \sqrt{t}}$$ AISI S310-20 Section D5.2

t (in)	S_F (in/kip)
0.0295	0.0073

Sidelap connector flexibility:

$$S_S = \frac{3}{1000 \cdot \sqrt{t}}$$ AISI S310-20-Section D5.2

t (in)	S_s (in/kip)
0.0295	0.0175

Shear Stiffness / Flexibility Factor Calculation:

$$G' = \frac{E \cdot t}{2.6 \cdot \frac{s}{d} + {}_{p}D_{n} + C}$$ AISI S310-20 Eq. D5.1.1-1

$$G' = \frac{E \cdot t}{2.6 \cdot \frac{s}{d} + 0.9 \cdot \frac{D}{I} + K1 \cdot I}$$ -

$$K1 = E \cdot t \cdot \frac{S_F}{W} \cdot \frac{2}{2 \cdot \alpha_1 + n_p \cdot \alpha_2 + 2 \cdot n_s \cdot \frac{S_F}{S_S}}$$ -

$$F = \frac{1000}{G'}$$ -

D (in)	d (in)	E (ksi)	I (in)	s (in)	t (in)	W (in)
10,314.600	6.000	29,500.000	216.000	8.189	0.0295	36.000

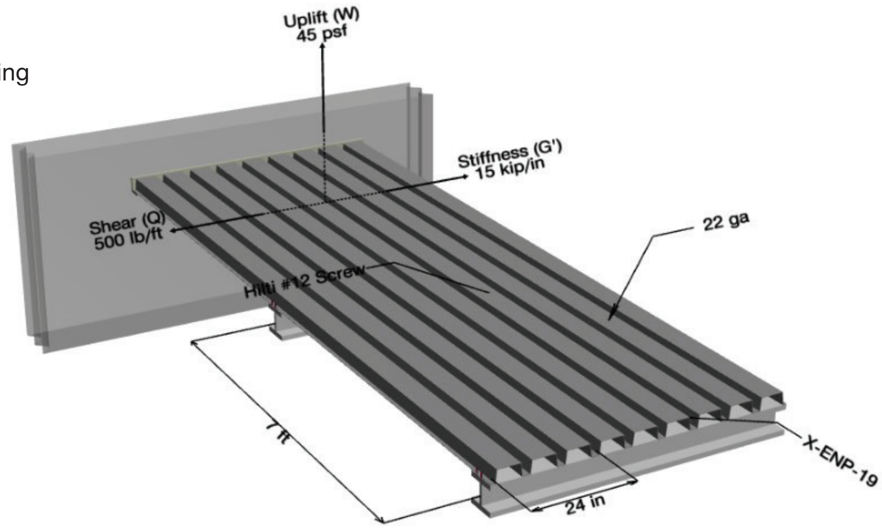
K1 (in^{-1})	G' (kip/in)	F (in/kip)
0.0274	16.5924	0.0603

3.0 STEEL DECK DIAPHRAGM DESIGN AND THEORY

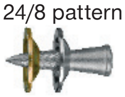
3.4 DESIGN EXAMPLES

Design Example #2:
Steel Roof Deck
3" N-Deck – Deep Rib or 3DR with beams at 7' spacing
Nestable – 24" panel width
Minimum joist thickness – 0.5"
Design Method – LRFD
Seismic Loads

Loads:
Diaphragm Shear - Q = 500 lb/ft
Uplift - W = 45 psf
Shear Stiffness - G' = 15 k/in



System:
22-gauge deck
24/8 pattern with Hilti X-ENP 19 Fasteners



Hilti #12 Drill Screw Sidelap Fasteners at 24" o.

Zone	Deck gauge	Frame fastener pattern	Framer fastener	Sidelap connector	Sidelap connector spacing	Diaphragm shear, Q	Uplift, W	Stiffness, G'	Status
1 Typical	22 ga	24/8	X-ENP-19	Hilti #12 Drill Screw	24 in o.c.	577.08 plf	424 psf	24.77 kip/in	OK

Design Checks:
Design Shear = 577.08 plf >= Q = 500.00 plf => OK
Design Uplift = 424 psf >= T = 45.00 psf => OK
Shear Stiffness G = 24.77 kip/in >= G' = 15.00 kip/in => OK

Design OK

Design Uplift and Shear-Tension Interaction Calculation for Zone A-1

Nominal uplift resistance:

$T_{n,F}$ = Hilti ESR — ICC ESR-2776, Table 10 and 11

$$T_n = \frac{K \cdot T_{n,F}}{C \cdot l_v}$$

C (ft)	K	l_v (ft)	$T_{n,F}$ (lb)	T_n (psf)
2.00	6.00	7.00	1,980	849

Design uplift resistance:

$T_{n,allow} = Tn \cdot ø$ -

T_n (psf)	ø	$T_{n,allow}$ (psf)	T (psf)
849	0.500	424	45

3.0 STEEL DECK DIAPHRAGM DESIGN AND THEORY

3.4 DESIGN EXAMPLES

Design Example #2: Steel Roof Deck (continued)

Design OK

Design Uplift and Shear-Tension Interaction Calculation for Zone A-1

Tension force per fastener:

Roof Deck Construction Handbook

$$T_{FF} = \frac{C \cdot l_v \cdot T}{K}$$

C (ft)	K	l_v (ft)	T (psf)	T_{FF} (lb)
2.00	6.00	7.00	45	105

Tension effect on shear frame fastener strength:

AISI S310 Eq. D3.1.3-1b

$$\frac{P_{nft}}{P_{nf}} + \frac{T}{\min(\varnothing_{nov} \cdot P_{nov}, \varnothing_{tot} \cdot P_{not})} = 1.0 \rightarrow \frac{Q_{F,red}}{Q_F} + \frac{T_{FF}}{\varnothing_{up} \cdot T_{n.F}} = 1.0$$

$$Q_{F,red} = \left(1 - \frac{T_{FF}}{\varnothing_{up} \cdot T_{n.F}}\right) \cdot Q_F$$ -

Q_F (lb)	T_{FF} (lb)	$T_{n,F}$ (lb)	$\varnothing_{up}$	$Q_{F,red}$ (lb)
1,603	105	1,980	0.500	1,433

Design Shear / Stiffness Calculation for Zone A-1

Frame fastener strength:

SDI DDM, Fourth Edition

$$Q_F = 56 \cdot t \cdot (1 - t)$$

t (in)	Q_F (lb)	$Q_{F,red}$ (lb)
0.0295	1,603	1,433

Sidelap connector strength:

SDI DDM, Fourth Edition

$$Q_S = 4.2 \cdot (t^3 \cdot d)^{½} \cdot F_u$$

d (in)	F_u (ksi)	t (in)	Q_S (lb)
0.211	55	0.0295	538

Shear strength calculation:

$$S_{ne} = (2 \cdot \alpha_1 + n_p \cdot \alpha_2 + n_e) \cdot \frac{Q_F}{l}$$ AISI S310-20 Eq. D1-3

$$S_{ni} = (2 \cdot A \cdot (\lambda - 1) + B) \cdot \frac{Q_F}{l}$$ AISI S310-20 Eq. D1-1

$$\lambda = 1 \frac{D \cdot l_v}{240 \cdot \sqrt{t}} \geq 0.7$$ -

$$B = n_s \cdot \alpha_s + \left[2 \cdot n_p \cdot \frac{\Sigma (x_p)^2}{w^2} + 4 \cdot \frac{\Sigma (x_e)^2}{w^2}\right]$$ AISI S310-20 Eq. D1-6

$$\alpha_s = \frac{Q_S}{Q_F}$$ -

$$S_{nc} = Q_F \cdot \sqrt{\frac{N^2 \cdot B^2}{l^2 \cdot N^2 + B^2}}$$ AISI S310-20 Eq. D1-2

$$S_{np} = n_d \cdot Q_F \cdot \frac{1}{wt}$$ AISI S310-20 Eq. D1-4a

$$S_n = \text{Min}(S_{ne}; S_{ni}; S_{nc}; S_{np})$$ -

A	D (in)	l (ft)	l_v (ft)	N (ft^{-1})	n_d
0	3.000	21.00	7.00	3.000	2.000

n_e	n_p	n_s	Q_F (lb)	t (in)	W (in)	w_t (in)
10.500	2	10.500	1,433	0.0295	24.000	8.000

α_1	α_2	$\Sigma(x_e)^2/W^2$	$\Sigma(x_p)^2/W^2$	B	α_s	λ
2.600	2.600	1.046	1.046	12.308	0.375	0.700

S_{nc} (plf)	S_{ne} (plf)	S_{ni} (plf)	S_{np} (plf)	S_n (plf)
824	1,426	840	4,300	824

3.0 STEEL DECK DIAPHRAGM DESIGN AND THEORY

3.4 DESIGN EXAMPLES

Design Example #2: Steel Roof Deck (continued)

Design OK

Design Shear / Stiffness Calculation for Zone A-1

Design shear strength:

$S_{n,allow} = S_n \cdot ø$ -

S_n (plf)	ø	$S_{n,allow}$ (plf)
824	0.700	577

Check for buckling:

$S_{nb} = \frac{7890}{l_v^2} \cdot \left(\frac{I^3 \cdot t^3 \cdot d}{s}\right)^{0.25}$ AISI S310-20 (Eq. D2.1-1)

$S_{nb,allow} = S_{nb} \cdot ø$ -

d (in)	I (in⁴/ft)	l_v (ft)	s (in)	t (in)	S_{nb} (plf)	ø
8.000	0.808	7.00	12.863	0.0295	8,674	0.800

$S_{nb,allow}$ (plf)
6,940

Governing:

$S_{n,gov} = \text{Min}\,(S_{n,allow} \cdot S_{nb,\,allow}) \geq Q$

$S_{n,allow}$ (plf)	$S_{nb,allow}$ (plf)	$S_{n,gov}$ (plf)	Q (plf)
577	6,940	577	500

Frame fastener flexibility:

$S_F = \frac{0.75}{1000 \cdot \sqrt{t}}$ AISI S310-20 Section D5.2

t (in)	S_F (in/kip)
0.0295	0.0044

Sidelap connector flexibility:

$S_S = \frac{3}{1000 \cdot \sqrt{t}}$ AISI S310-20 Section D5.2

t (in)	S_S (in/kip)
0.0295	0.0175

Shear Stiffness / Flexibility Factor Calculation:

$G' = \frac{E \cdot t}{2.6 \cdot \frac{s}{d} + {}_pD_n + C}$ AISI S310-20 Eq. D5.1.1-1

$G' = \frac{E \cdot t}{2.6 \cdot \frac{s}{d} + 0.9 \cdot \frac{D}{1} + K1 \cdot l}$ -

$K1 = E \cdot t \cdot \frac{S_F}{W} \cdot \frac{2}{2 \cdot \alpha_1 + n_p \cdot \alpha_2 + 2 \cdot n_s \cdot \frac{S_F}{S_S}}$ -

$F = \frac{1000}{G'}$ -

D (in)	d (in)	E (ksi)	l (in)	s (in)	t (in)	W (in)
7,237.171	8.000	29,500.000	252.000	12.863	0.0295	24.000

K1 (in^{-1})	G' (kip/in)	F (in/kip)
0.0202	24.7746	0.0404

4.0 CONCRETE FILLED DIAPHRAGM DESIGN AND THEORY

4.1 GENERAL OVERVIEW

Design equations for calculating steel deck diaphragm strength (S) and stiffness (G') or flexibility factor (F) with Hilti X-HSN 24, X-ENP-19 L15 or S-MD 12-24x1-5/8 M HWH5 (RT5) frame fasteners and Hilti Sidelap Connectors (SLC) are provided. The equation numbers correspond to the equation numbers provided in the AISI S310.

4.2 DIAPHRAGM SHEAR AND STIFFNESS CALCULATIONS

For concrete filled diaphragms, the equations of AISI S310 Section D4 are used to determine the shear capacity of the diaphragm. Similar to roof deck calculations, users may select a design method from Allowable Stress Design (ASD), Load Resistance Factor Design (LRFD), or Limit States Design (LSD) for these calculations. Uplift is not taken into account for concrete filled diaphragms due to the effect of the concrete weight.

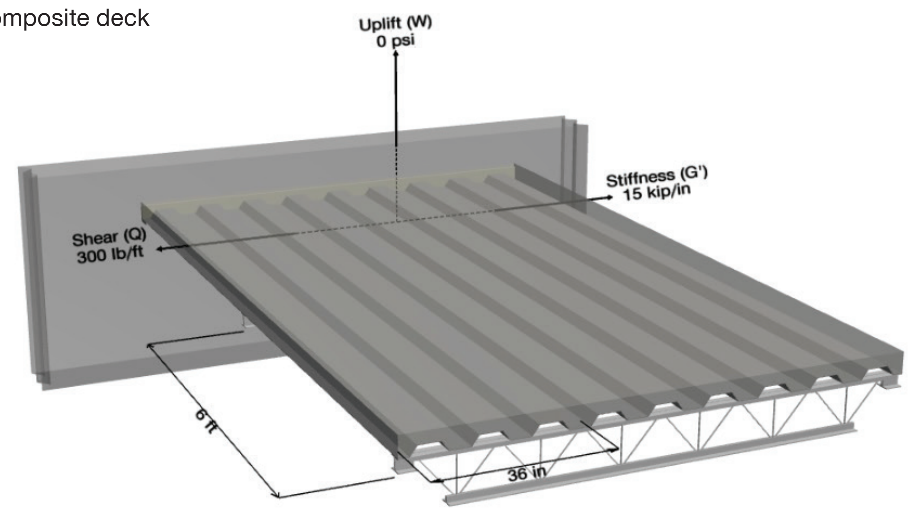
The software features multiple concrete types that users may select when modeling including:

- Lightweight insulation concrete without board in fill
- Lightweight insulation concrete with board in fill
- Structural lightweight concrete
- Structural normalweight concrete
- Structural sand-lightweight concrete

4.3 DESIGN EXAMPLES

Design Example #1:
Structural Normal Weight Concrete-filled Deck 3000 psi Normal Weight Concrete
4 inches of concrete fill over the top of a composite deck
2 x12 with bar joists at 6' spacing
Nestable deck – 36" panel width
Minimum joist thickness – 0.25"
Design Method – ASD
Wind Loads

Loads:
Diaphragm Shear: Q = 300 plf
Stiffness G' = 15 k/in



System:
22-gauge deck
36/4 pattern with Hilti S-RT5+ M9 Screw Fasteners

Hilti S-SLC02 Sidelap Fasteners at 24" o.c.

Zone	Deck gauge	Frame fastener pattern	Framer fastener	Sidelap connector	Sidelap connector spacing	Diaphragm shear, Q	Uplift, W	Stiffness, G'	Status
1 Zone	22 ga	36/4	S-RT5+ Screw	S-SLC 02 M HWH Sidelap Connector	24 in o.c.	5498.59 plf	0.00 psf	3898.95 kip/in	OK

4.0 CONCRETE FILLED DIAPHRAGM DESIGN AND THEORY

4.3 DESIGN EXAMPLES

Design Example #1: Structural Normal Weight Concrete-filled Deck 3000 psi Normal Weight Concrete (continued)

Design Shear / Stiffness Calculation for Zone A-1

Frame fastener strength:

$Q_F = 2.7 \cdot t_1 \cdot d \cdot F_{u1}$ AISI S100 Eq. J4.3.1-4

d (psf)	F_{u1} (ksi)	t_1 (in)	Q_F (lb)
0.228	45	0.0295	817

Sidelap connector strength:

$Q_S = 4.2 \cdot (t_3 \cdot d)^{½} \cdot F_{u1}$ AISI S100 Eq. J4.3.1-1

d (in)	F_{u1} (ksi)	t (in)	Q_S (lb)
0.211	45	0.0295	440

Shear strength calculation:

$S_n = k_c \cdot \lambda_{LW} \cdot b \cdot t_c \sqrt{f'_c}$ AISI S310-20 Eq. D4.1.1-1

$k_c = 3.2/1000$ AISI S310-20 Eq. D4.1.1-2a

$t_c = t_a + n_{sc} \cdot t \cdot \frac{d}{s}$ AISI S310-20 Eq. D4.1.1-3

$n_{sc} = \frac{E}{E_c}$ AISI S310-20 Eq. D4.1.1-4

$E_c = w_c^{1.5} \cdot 33 \cdot \sqrt{f'_c}$ ACI 318-19- Eq. 19.2.2.1.a

b (in)	d (in)	E (psi)	f'_c (psi)	s (in)	r (in)	t_a (in)
12.000	12.000	29,500,000.000	3,000	14.472	0.0295	5.0000

w_c (lb/ft²)	λ_{LW}	E_c (psi)	n_{sc}	t_c (in)	S_n (plf)
145.0	1.00	3,155,924.251	9.347	5.2286	10,997

Design shear strength:

$S_{n,allow} = \frac{S_n}{\Omega}$ -

S_n (plf)	Ω	$S_{n,allow}$ (plf)
10,997	2.00	5,499

Frame fastener flexibility:

$S_F = \frac{1.25}{1000 \cdot \sqrt{t}}$ AISI S310-20 Section D5.2

t (in)	S_F (in/kip)

4.0 CONCRETE FILLED DIAPHRAGM DESIGN AND THEORY

4.3 DESIGN EXAMPLES

Design Example #1: Structural Normal Weight Concrete-filled Deck 3000 psi Normal Weight Concrete (continued)

Design Shear / Stiffness Calculation for Zone A-1
Sidelap connector flexibility:

$$S_S = \frac{3}{1000 \cdot \sqrt{t}}$$ AISI S310-20 Section D5.2

t (in)	S_S (in/kip)
0.0295	0.0175

Perimeter fasteners calculation:

$$N = \frac{S_n}{Q_f}$$ AISI S310-16 Eq. D4.4-3

$$n_e = \frac{S_n \cdot L}{Q_f}$$ AISI S310-16 Eq. D4.4-1

$$n_e = \text{Max}\left(\frac{S_n \cdot L}{Q_f}, \frac{L}{\alpha}\right)$$ AISI S310-16 Eq. D4.4-2

L (ft)	Sn (plf)	QF (lb)	n_e	α	N
18.00	10,997	817	242.5	3.0	13.5

Note: When shear studs are included, the perimeter fastener spacing may not be relevant. Shear studs are assumed to transfer the diaphragm shear forces to the vertical lateral force resisting elements. The engineer should check the shear studs to determine if there is sufficient capacity for diaphragm forces in addition to composite beam action.

Shear stiffness / flexibility factor calculation:

$$G' = \frac{E \cdot t}{2.6 \cdot \frac{s}{d} + +C} + 3.5 \cdot d_c \cdot (f'_c)^{0.7}$$ AISI S310-20 Section D5.4

$$G' = \frac{E \cdot t}{2.6 \cdot \frac{s}{d} + +K1 \cdot l} + 3.5 \cdot d_c \cdot (f'_c)^{0.7}$$ -

$$K1 = E \cdot t \cdot \frac{S_F}{W} \cdot \frac{2}{2 \cdot \alpha_1 + n_p \cdot \alpha_2 + 2 \cdot n_s \cdot \frac{S_F}{S_S}}$$ -

$$F = \frac{1000}{G'}$$ -

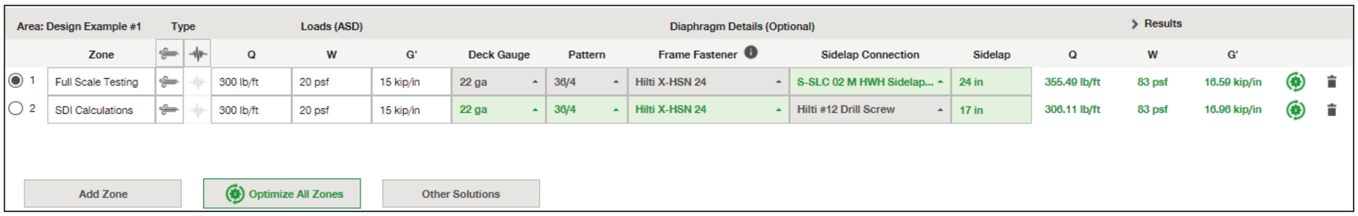
d (in)	d_c (in)	E (psi)	f'_c (psi)	l (in)	n_p	n_s
12.000	4.000	29,500,000.000	3,000	216.000	2	9.000

s (in)	S_F (in/kip)	S_S (in/kip)	t (in)	W (in)	α_1	α_2
14.472	0.0073	0.0175	0.0295	36.000	1.333	1.333

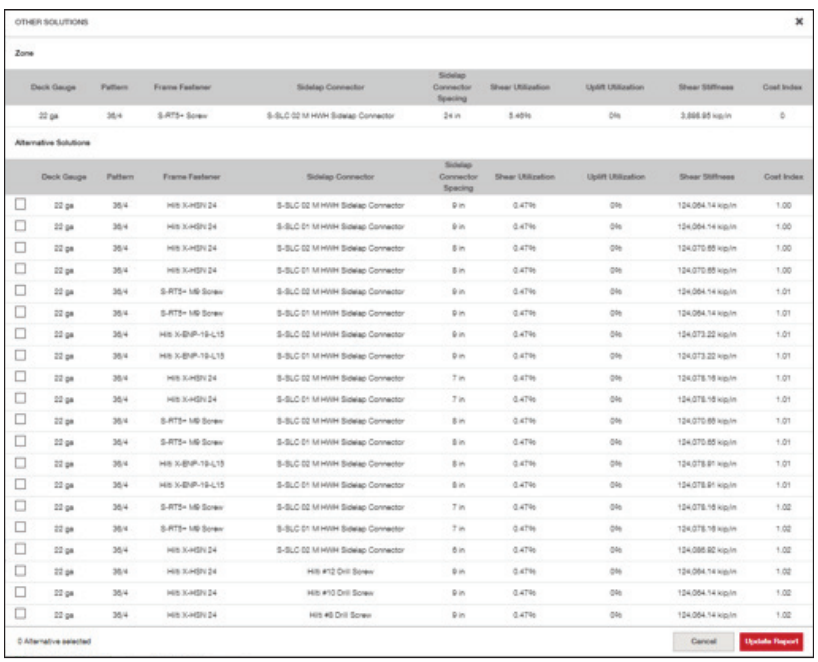
K1 (in^{-1})	G' (kip/in)	F (in/kip)
0.0274	3,898.9531	0.0003

5.0 DESIGN OPTIMIZATION AND ALTERNATE SOLUTIONS

The Diaphragm Design Module offers several ways to find cost effective productive solutions to deck diaphragm design problems through design optimization solutions offered in the software. The design optimization selects a system based on the total cost of the installed system and offers a solution for the most efficient system based on the loads entered for the design. The end user can allow the software to optimize all parameters against the system demand to get the most optimized result. However, some parameters can be set by other conditions, for example the deck gauge may already be selected to account for snow or dead loads. Therefore the software allows the user to pre-select existing parameters and optimize the system for the remaining parameters. The optimization takes into account the number and cost of the fasteners, the cost of the deck material, the speed of the installation, and returns the most cost-effective system for your project.



You do not need to do a design using the optimization function; however, you may not be using the most cost-effective system for your designs. If you would like to review alternative solutions, you can select the "Other Solutions" button at the bottom of the Zones panel. This allows you to compare alternative solutions to the selected solution whether you have optimized or selected a solution to see other solutions that work for your loads. You can select up to three solutions to be included in the summary table that is included in the report.



Design Example # 1

Zone	Deck gauge	Frame fastener pattern	Framer fastener	Sidelap connector	Sidelap connector spacing	Diaphragm shear, Q	Uplift, W	Stiffness, G'	Status
1 Zone	22 ga	36/4	S-RT5+ Screw	S-SLC 02 M HWH Sidelap Connector	24 in o.c.	5498.59 plf	0.00 psi	3898.95 kip/in	OK
Alternate 1	22 ga	36/4	Hilti X-HSN 24	S-SLC 01 M HWH Sidelap Connector	9 in o.c.	63565.05 plf	0.00 psi	124064.21 kip/in	OK
Alternate 2	22 ga	36/4	Hilti X-HSN 24	Hilti #12 Drill Screw	9 in o.c.	63565.05 plf	0.00 psi	124064.21 kip/in	OK
Alternate 3	22 ga	36/4	Hilti X-HSN 24	Hilti #8 Drill Screw	9 in o.c.	63565.05 plf	0.00 psi	124064.21 kip/in	OK

6.0 DEFLECTION CALCULATION

The Diaphragm Design module allows the user to perform a simple deflection calculation of the deck diaphragm using provisions of the SDI Deck Design Manual (DDM 04). The following are the details of different parameters used in Deflection Calculation in the Diaphragm Design Module.

6.1 DEFINITIONS

Angle Area A — This is the cross-sectional area of the perimeter angle or beam and is used to calculate the Moment of Inertia, I, for a chord steel member.

W_{wind} — The resulting wind load acting on the area in force per unit length (lb/ft).

When the Wwind is defined, the corresponding Flange and Web deflections due to wind load will be calculated.

$W_{seismic}$ — The resulting seismic load acting on the area in force per unit length (lb/ft).

When the $W_{seismic}$ is defined, the corresponding Flange and Web deflections due to seismic load will be calculated.

6.2 CALCULATIONS

The deck diaphragm deflection (ΔT) is made up of two components, flexural and web deflection. The flexural deflection (ΔF term) is for the perimeter steel beam flange or diaphragm chords, based on classical beam deflection equations. The web deflection (DW term) is due to the deflection of the steel deck diaphragm itself and is based on average diaphragm shear (q_{avg}) and the flexibility of the deck connections (F).

$$\Delta = \frac{5qL^4}{384EI} + \frac{qL^2}{8bG'} \qquad \Delta f = \frac{5 \cdot W \cdot l^4}{384 \cdot EI} \qquad \Delta w = \frac{W \cdot l^2}{8 \cdot b \cdot G'}$$

$$q_{avg} = \frac{wl}{4d}$$

where:

w = entered value from deflection calculation window (w_{wind} or $w_{seismic}$)

L = length of diaphragm, perpendicular to deck flutes

I = moment of inertia of the chord element

E = is the Young's modulus for steel

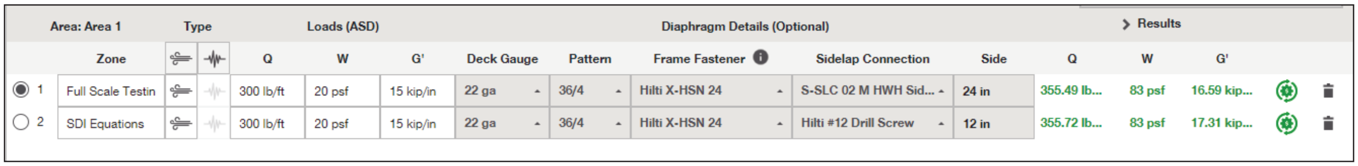
b = width of diaphragm area, parallel to deck flutes

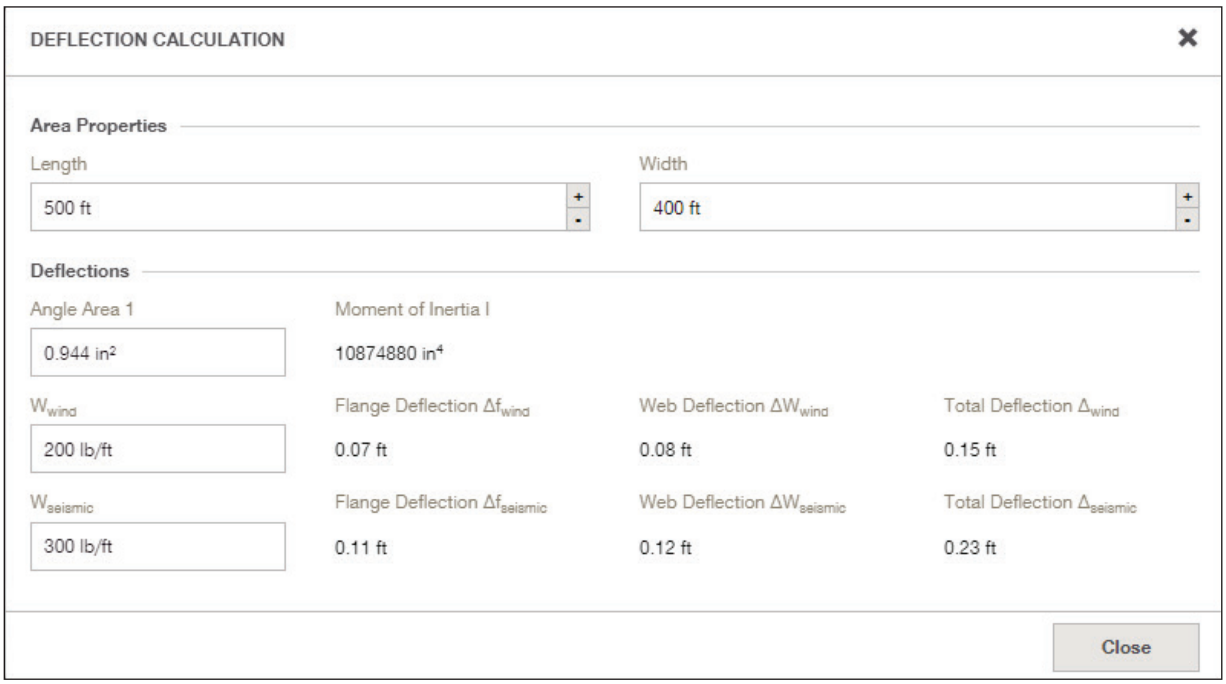
G' = diaphragm shear stiffness

6.0 DEFLECTION CALCULATION

6.3 DESIGN EXAMPLE

Using the Design Example #1 from the Steel Deck Design examples, see below for the deflection calculations. The building is assumed by be 500 feet long by 400 feet wide with a L2x2x1/4 perimeter angle (A=0.944 in2). Design loads are 200 plf for wind and 300 plf for seismic. The Zone 2 has been adjusted to use a 12 inch sidelap spacing to allow the design to work for the loads. All other parameters have been maintained.





Deflection calculations are included in the design report of the detailed report.

Deflections for Design Example #1:

$$\Delta f = \frac{5 \cdot W \cdot l^4}{384 \cdot EI}$$ SDI DDM, Fourth Edition

$$\Delta w = \frac{W \cdot l^2}{8 \cdot b \cdot G'}$$ SDI DDM, Fourth Edition

$$I = 2 \cdot A \cdot \left(\frac{b}{2}\right)^2$$ SDI DDM, Fourth Edition

A (in^2)	b (ft)	E (ksi)	G' (kip/in)	l (ft)	I (in^4)
0.9	400.0	29,500.000	16.5924	500.0	10,874,880.000

Deflections (Wind)

W (plf)	Δf (in)	Δw (in)	Δw + Δf (in)
200	0.8767	0.9417	1.8184

Deflections (Seismic)

W (plf)	Δf (in)	Δw (in)	Δw + Δf (in)
300	1.3150	1.4125	2.7276

7.0 FASTENER ESTIMATION

The fastener estimation estimates the number of frame and sidelap fasteners needed for the project based on the design parameters for the project.

Frame Fasteners:

Number of Frame Fasteners without waste = zone area * (N_{ffpf} *100 *(100/span + 1) + 2*(span*12/ perimeter fastener spacing - 1)(100/span))/100*100)

Frame fastenings per lineal foot of support member, N_{ffpf} is calculated based for the deck type and fastener pattern.

Note: some values of N_{ffpf} are shown, but the table does not include all values for all deck types.
See the example below for a B-deck, 36/7 pattern:

Table 1: Sample values for N_{ffpf}

Frame fastening pattern	B & F	BI	Frame fastening pattern	N	NI	Frame fastening pattern	Floor deck 2" and 3" composite
36/14	4	4.667	24/6	2	3	36/4	1.333
36/11	3	3.667	24/4	1.5	2	24/3	1.5
36/9	2.333	3					**9/16” form deck**
36/7	2	2.333				30/7	2.4
36/5	1.333	1.667				30/5	1.6
36/4	1	1.333				30/4	1.2
36/3	0.667	1				35/8	2.4
30/8	2.4	3.2				35/7	2.057
30/6	2	2.4				35/6	1.714
30/4	1.2	1.6				35/5	1.371
30/3	0.8	1.6					**1” and 1-5/16” form deck**
24/7	2.5	3.5				32/4	1.125
24/5	2	2.5					
24/3	1	1.5					
24/4	1.5	2					
36/7/4	1.5	2					

Sample Calculation:

Known:

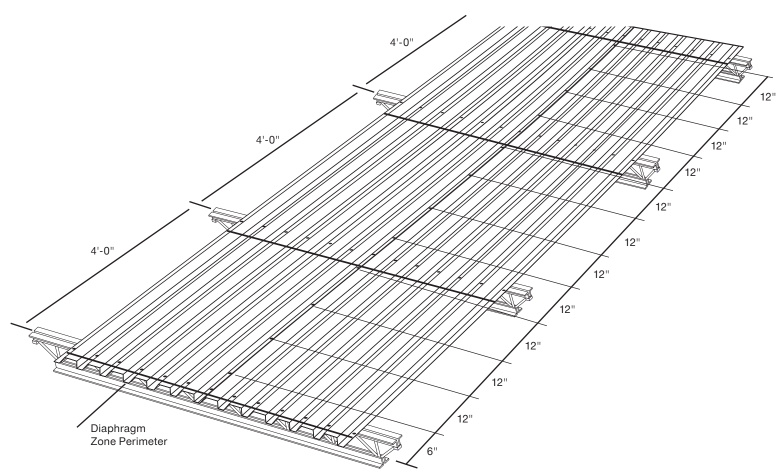
B-Deck, 36 7 pattern (N_{FFPF} = 2) · 4 ft span, 12-inch PFS

$2 \times 100 \times (\frac{100}{4} + 1) + 2 \times (\frac{100}{4} + 1) + 2 \times (\frac{4 \times 12}{12} - 1) \times \frac{100}{4}$

= 5200 + 52 + 150 = 5402

5402/100 = 54 fasteners per 100 ft^2

Then multiply based on the total square foot of deck.



Total = (1 + %waste) * Number of frame fasteners without waste

7.0 FASTENER ESTIMATION

Sidelap Fasteners:

When “number of sidelaps connections” design setting is used.

Number of sidelap fasteners = zone area * (number of sidelaps) * (1 + waste) / (sheet width*deck area)

When “sidelap connection spacing” design setting is used.

Number of sidelap fasteners = zone area * (span*12/spacing) * (1 + waste)

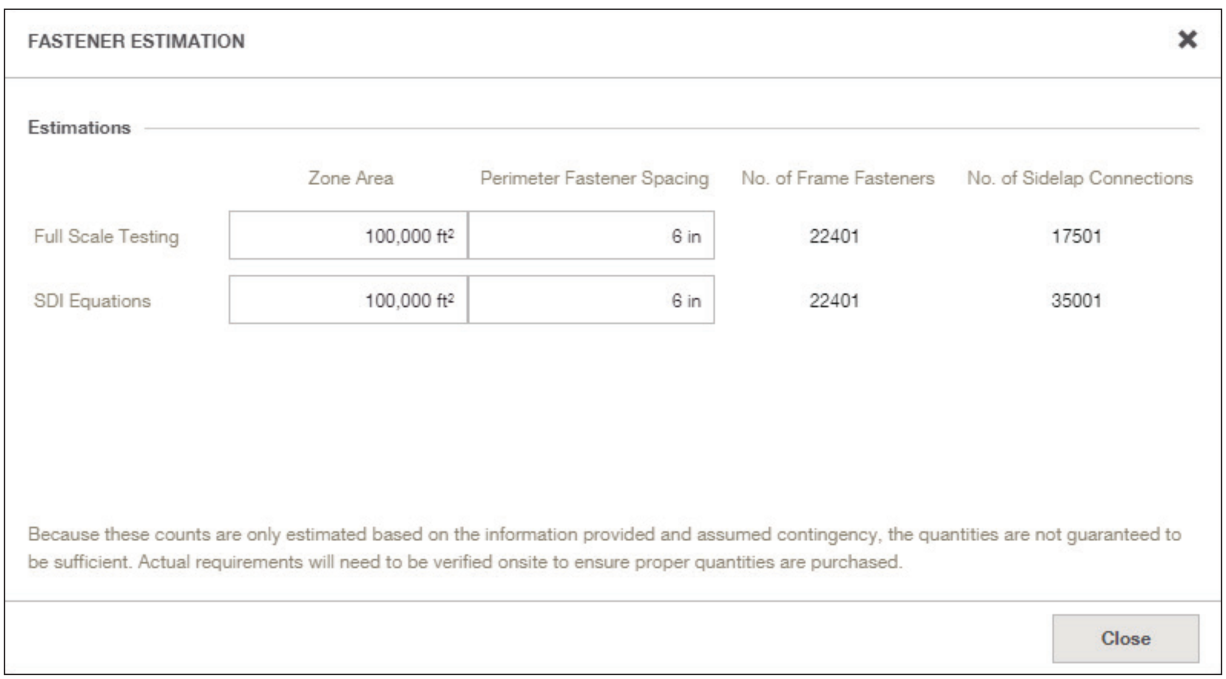
Span = average joist span for zone , ft.

Zone area = area of the zone

Waste = the percentage of waste to include in the estimation. A waste value of 5% is included in the calculations by default for the design module.

7.1 DESIGN EXAMPLE

Using the same design example from Steel Roof Deck Design Example #1 and the Deflection calculation in previous sections, a fastener estimation has been performed. The zone area for each has been estimated as 100,000 square feet with a perimeter fastener spacing of 6".


FASTENER ESTIMATION

Estimations

	Zone Area	Perimeter Fastener Spacing	No. of Frame Fasteners	No. of Sidelap Connections
Full Scale Testing	100,000 ft²	6 in	22401	17501
SDI Equations	100,000 ft²	6 in	22401	35001

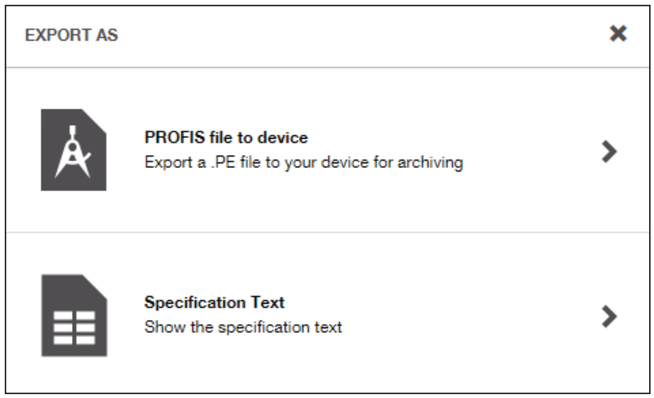
Because these counts are only estimated based on the information provided and assumed contingency, the quantities are not guaranteed to be sufficient. Actual requirements will need to be verified onsite to ensure proper quantities are purchased.

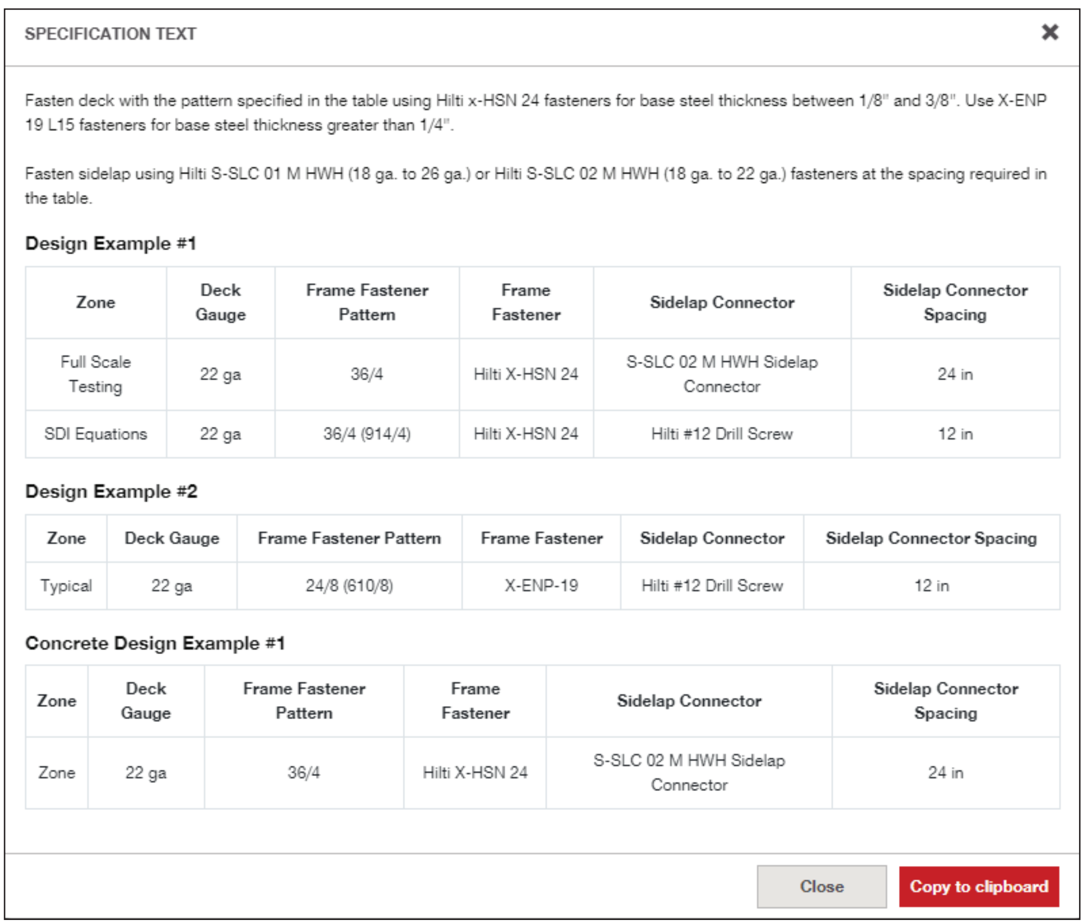
Close

8.0 SPECIFICATION TEXT

PROFIS Engineering provides tools to support structural engineers in creating more accurate design documents such as specification text generated by the software. The Diaphragm Design Module also includes a user-friendly tool to help the user quickly transfer designs to CAD or BIM.

After completing your designs, use the export icon to open the specification text window. This will generate a table of all your designs for each area and zone in a convenient table format for you to quickly export. Select copy to clipboard and you will be able to import the table quickly into your design files to create an attachment schedule or notes to complete your design documents.




SPECIFICATION TEXT

Fasten deck with the pattern specified in the table using Hilti x-HSN 24 fasteners for base steel thickness between 1/8" and 3/8". Use X-ENP 19 L15 fasteners for base steel thickness greater than 1/4".

Fasten sidelap using Hilti S-SLC 01 M HWH (18 ga. to 26 ga.) or Hilti S-SLC 02 M HWH (18 ga. to 22 ga.) fasteners at the spacing required in the table.

Design Example #1

Zone	Deck Gauge	Frame Fastener Pattern	Frame Fastener	Sidelap Connector	Sidelap Connector Spacing
Full Scale Testing	22 ga	36/4	Hilti X-HSN 24	S-SLC 02 M HWH Sidelap Connector	24 in
SDI Equations	22 ga	36/4 (914/4)	Hilti X-HSN 24	Hilti #12 Drill Screw	12 in

Design Example #2

Zone	Deck Gauge	Frame Fastener Pattern	Frame Fastener	Sidelap Connector	Sidelap Connector Spacing
Typical	22 ga	24/8 (610/8)	X-ENP-19	Hilti #12 Drill Screw	12 in

Concrete Design Example #1

Zone	Deck Gauge	Frame Fastener Pattern	Frame Fastener	Sidelap Connector	Sidelap Connector Spacing
Zone	22 ga	36/4	Hilti X-HSN 24	S-SLC 02 M HWH Sidelap Connector	24 in

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The data contained in this literature was current as of the date of publication. Updates and changes may be made based on later testing. If verification is needed that the data is still current, please contact the Hilti Technical Support Specialists at 1-800-879-8000. All published load values contained in this literature represent the results of testing by Hilti or test organizations. Local base materials were used. Because of variations in materials, on-site testing is necessary to determine performance at any specific site. Laser beams represented by red lines in this publication. Printed in the United States.

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