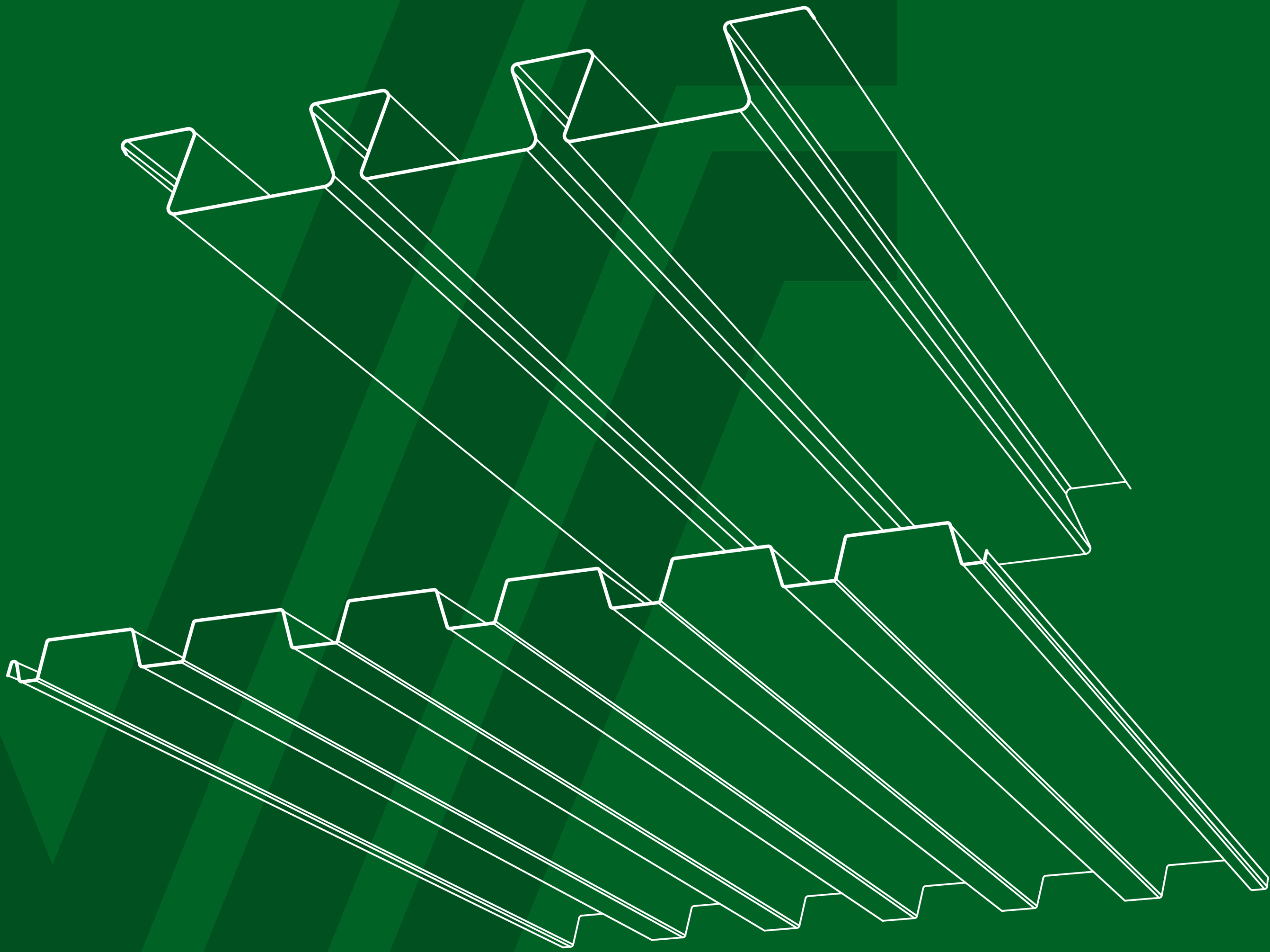
Green Book



Kelsey Lavicka, PE , Jeff Martin, PE

VERCO DECKING, INC.
a NUCOR company

V2024

Verco® Roof Deck Design Guide 1st Edition

This manual is dedicated to **Virgil Morton** the **“God-Father”** of Cold Formed Steel Deck. Without his contributions and knowledge the art and science of deck engineering would be decades behind.

In memory of **John Whiteman P.E. / S.E.**
His contributions to Verco and Vulcraft along with his love of teaching engineering will be missed.

1973 - 2023

Editorial Contributors:
Benton Cooper
Lauren Maes

Special Thanks
Pat Bodwell

PUTTING THE POWER IN YOUR HANDS

Verco makes it easy for you to generate steel deck product data specific to your project with our Online Design Tools, helping you increase project performance and reduce project costs. They're compliant with 2021 IBC/2022 CBC, include detailed supporting data for transparency, and incorporate the latest research in referenced IAPMO evaluation reports.

ROOF DECK TOOLS - FOR BARE DECK

BARE DECK DIAPHRAGM: Calculate the bare deck diaphragm shear and stiffness for your configuration based on AISI S310 and current IAPMO evaluation reports.

BARE DECK UNIFORM LOAD: Determine the uniform gravity and wind-uplift capacities for your bare deck configurations.

Explore additional tools to design bare deck for **Bare Deck Wall Anchorage** and to calculate a **Bare Deck Concentrated Load**.

FLOOR DECK TOOLS - FOR CONCRETE-FILLED DECK

COMPOSITE DECK-SLAB SUPERIMPOSED LOAD: Calculate composite deck-slab strength and maximum unshored span tables for your composite deck configurations.

DECK-SLAB DIAPHRAGM: Calculate diaphragm strengths and stiffness for deck-slabs with plain concrete, or concrete reinforced with Bekaert Dramix steel fibers, WWR or rebar.

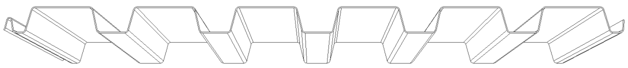
UNSHORED CONSTRUCTION SPAN: Calculate maximum unshored construction spans and cantilevers for thick slabs based on your design criteria.

Explore the **Composite Deck-Slab Superimposed Load** tool further to find multi-span **composite deck-slab design** and **composite deck-slab vibration analysis**.

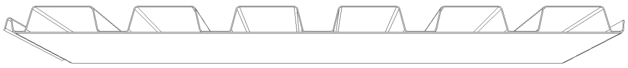
VISIT VERCODECK.COM/DESIGN-TOOLS

VERCO DECKING, INC.
a NUCOR company

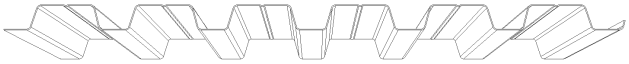
COMMON VERCO® ROOF PROFILES



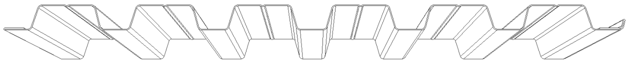
PLB™-36 and HSB®-36
1½"Deep, 36" Wide



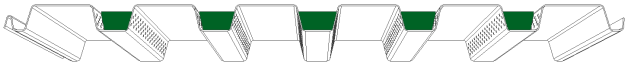
PLBCD-36 and HSBCD-36
1½"Deep, 36" Wide



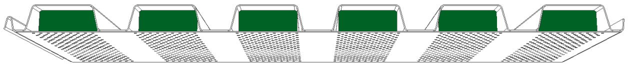
NSB-36
1½"Deep, 36" Wide



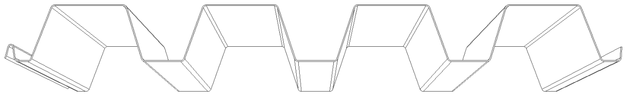
XTB-36
1½"Deep, 36" Wide



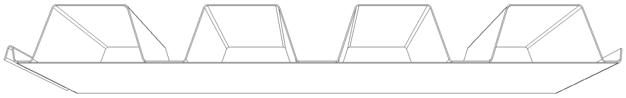
PLB™-36 AC and HSB®-36 AC
1½" Deep, 36" Wide



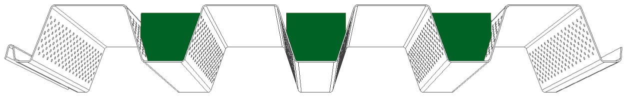
PLBCD-36 AC and HSBCD-36 AC
1½" Deep, 36" Wide



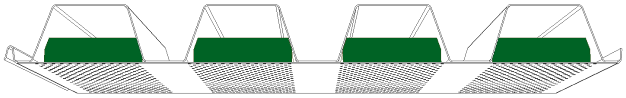
PLN3™-32 and HSN3™-32
3" Deep, 32" Wide



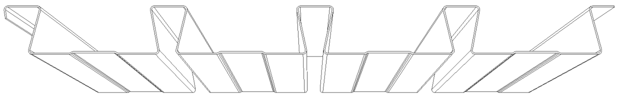
PLN3CD-32 and HSN3CD-32
3" Deep, 32" Wide



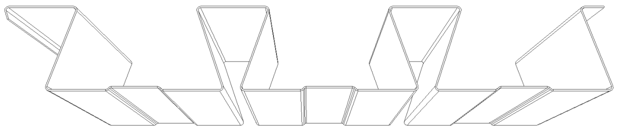
PLN3™-32 AC and HSN3™-32 AC
3" Deep, 32" Wide



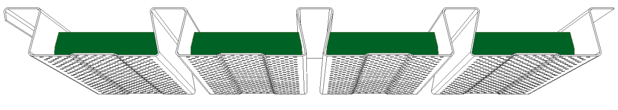
PLN3CD-32 AC and HSN3CD-32 AC
3" Deep, 32" Wide



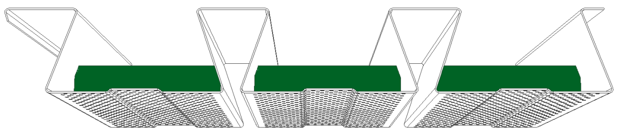
2.0D-24.5 Dovetail
2" Deep, 24½" Wide



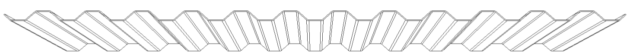
3.5D-24 Dovetail
3½" Deep, 24" Wide



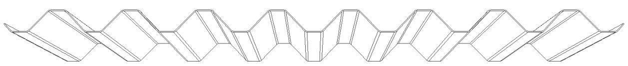
2.0DA-24.5 Dovetail
2" Deep, 24½" Wide



3.5DA-24 Dovetail
3½" Deep, 24" Wide



Shallow VERCOR® (SV-36)
$^{9}/_{16}$" Deep, 36" Wide



Deep VERCOR® (DV-36)
1$^{5}/_{16}$" Deep, 36" Wide

TABLE CONTENTS

TABLE CONTENTS

VERCO® ROOF DECK DESIGN GUIDE

Verco Decking, Inc. is noted for its innovative development of steel roof decks including the use of mechanical sidelap connections (the PunchLok Systems). In this technical guide Verco features a complete range of systems utilizing the PunchLok II System for sidelap connections: 1.5" deep PLB-36, 3" deep PLN3-32. Verco also features 2" deep Dovetail and 3.5" deep Dovetail with either a screwed or welded sidelap. All decks either use welds or mechanical fasteners (power actuated fasteners and screws) to the supports.

With the PunchLok II System, Verco continues its industry leading history of improvement and innovation to serve the construction community.

Profile Designations

Deck for PunchLok® II Systems:

- PLB-36, PLB-36 AC, PLB-36-CD, and PLB-36-CD AC
- PLN3-32, PLN3-32 AC, PLN3-32-CD, and PLN3-32-CD AC

Deck for Button Punch and Top Seam Weld Sidelaps:

- HSB-36, HSB-36 AC, HSB-36-CD, and HSB-36-CD AC
- HSN3-32, HSN3-32 AC, HSN3-32-CD, and HSN3-32-CD AC

Deck for Screwed Sidelaps:

- XTB-36 and NSB-36
- HSB-36-SS and HSB-36-SS AC (Interlocking Screwed Sidelap)
- HSN3-32-SS and HSN3-32-SS AC (Interlocking Screwed Sidelap)
- HSB-36-NS, HSN3-32-NS and HSN3-32-NS AC (Nestable Screwed Sidelap)
- 2.0D and 2.0DA Dovetail (Nestable Screwed Sidelap)
- 3.5D and 3.5DA Dovetail (Nestable Screwed Sidelap)
- 9/16 Shallow VERCOR (Nestable Screwed Sidelap)
- 1-5/16 Deep VERCOR (Nestable Screwed Sidelap)

As of September 2023 Verco phased out the PLN-24 and N-24 family family of products. Legacy information can be requested through the Verco Engineering Department.

Material

Galvanized fluted roof deck panels are formed from either ASTM A653 or A1063 steel. Painted/painted or mill finished fluted roof deck panels are formed from either ASTM A1008 or A1039.

Cellular roof deck sections are fabricated from galvanized steel conforming to ASTM A653. The fluted top and flat bottom sections are factory resistance-welded together. Note: Weld marks will be visible on the exposed flat bottom.

Deep and Shallow VERCOR decks are fabricated from G90 galvanized steel conforming to ASTM A653.

ROOF DECK VERTICAL LOADS

Uniform Loads

ASD or LRFD uniform load values are based on the bending moment (stress) and limiting service load deflection to L/360, L/240 or L/180. ASD or LRFD uniform load values for cellular deck panels are also governed by the vertical shear (governed by the horizontal shear strength of the resistance welds between the fluted top section and the flat bottom section). The symbol "-" in the Verco design tools indicates that the uniform load based on deflection exceeds the available design load based on flexure (stress) or vertical shear (shear). Note that self-weight of the deck should be included when determining dead load.

The formulas used to determine the uniform loads due to flexure (stress), shear and deflection are as follows:

Design Formulas

+M = Positive Bending Moment in ft-lb
–M = Negative Bending Moment in ft-lb
Δ = Deflection in inches
E = 29,500,000 psi
w = Required uniform design live load in psf
L = Span length in feet. Span lengths shown below are center-to-center spans.

R_e = End reaction in lb/ft
R_i = Interior reaction in lb/ft
V_e = Vertical Shear adjacent to end support
V_i = Vertical Shear adjacent to interior support

Span	Bending Moment	Deflection	Bearing	Shear
Single	$+M = 0.125 \cdot w \cdot L^2$	$\Delta = \frac{0.013 \cdot w \cdot L^4 \cdot 1728}{E \cdot I}$	$R_e = 0.5 \cdot w \cdot L$	$V_e = 0.5 \cdot w \cdot L$
Double	$-M = 0.125 \cdot w \cdot L^2$	$\Delta = \frac{0.0054 \cdot w \cdot L^4 \cdot 1728}{E \cdot I}$	$R_e = 0.375 \cdot w \cdot L$ $R_i = 1.25 \cdot w \cdot L$	$V_e = 0.375 \cdot w \cdot L$ $V_i = 0.625 \cdot w \cdot L$
Triple	$-M = 0.1 \cdot w \cdot L^2$	$\Delta = \frac{0.0069 \cdot w \cdot L^4 \cdot 1728}{E \cdot I}$	$R_e = 0.4 \cdot w \cdot L$ $R_i = 1.1 \cdot w \cdot L$	$V_e = 0.4 \cdot w \cdot L$ $V_i = 0.6 \cdot w \cdot L$

Bearing

Verco recommends 2 in. minimum bearing on perpendicular supports. The required bearing should be verified based on specific load and span conditions. Adequate bearing at perpendicular supports is required to prevent web crippling of the deck and to allow for proper attachment. Sufficient bearing at parallel supports should be provided to make the specified connections.

The allowable reactions as well as allowable concentrated line loads based on web crippling (one and two flange loading) are shown in the Verco datasheets, Verco web based design tools, and Verco legacy literature as appropriate.

Figure 1 illustrates the difference between one flange and two flange loading for web crippling.

Web Crippling: One vs. Two Flange Loading

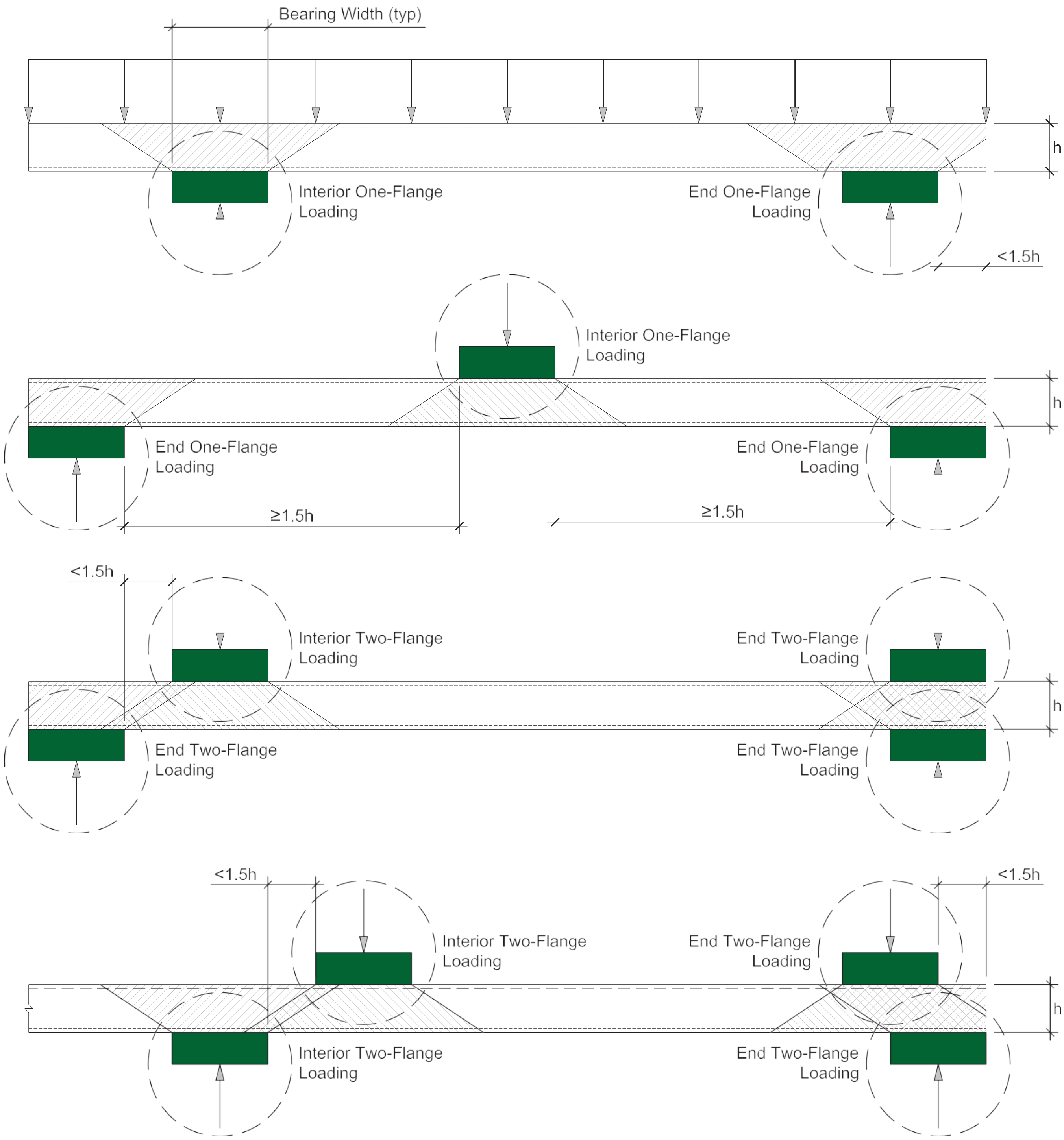


FIGURE 1

Suspended Loads

The engineer of record should evaluate suspended or hanging loads attached directly to the roof deck on the basis of the project conditions. The specific method of attachment will determine the load distribution or effective width of deck to be used in the evaluation. Verco offers a web based design tools to assist with this, which can be found at: Bare Deck Concentrated Loads.

Concentrated Loads

Concentrated loads, such as those due to construction or maintenance workers, should be evaluated based on the deck section properties, material strengths, and web crippling capacities. See the Bare Deck Concentrated Load Tool.

Cantilevered Deck

The length of Verco roof deck cantilevers can be determined based on material and section properties. Consider construction or maintenance workers and materials attached to the deck, particularly with regard to deflection. Attach cantilevers to supports prior to loading and check tension capacity of fasteners. See Figure 2 and the design example in Appendix B.3.

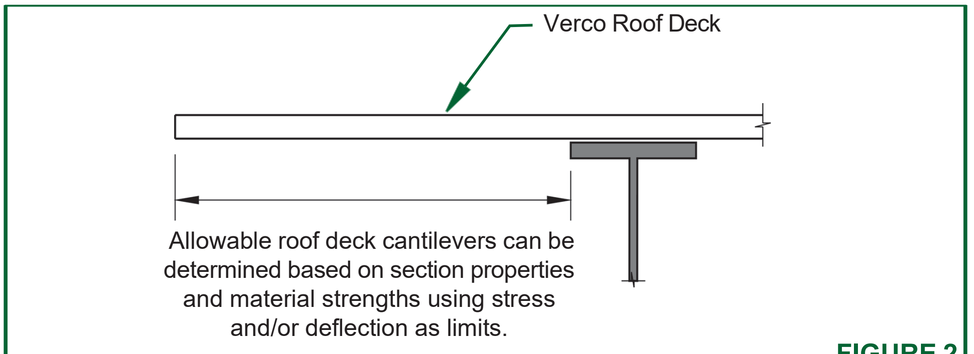


FIGURE 2

Wind Uplift

Determine appropriate spans to resist uplift forces using the Bare Deck Uniform Load.

Alternatively, the engineer of record can determine maximum spans to resist uplift forces based on the deck section properties and material strengths, including applying the appropriate resistance or safety factors. Evaluation may be warranted on specific projects including tension capacity of support fasteners.

Nominal tension strengths of arc spot welds and screws are determined in accordance with AISI's "S100 North American Specification for the Design of Cold-Formed Steel Structural Members."

Nominal tension strengths of Hilti and Pneutek fasteners are based on manufacture's data for the specific combination of fastener, substrate thickness, and deck gage.

Fastener Tension Formulas

Verco Design Tools incorporate fastener tension caclulations, including perforated material when applicable, and can be found in the tab bar at the top of the Design Tool Page. The formulas below can be used to determine the Nominal, Allowable (ASD), or Factored (LRFD) capacity of individual fasteners. The resistance or safety factors for individual connections may vary from the system resistance or safety factors used for diaphragm calculations in AISI S310. These formulas do not apply to connections made through perforated material. Please see the Verco IAPMO reports ER-2018 and ER0423 report or contact Verco Engineering Department for any questions about perforated material.

Arc Spot Weld

AISI S100-16 J2.2.3

$$P_{nt} = minimum \begin{bmatrix} \frac{\pi d_e^2}{4} F_{xx} \\ 0.8\left(F_u/F_y\right)^2 t d_a F_u \end{bmatrix}$$

$\Omega = 2.50$
$\Phi = 0.60$

The following limits shall apply:

(a) $td_aF_u \leq 3$ kips
(b) $F_{xx} \geq 60$ ksi
(c) $F_u \leq 82$ ksi of connecting sheets
(d) $F_{xx} > F_u$

Hilti PAFs

IAPMO ER-2018 & AISI S100-16 J5.2

X-HSN-24	X-ENP-19	
$P_{not} = 8 \cdot t_{support} + 0.088 \leq 1.875\ kips$	$P_{not} = 2.625\ kips$	$\Omega = 2.50$ $\Phi = 0.65$
$P_{nov} = 1.5 t_1 d'_w F_{u1}$		$\Omega = 3.00$ $\Phi = 0.50$
$P_{ntp} = (d/2)^2 \pi F_{uh}$		$\Omega = 2.65$ $\Phi = 0.60$

$$(ASD)\ P_t = min \begin{bmatrix} P_{not}/\Omega \\ P_{nov}/\Omega \\ P_{ntp}/\Omega \end{bmatrix} \qquad (LRFD)\ P_t = min \begin{bmatrix} \Phi\ P_{not} \\ \Phi\ P_{nov} \\ \Phi\ P_{ntp} \end{bmatrix}$$

The appropriate resistance and safety factors shall be used based on the selected P_{not}, P_{nov} or P_{ntp} shown above.

Pneutek PAFs

IAPMO ER-2018 & AISI S100-16 J5.2

SDK61, SDK63, K64, K66	
$P_{not} = 18.37 \cdot t_{support} \leq 4.811\ kips$	$\Omega = 2.45$ $\Phi = 0.65$
$P_{nov} = 1.5 t_1 d'_w F_{u1}$	$\Omega = 3.00$ $\Phi = 0.50$
$P_{ntp} = (d/2)^2 \pi F_{uh}$	$\Omega = 2.65$ $\Phi = 0.60$

$$(ASD)\ P_t = min \begin{bmatrix} P_{not}/\Omega \\ P_{nov}/\Omega \\ P_{ntp}/\Omega \end{bmatrix} \qquad (LRFD)\ P_t = min \begin{bmatrix} \Phi\ P_{not} \\ \Phi\ P_{nov} \\ \Phi\ P_{ntp} \end{bmatrix}$$

The appropriate resistance safety factors shall be used based on the selected P_{not}, P_{nov} or P_{ntp} shown above.

Screws Steel Supports[3]

AISI S100-16 J4.4

$$P_{not} = 0.85 t_c d F_{u2}$$

$$P_{nts} = 1.545\ kips$$

$$P_{nov} = 1.5 t_1 d'_w F_{u1}$$

$\Omega = 3.00$
$\Phi = 0.50$

$$(ASD)\ P_t = min \begin{bmatrix} P_{not}/\Omega \\ P_{nts}/\Omega \\ P_{nov}/\Omega \end{bmatrix} \qquad (LRFD)\ P_t = min \begin{bmatrix} \Phi\ P_{not} \\ \Phi\ P_{nts} \\ \Phi\ P_{nov} \end{bmatrix}$$

The appropriate resistance safety factors shall be used based on the selected P_{not}, P_{nts} or P_{nov} shown above.

Screws Wood Supports AISI S310-16 D3.1.2.2		
	$P_{not} = 6.16G^2 d h_s$	$\Omega = 3.00$ $\Phi = 0.55$
	$P_{nts} = 1.545\ kips$	$\Omega = 3.00$ $\Phi = 0.50$
	$P_{nov} = 1.5 t_1 d'_w F_{u1}$	

$$(ASD)\ P_t = min \begin{bmatrix} P_{not}/\Omega \\ P_{nts}/\Omega \\ P_{nov}/\Omega \end{bmatrix} \qquad (LRFD)\ P_t = min \begin{bmatrix} \Phi\ P_{not} \\ \Phi\ P_{nts} \\ \Phi\ P_{nov} \end{bmatrix}$$

The appropriate safety factors shall be used based on the selected P_{not}, P_{nts} or P_{nov} shown above.

d	Nominal diameter of fastener (screw, PAF, bolt) or visible diameter of outer surface of Arc Spot Weld (ASW)
d_e	Effective diameter of fused area = $0.7d - 1.5t \leq 0.55d$
d_a	Average diameter of arc spot weld (ASW) at md-thickness of t where $d_a = (d - t)$
d_h	Diameter of head (including integrated washer if fully attached to head)
d_w	Diameter of washer (if used)
d'_w	Effective Pull-over diameter of fastener head $d'_w = d_h + 2t_w + t_1 \leq d_w$; For a fastener without separate washer $d'_w = d_h \leq 0.75$ in.
E	Modulus of elasticity of steel, 29,500 ksi
F_u	Tensile strength of deck
F_{u1}	Tensile strength of member in contact with fastener, screw head or washer
F_{u2}	Tensile strength of member not in contact with fastener, screw head or washer
F_{uh}	260 ksi for HRC_p greater than 52 – Hilti and Pnetuek PAFs are both greater than 52
F_{xx}	Tensile strength of electrode classification
F_y	Yield stress
G	Specific gravity of wood
h_s	Threaded length of screw, including tapered tip that is penetrated into the wood support
P_t/Ω or ΦP_t	Available tensile strength [Allowable or factored resistance] per PAF or screw
P_{not}	Nominal tensile strength [resistance] of support connection controlled by pullout
P_{nov}	Nominal pull-over strength [resistance] per PAF or per screw
P_{nt}	Uplift nominal tensile strength [resistance] of a concentrically loaded support connection
P_{ntp}	Nominal tensile strength [resistance] of PAFs where:
P_{nts}	Nominal tensile breaking strength [resistance] of a fastener as reported by manufacturer or determined by independent laboratory testing
t	Base steel thickness of deck
t_1	Base steel thickness of member in contact with fastener, screw head or washer
t_2	Base steel thickness of member not in contact with fastener, screw head or washer
$t_{support}$	Base steel thickness of support member

Notes:

1. The Hilti fasteners are applicable to the following substrate thicknesses:
   a. X-HSN 24: 1/8 in. ≤ substrate thickness ≤ 3/8 in.
   b. X-ENP-19: substrate thickness ≥ 1/4 in.
2. The Pneutek fasteners are applicable to the following substrate thicknesses:
   a. SDK61 series: 0.113 in. ≤ substrate thickness ≤ 0.155 in.
   b. SDK63 series: 0.155 in. ≤ substrate thickness ≤ 0.250 in.
   c. K64 series: 0.187 in. ≤ substrate thickness ≤ 0.312 in.
   d. K66 series: substrate thickness ≥ 0.281 in.
3. The screws are self-drilling and/or self-tapping screws with the following:
   a. Minimum washer diameter of 5/16 in. and a minimum washer thickness of 0.05 in. The screws must be compliant with ASTM C1513.
   b. Steel Substrate thickness ≤ 0.5 in. Select drill point appropriate to material thickness.
   c. Wood substrate must be selected based on requirements of screw embedment
   d. P_{nts} is conservatively the lowest bound of a #8 screw from major manufacture's literature, check screw manufacturer's literature for individual fastener capacity of selected screw.
4. This table does not address edge distance or spacing of connections, see AISI S100 or applicable evaluation reports for those limits.

ROOF DECK DIAPHRAGMS

The allowable diaphragm shear values in the Verco Bare Deck Diaphragm Tool are based on attachment of the deck to the perpendicular supports with welds or mechanical fasteners. The attachment patterns for each profile are shown in the illustrations included in the Verco web based design tools or Appendix A.1.

Diaphragm Loads

Designers should observe the following notes when working with the Verco web-based design tool or Verco legacy tables:

- The historic practice for general design, which has been reflected in manufacturer's catalogs and Steel Deck Institute publications, is to design using a 3-span condition unless project specific conditions dictate otherwise. The Verco Bare Deck Diaphragm Tool allows the Engineer of Record (EOR) to design for project specific requirements.

- The allowable stress increase permitted for load combinations in IBC Section 1605.2, including wind or seismic forces, shall not be used for allowable diaphragm shears.

- The diaphragm shear stiffness, G', can be determined in accordance with the deck section properties and AISI S310 or by use of the Verco web-based design tools.

The historical flexibility factor (F) can be found in the legacy Verco IAPMO/ICC reports. It is inversely proportional to G' the diaphragm shear stiffness.

$$G' = 1000 / F$$

Where:

F = micro-in/lb

G' = kip/in

- In-plane or diaphragm deflection can be calculated in accordance with the example in Appendix B.2 of this guide.

- See "Sidelap Connections" on page 13 for information regarding connection spacing.

- Deck panels may be butted or lapped. When deck panels are lapped, the suggested minimum nominal end lap length is 2 inches.

- See additional footnotes for Diaphragm Shear Strength and Stiffness Factors listed in the appropriate report or design tool.

FORMLOK® and VERCOR Bare Deck Diaphragms without Concrete Fill

Refer to Bare Deck Diaphragm Tool for diaphragm values for Deep Vercor, Shallow Vercor, PLW2-36, W2-36, PLW3-36, and W3-36 FORMLOK deck without concrete fill. These profiles can be found under the Deck Selection menu "Deck Option" under either Non-Compsite Deck-No fill or Composite Deck-No fill.

Axial Loads

Axial load strength of steel deck can be evaluated in accordance with AISI S100 or using Verco's Bare Deck Wall Anchorage Tool.

ATTACHMENT OF ROOF DECK

Support Fastening

The two most common methods of attaching Verco deck to structural supports are welds and mechanical fasteners, which include power actuated fasteners (PAFs) or self-drilling, self-tapping screws.

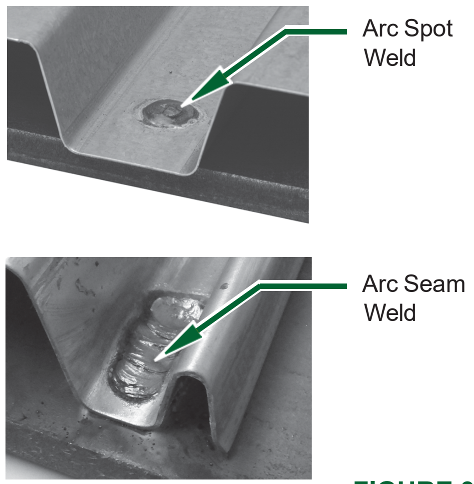


FIGURE 3

Welds: When Verco roof deck is to be welded to supports, the visible fusion area is to be at least 5/8 in. visible diameter for Arc Spot Welds (ASW), which are also known as puddle welds (Figure 3) or alternatively a 3/8 in. x 1 in. long for arc seam welds. Arc seam and arc spot welds are to be located and spaced as per design tools, legacy tables or Appendix A.

Historically on the West Coast, arc spot welds were specified with 1/2” minimum effective diameter, which were often referred to in the field as 3/4” puddle welds.   Specifying arc spot welds based on visible diameter aligns with long held common practice across the rest of the United States.

Hilti Fasteners: X-HSN 24 or X-ENP-19 fasteners are to be installed as shown in Figure 4. Hilti X-HSN 24 fasteners have a dome style head, red guidance washer and a steel silver-colored top-hat washer. The Hilti X- ENP-19 fastener has a fully knurled tip and tapered shank fitted with two 0.590 inch diameter steel cupped washers. Contact Hilti for additional information on the fasteners.

Proper penetration of the Hilti fasteners into structural supports is shown in Figure 4. Fasteners shall be placed to maintain proper edge distance and spacing across the sheets.

Select the appropriate fastener based on the actual substrate thickness.

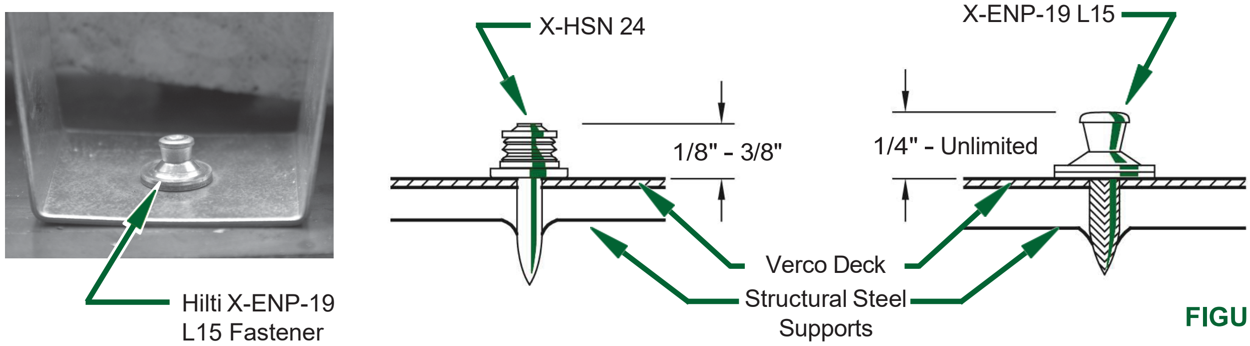


FIGURE 4

Pneutek Fasteners: Pneutek K66, K64, SDK63 or SDK61 fasteners are to be installed as shown in Figure 5. The Pneutek fasteners have ½ inch diameter heads. Contact Pneutek for additional information on the fasteners.

Fasteners must be driven with the Pneutek Air/Safe fastening system to ensure tight contact between the fastener head and the attached deck as shown in Figure 5. Fasteners shall be placed to maintain proper edge distance and spacing across the sheets.

Select the appropriate fastener based on the actual substrate thickness. Note that K66075 or K64075 pins are to be used for attachment of four layers of 20 gage deck, or three or four layers of 18 or 16 gage deck.

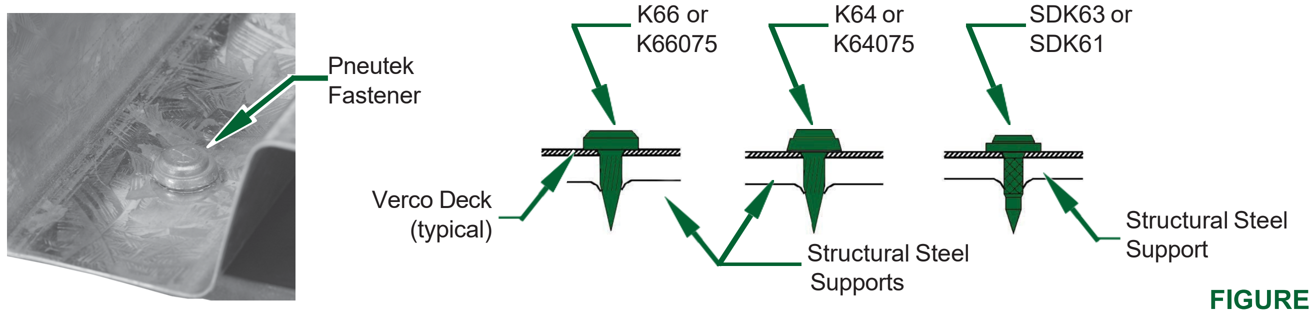


FIGURE 5

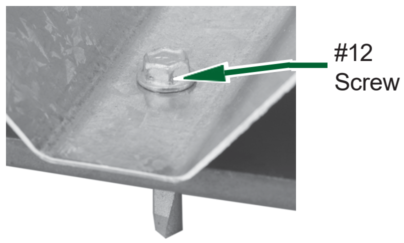


FIGURE 6

Screws: #8, #10, #12, or #14 self-drilling, self-tapping screws are to be installed as shown in Figure 6. The screws must comply with ASTM C1513 with a minimum washer diameter of 5/16-in. and a minimum washer thickness of 0.05 in.

ShearTranz® II-42 System: **In January of 2019, Verco stopped offering any version of the historic ShearTranz® product line.**

Verco first introduced the use of restraining elements to increase roof deck diaphragm strength and stiffness to the West Coast market with the original ShearTranz element in 1979. The ShearTranz II-42 elements in conjunction with the original PunchLok tool to mechanically attach sidelaps.

The performance of the PunchLok II system reduced the need for the additional restraining element to economically meet expected diaphragm performance.

Sidelap Connections

Verco roof decks are typically fastened at the sidelaps by one of four methods: VSC2s made with the PunchLok II Tool, 1½ in. long top seam welds, button punches, or #8 to #14 screws. Other methods of fastening in accordance with AISI S310 can be used.

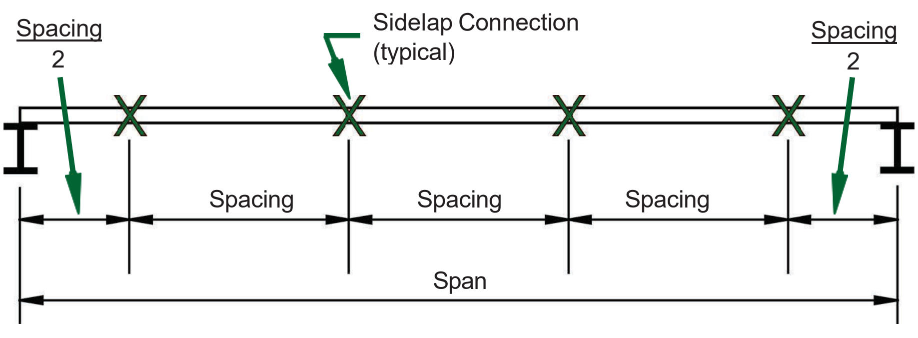


FIGURE 7

The dimension from the centerline of the supports to the first and last sidelap connection within each span is to be no more than one half the specified spacing, as shown in Figure 7. The number of connections per span based on spacing are listed in Table 1.

Table 1: Number of Sidelap Connectiond per Span Based on Spacing

Spacing in inches	Span (ft-in.)																		
	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'	12'	13'	14'	15'	16'	17'	18'	19'	20'
24""	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10
18""	2	2	3	4	4	5	6	6	7	8	8	9	10	10	11	12	12	13	14
12""	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
8""	3	5	6	8	9	11	12	14	15	17	18	20	21	23	24	26	27	29	30
6""	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
4""	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60

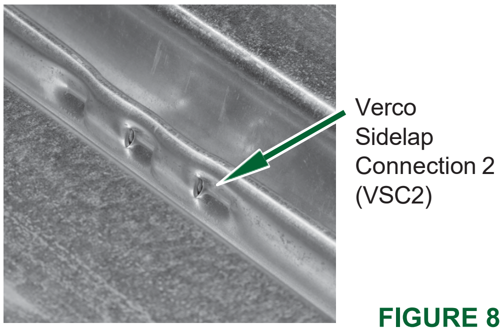


FIGURE 8

PunchLok®II System: The connection made by the PunchLok II Tool is referred to as a VSC2 (Verco Sidelap Connection 2). An acceptable VSC2 connection has been made when the sidelap material has been sheared and offset so the sheared surface of the male leg is visible in the cut (Figure 8).

The VSC2 connection may be made in either direction relative to the sidelap.

Top Seam Welds: When roof deck sidelaps are connected with top arc seam welds (TSW) (Figure 9a), the 1½ in. long weld must engage the top of the inner (male) leg. Clinch the joint before welding to create contact between the lips.

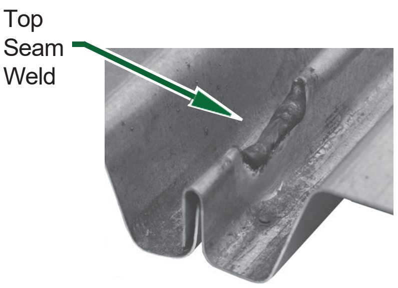


FIGURE 9a

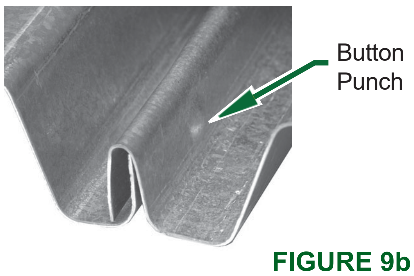


FIGURE 9b

Button Punches: When roof deck sidelaps are connected with button punches (Figure 9b), an average-sized person should be able to stand (not jump) on the flute adjacent to the attachment without the joint coming apart.

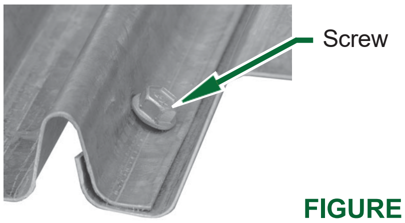


FIGURE 10

Screws: When self-drilling, self-tapping screws are used to connect the sidelaps of roof decks, they are installed as shown in Figure 10. The diaphragm shear strength and shear stiffness shown in the Verco Bare Deck Diaphragm tools are based on the selected self-drilling, self-tapping screws. The "SS" designation for roof deck indicates interlocking deck provided with extended female lip for screw fastening. The "NS" designation for HSN3-32 or HSB-36-NS roof deck indicates deck provided with nested sidelap. Deep and Shallow VERCOR deck are provided with a nested sidelap.

Screws shall be self-drilling self tapping screw with minimum washer diameter of 5/16 in. and min washer thickness of 0.05 in. in accordance with ASTM C1513

Parallel Collectors

Spacing of the attachments at diaphragm chords, struts, ties or other collector elements that are parallel to the deck flutes is based on the shear to be transferred and shear capacity of the connections used. The spacing of the connections at these shear transfer elements parallel to the deck flutes should not be larger than that for the interior sidelap connections in order to maintain diaphragm rigidity. The maximum spacing of attachments at parallel collectors is 3 ft on center.

Nominal connection strengths for Arc Spot Welds, Arc Seam Welds, Hilti Fasteners, Pneutek Fasteners, and Simpson Strong-Tie Screws, and various other screws are listed in Verco web-based design tools.

Fillet Welds: Spacing of fillet welds used at collectors parallel to the deck flutes should be based on the shear to be transferred. Available shear strength for fillet welds should be determined in accordance with AISI S100.

Skewed Conditions

The number of support fasteners at skewed conditions shall be based on the actual shear to be transferred and the shear capacity of the connections used. Bearing at supports shall allow for proper end distance and fastener spacing. Consult the project Engineer of Record for the project for further requirements.

Fastener Shear Formulas

Verco Design Tools incorporate fastener shear calculations, including perforated material when applicable, and can be found in the tab bar at the top of the Design Tools Page. The formulas below can be used to determine the nominal or available capacity of individual fasteners. The resistance or safety factors for individual connections may vary from the system resistance or safety factors used for diaphragm calculations used in AISI S310. These formulas do not apply to connections made through perforated material. Please see the Verco IAPMO reports ER-2018 or ER-0423 or contact Verco Engineering Department for any questions about perforated material.

Arc Spot Weld

AISI S100-16 J2.2.2

(A)

$$P_{nv} = \frac{\pi d_e^2}{4} 0.75F_{xx}$$

$\Omega = 2.55$, $\Phi = 0.60$

(B)

For $(d_a/t) \leq 0.815\sqrt{E/F_u}$	For $0.815\sqrt{E/F_u} < (d_a/t) < 1.397\sqrt{E/F_u}$	For $(d_a/t) \geq 1.397\sqrt{E/F_u}$
$P_{nv} = 2.20td_aF_u$	$P_{nv} = 0.280\left[1 + 5.59\frac{\sqrt{E/F_u}}{d_a/t}\right]td_aF_u$	$P_{nv} = 1.40td_aF_u$
$\Omega = 2.20$, $\Phi = 0.70$	$\Omega = 2.80$, $\Phi = 0.55$	$\Omega = 3.05$, $\Phi = 0.50$

$$P_a = min\begin{bmatrix} A/\Omega \\ B/\Omega \end{bmatrix} \qquad P_a = min\begin{bmatrix} \Phi A \\ \Phi B \end{bmatrix}$$

The appropriate safety factors shall be used based on the selected A and B formulas shown above.

Hilti PAFs[1]

IAPMO ER-2018 & AISI S100-16 J5.3

	X-HSN-24	X-ENP-19	
	$P_{nvp} = 3.020$ kips	$P_{nvp} = 3.838$ kips	$\Omega = 2.65$, $\Phi = 0.60$
	$P_{nf} = 52 \cdot t \cdot (1 - t) \leq P_{nvp}$	$P_{nf} = 56 \cdot t \cdot (1 - t) \leq P_{nvp}$	$\Omega = 2.65$, $\Phi = 0.60$

Pneutek PAFs[2]

IAPMO ER-2018 & AISI S100-16 J5.3

SDK61	SDK63	K64	K66	
$P_{nvp} = 2.345$	$P_{nvp} = 3.385$	$P_{nvp} = 3.705$	$P_{nvp} = 4.479$	$\Omega = 2.65$, $\Phi = 0.60$
$P_{nf1} = 0.735\ t\ F_u(1 - 0.016tF_u) \leq P_{nvp}$ $P_{nf2} = 0.788\ t\ F_u(1 - 0.028tF_u) \leq P_{nvp}$	$P_{nf} = 1.264\ t\ F_u(1 - 0.053tF_u) \leq P_{nvp}$			$\Omega = 2.40$, $\Phi = 0.65$

Screws[3] Steel Supports

AISI S100-16 J4.3

#8 Screw	#10 Screw	#12 Screw	#14 Screw
$P_{nv} = 1.000$ kip	$P_{nv} = 1.400$ kip	$P_{nv} = 2.000$ kip	$P_{nv} = 2.600$ kip

For $(t_2/t_1) \leq 1.0$

$$P_{nv} = Minimum\begin{bmatrix} 4.2({t_2}^3 d)^{1/2}F_{u2} \\ 2.7t_1dF_{u1} \\ 2.7t_2dF_{u2} \end{bmatrix} \leq P_{nvp}$$

For $1.0 < (t_2/t_1) < 2.5$

Interpolate between the above and below screw cases $\leq P_{nvp}$

For $(t_2/t_1) \geq 2.5$

$$P_{nv} = Minimum\begin{bmatrix} 2.7t_1dF_{u1} \\ 2.7t_2dF_{u2} \end{bmatrix} \leq P_{nvp}$$

$\Omega = 3.00$, $\Phi = 0.50$

	#8 Screw	#10 Screw	#12 Screw	#14 Screw	
Screws[3] Wood Supports AISI S310-16 D1.1.4.2	$P_{nfw} = 1.00G$	$P_{nfw} = 1.12G$	$P_{nfw} = 1.43G$	$P_{nfw} = 1.97G$	$\Omega = 3.00$ $\Phi = 0.55$
	$P_{nss} = 1.000$ kip	$P_{nss} = 1.400$ kip	$P_{nss} = 2.000$ kip	$P_{nss} = 2.600$ kip	
	$P_{nfws} = 2.2t_1dF_{u1}$		$P_{nfws} = 2.7t_1dF_{u1}$		
	For $4d \leq h_s < 7d$ $P_{nf} = min\begin{bmatrix} h_s/7d \cdot P_{nfw} \\ P_{nss} \\ P_{nfws} \end{bmatrix}$		For $h_s \geq 7d$ $P_{nf} = min\begin{bmatrix} P_{nfw} \\ P_{nss} \\ P_{nfws} \end{bmatrix}$		

d Nominal diameter of fastener (screw or PAF) or Visible diameter of outer surface of Arc Spot Weld (ASW) (in)
E Modulus of elasticity of steel, 29,500 (ksi)
d_a Average diameter of ASW at d-thickness of t where $d_a = (d - t)$ (in.)
d_e Effective diameter of fused area $= 0.7d - 1.5t \leq 0.55d$ (in.)
F_u Tensile strength of deck (ksi)
F_{u1} Tensile strength of member in contact with screw head or washer (ksi)
F_{u2} Tensile strength of member not in contact with screw head or washer (ksi)
F_{xx} Tensile strength of electrode classification (ksi)
G Specific gravity of wood
h_s Threaded length of screw, including tapered tip that is penetrated into the wood support (in.)
P_{nf} Nominal shear strength [resistance] of a support connection per fastener (kips)
P_{nfws} Nominal shear strength [resistance] of wood support screw fully penetrated controlled by bearing against steel panel (kips)
P_{nfw} Nominal shear strength [resistance] of wood support screw fully penetrated controlled by bearing against wood (kips)
P_{nv} Nominal shear strength [resistance] of screw or weld (kips)
P_{nvp} Nominal shear strength [resistance] of PAF reported by manufacturer or by testing (kips)
P_{nss} Nominal shear strength [resistance] of screw reported by manufacturer or by testing (kips)
t Base steel thickness of deck (in.)
t_1 Thickness of member in contact with screw head or washer (in.)
t_2 Thickness of member not in contact with screw head or washer (in.)

Notes:

1. The Hilti fasteners are applicable to the following substrate thicknesses:
   a. X-HSN 24: 1/8 in. ≤ substrate thickness ≤ 3/8 in.
   b. X-ENP-19: substrate thickness ≥ 1/4 in.
2. The Pneutek fasteners are applicable to the following substrate thicknesses:
   a. SDK61 series: 0.113 in. ≤ substrate thickness ≤ 0.155 in.
      i. P_{nf1} = for substrate thickness of 0.113 in.
      ii. P_{nf2} = for substrate thickness of 0.155 in.
   b. For substrate thickness between 0.133 in. and 0.155 in., P_{nf} shall be determined by interpolation.
   b. SDK63 series: 0.155 in. ≤ substrate thickness ≤ 0.250 in.
   c. K64 series: 0.187 in. ≤ substrate thickness ≤ 0.312 in.
   d. K66 series: substrate thickness ≥ 0.281 in.
3. The screws are self-drilling and/or self-tapping screws with the following:
   a. Minimum washer diameter of 5/16 in. and a minimum washer thickness of 0.05 in. The screws must be compliant with ASTM C1513.
   b. Steel substrate thickness ≤ 0.5 in depending on drill point selected
   c. Wood substrate must be selected based on requirements of screw embedment
4. This table does not address edge distance or spacing of connections, see AISI S100 or applicable evaluation reports for those limits.

VERCO ROOF DECK FINISHES

Verco roof decks are offered in various finishes:

Galvanized

Cold rolled zinc coated steel (ASTM A653) with coating designation G60 is the standard zinc coated material of the deck industry. Coating designation G90 is a heavier, more costly zinc coating often specified for exposed exterior applications or other project specific requirements. Other ASTM A653 galvanized coatings may be available on special request – contact your Verco representative regarding availability.

Cold Rolled with Primer

Acrylic primer is applied to cold rolled steel (ASTM A1008). The Verco acrylic primer is applied by a roller coat process and oven cured. Verco gray primer is approved by UL for use in direct applied fire-rated assemblies. Refer to Verco Website for specific listings.

Due to varying job site conditions, application methods, coating manufacturers, environmental conditions and expectations, it is essential to conduct a field test to determine compatibility of the field applied top coat with the primer coat prior to full scale painting. Verco is not responsible for topcoat compatibility. Primer specifications are available from the Verco Website.

Primer paint is intended to protect steel deck for a short period of exposure in ordinary atmospheric conditions. It should be considered as an impermanent and provisional coating. Rust can occur.

Minor aesthetic irregularities and/or imperfections may appear in the paint coating as a result of the manufacturing process.

Galvanized with Primer

Galvanized fluted roof deck is available with factory gray or white primer applied to the underside of the deck exposed to view. Primed galvanized deck is suitable for applications where the deck will be field-painted (may eliminate the need for field priming) or to meet other specific requirements.

Optionally, the primer paint may be left exposed in certain interior applications. Custom color primers are available. Contact your Verco representative regarding availability.

Exposed Product Appearance

Fluted and cellular roof deck are structural products. Minor dents and scratches which do not affect the structural capacity of deck are not grounds for rejection. Note that lighter gage material is more susceptible to the appearance of oil canning and minor dents during the shipping, handling and installation process. For cellular deck, flat bottom pans are susceptible to the appearance of oil-canning, particularly when perforated. The appearance of oil canning does not affect the structural integrity of fluted and cellular roof decks and is not grounds for rejection.

What are the considerations if rust occurs on structural steel deck? There are three primary concerns; first the adherence of paint and concrete to the deck; second the aesthetics of the deck if exposed; and lastly the structural integrity of the deck. SDI notes that the corrosion process should stop once the deck is enclosed and removed from wetting/drying cycles. As long as the rust is light and tight, loss of section is unlikely and thus the structural integrity should be maintained.

ROOF DECK PRODUCT SELECTION

Spans

Span length is one of the key factors in determining an appropriate roof deck profile. Determine logical span lengths (three span is suggested whenever possible) based on the bay size. Contact your Verco representative regarding the availability of deck lengths greater than 40 feet. Consider handling the weight of the deck during installation when evaluating long deck lengths, especially in heavier gages and cellular decks. Utilize Verco Roof Deck Design Tools on to evaluate project specific conditions..

Roofing

Verco roof and cellular deck is a structural product resisting horizontal and vertical loads. Normally, insulation and roofing materials are applied over Verco roof deck to create a water tight roofing system.

However, Verco fluted deck can be used for walkways, canopies, sunshades, or other structures which do not require a watertight roof. Attachments for exposed exterior applications should comply with building code requirements.

Vent Tabs

Galvanized Verco roof deck is available with factory punched vent tabs to provide positive venting (see Figure 11). Determine venting requirements based on the specific materials installed over the deck. Some leakage during concrete placement should be anticipated with vented deck. Vent tabs projecting upwards are staggered in interior low flutes at approximately 6 in. on center:

- 5 rows in PLB-36 and HSB-36.
- 3 rows in PLN3-32 and HSN3-32.

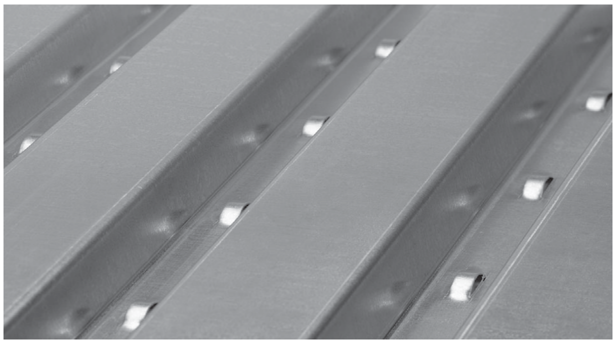


FIGURE 11

ROOF DECK DESIGN EXAMPLE

This design example illustrates the basic process involved in the design and selection of Verco roof deck. Various choices are outlined for each point to be considered. This example illustrates particular criteria, not all of the possible options. The Verco Roof Deck Design Tools were used to determine the spans and available diaphragm strengths and shear stiffnesses for the suggested solutions. If you have additional questions, please contact the Verco Engineering Department.

Design Goals

The design goals for this example are as follows:

- Select Design Method
- Resist specified uniform vertical loads
- Resist specified horizontal diaphragm loads
- Select an economical roof deck system

Given:

48'-0" x 30'-0" bay size
Deck oriented parallel to 48 ft dimension
Perimeter walls provide lateral restraint
Fire rating not required
Loads:
Dead Load = 30 psf
Live Load = 50 psf
Total Vertical Load = 80 psf
Uplift (MWFRS) = 0 psf
Maximum seismic diaphragm shear required (LRFD) = 1070 plf
Maximum seismic diaphragm shear required (ASD) = 750 plf
Minimum G' Stiffness required = 30.0
Both Ends lapped for 3 span condition

Span Options

Spacing between the beams or joists will suggest the deck profile options. Refer to Roof Deck Design Tools for more information. Based on the profile options, determine the minimum gages to meet vertical load requirements, assuming triple span sheets.

1. 12'-0" spans
   Choice: 20 gage PLN3-32 roof deck.
2. 8'-0" spans
   Choice: 20 gage PLB-36 roof deck.
3. 6'-0" spans
   Choice: 22 gage PLB-36 roof deck

Selection: Option 1 is the most expensive deck choice, but minimizes the number of supports. Option 2 optimizes deck gage based on span. Option 3 minimizes the deck cost but requires the most supports.

ROOF DECK DESIGN EXAMPLE (CONTINUED)

Diaphragm Attachment Options

Determine the minimum deck gage and minimum attachments necessary to meet the specified required horizontal diaphragm strength (S_{req}). Verify that the horizontal deflection of the diaphragm is within acceptable limits. G' based on the stated number of spans is provided for comparison.

Historical tables typically used the ASD, LRFD or LSD factors of safety and resistance for Earthquake and Wind loading from AISI S100, Table D5, excerpt below.

1. If needed to convert from Earthquake loading to Wind loading, utilizing ASD, the published allowable diaphragm shear strength may be multiplied by Ω_d (Earthquake), and then divided by Ω_d (Wind):
   As an example:
   Welds: 3.00/2.35 = 1.27
   Mechanical Fasteners: 2.5/2.35 = 1.06

2. To convert from ASD to LRFD for each connection type, the published allowable diaphragm shear values may be multiplied by the applicable conversion factor, $C = \Omega_d \times <\Phi_d$

The following examples are for Earthquake loading:

For welds: C_{WELD} = 3.00 x 0.55 = 1.65
For mechanical fasteners: $C_{MECHANICAL\ FASTENER}$ = 2.5 x 0.65 = 1.625
For deck panel buckling*: $C_{BUCKLING}$ = 2.00 x 0.80 = 1.60

Safety Factors and Resistance Factors for Diaphragms

Load Type or Combinations Including	Connection Type[1]	Limit State			
		Connection Related		Panel Buckling[2]	
		Q_d (ASD)	$<I_d$ (LRFD)	Q_d (ASD)	$<I_d$ (LRFD)
Earthquake	Welds	3.00	0.55		
	Screws	2.50	0.65		
Wind	Welds	2.35	0.70	2.00	0.80
	Screws				
All Others	Welds	2.65	0.60		
	Screws	2.50	0.65		

1. For mechanical fasteners - such as Power Actuated Fasteners or Forced Entry Fasteners, the factors of safety for screws may be used.
2. Panel buckling is considered out-of-plane deck buckling and not local buckling at fasteners.

ROOF DECK DESIGN EXAMPLE (CONTINUED)

In general a lighter gage deck with more attachments is more economical than using a heavier deck with fewer attachments. When selecting the attachment system, consider the use of mechanical fasteners (power-actuated fasteners or screws) in conjunction with the PunchLok II System to minimize both installation and inspection costs. Together these benefits offer an economical deck system which can be installed in a minimum amount of time.

For a more in-depth deck selection example see Appendix B.3.

1. 12'-0" c-c spans
   Attachment Choices:

Deck	Supports		Sidelaps		q, Sesmic (plf)		Stiffness G'
	Type	Pattern	Type	Spacing	ASD	LRFD	
3" Deep Roof Deck							
20 ga PLN3-32	Hilti HSN-24	32/5	VSC2	18" o.c.	797	1283	121
20 ga PLN3-32	Pneutek SDK63	32/5	VSC2	18" o.c.	899	1447	115
20 ga PLN3-32	#12 Screw	32/5	VSC2	12" o.c.	857	1379	144
20 ga PLN3-32	3/4" ASW	32/5	VSC2	12" o.c.	979	1615	145

2. 8'-0" c-c spans
   Attachment Choices:

Deck	Supports		Sidelaps		q, Sesmic (plf)		Stiffness G'
	Type	Pattern	Type	Spacing	ASD	LRFD	
1 1/2" Deep Roof Deck							
20 ga PLB-36	Hilti HSN-24	36/5	VSC2	18" o.c.	783	1260	149
20 ga PLB-36	Pneutek SDK63	36/5	VSC2	18" o.c.	1018	1640	140
20 ga PLB-36	#12 Screw	36/7	VSC2	18" o.c.	861	1386	151
20 ga PLB-36	3/4" ASW	36/5	VSC2	18" o.c.	864	1425	150

3. 6'-0" c-c spans
   Attachment Choices:

Deck	Supports		Sidelaps		q, Sesmic (plf)		Stiffness G'
	Type	Pattern	Type	Spacing	ASD	LRFD	
1 1/2" Deep Roof Deck							
22 ga PLB-36	Hilti HSN-24	36/7/4	VSC2	12" o.c.	893	1437	135
22 ga PLB-36	Pneutek SDK63	36/7/4	VSC2	18" o.c.	819	1319	104
22 ga PLB-36	#12 Screw	36/7/4	VSC2	12" o.c.	776	1250	134
22 ga PLB-36	3/4" ASW	36/7/4	VSC2	12" o.c.	821	1354	136

Note:

- Diaphragm shear and stiffness values listed for all mechanical fasteners assume minimum 0.188 in. thick A572 steel supports.

ROOF DECK DESIGN EXAMPLE (CONTINUED)

- Values shown are those necessary to meet the maximum required shear, q, and stiffness G'. Maximum economy can be achieved by zoning the diaphragm, reducing deck gage and/or attachments as shear requirements diminish across the building.
- Attachment of deck to parallel shear collectors is required but not shown.

Finish Options

The total installed cost, including field painting, should be used to determine the deck finish choice. Choices include:

1. Cold rolled with primer.
2. Galvanized.
3. Galvanized with primer.

Fire Ratings

Hourly fire ratings, if required, may affect the maximum allowable deck span and/or minimum deck gage. Refer to the UL Fire Resistance Directory or Verco's Evaluation Report for further information. Note that only cold rolled steel with Verco factory gray primer or galvanized finishes are approved for use with spray applied fire proofing.

LEED

On the West Coast, steel products can typically meet LEED sections 4.1 and 4.2 for recycled content of the steel. The commonly available coils can meet or exceed the 20% recycled content required for those two categories. If higher recycled content is needed, typically a special ordered coil from mills in the Eastern United States are used. Other LEED regional requirements cannot be met due to the lack of steel furnaces and iron mines in the Western United States.

EPD

An Environmental Product Declaration (EPD) is an independently verified and registered document that communicates transparent and comparable information about the environmental impact of a product over its life cycle. Global Warming Potential (GWP) is the primary metric, or impact category, indicated on EPDs. If an EPD is required, the specifier should ensure that the specifications clearly state the EPD or GWP requirements, so that all suppliers bid to the same criteria and vital information is not missed.

Verco manufactures steel deck at three facilities and sources the primary raw material, steel coils, produced using either blast furnace (BF) technology or electric arc furnace (EAF) technology. Verco's manufacturer-specific EPD, which includes facility-specific GWP values, can be downloaded from the Verco Website. Within this EPD, the results of Verco products made from EAF-based coils and BF-based coils are separated to more accurately represent the impact of raw material procurement for Verco products. For assistance, please contact the Verco Engineering or Sales Departments.

Domestic Steel

Verco sources steel coil from various suppliers that can use domestic or overseas steel sources. Typically, West Coast coil production uses steel slab from mills outside the United States. Verco can supply 100% domestic steel coil on projects where it is required. Contact your Verco representative for lead times.

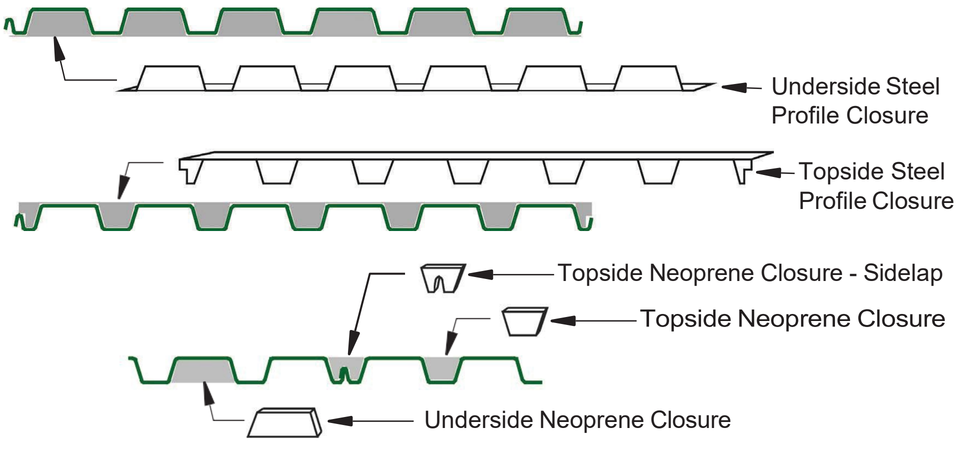
ROOF DECK ACCESSORIES

Profile Closures

Profile closures made from steel or neoprene are designed to fit Verco's deck products. See Table 6 for availability of closures by deck profile. Steel closures are 22 gage with a 1 in. return lip for fastening to deck with screws or tack welds. Neoprene closures for PLB-36, HSB-36, PLN3-32, HSN3-32, 2.0D and 3.5D Dovetail decks are 1 in. thick individual plugs. See Figure 12 and 13 for typical installation of closures.

Table 6: Availability of Profile Closures

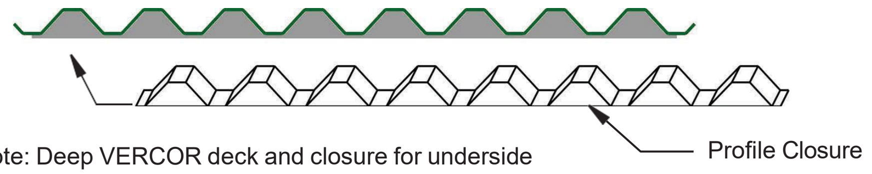
Deck Profile	Steel Closures		Neoprene Closures	
	Underside	Topside	Underside	Topside
PLB-36 or HSB-36	✓	✓	✓	✓
PLB-36 or HSB-36	✓	✓	✓	✓
PLN3-32 or HSN-32	✓	✓	✓	✓
2.0D-24.5 Dovetail	n/a	n/a	✓	✓
3.5D-24 Dovetail	n/a	n/a	✓	✓
Shallow Vercor (SV-36)	n/a	n/a	✓	✓
Deep Vercor (DV-36)	n/a	n/a	✓	✓



Note: PLB-36 or HSB-36 deck and closures shown; closures for other profiles are installed similarly.

FIGURE 12

Neoprene profile closures for Deep and Shallow VERCOR decks. 1 in. thick, 36 in. long strips and are designed to fit into either the underside or topside of the profile.



Note: Deep VERCOR deck and closure for underside application is shown; closures for Shallow VERCOR and topside application are installed similarly.

FIGURE 13

Sump Pan

- 14 gage
- Flat recessed

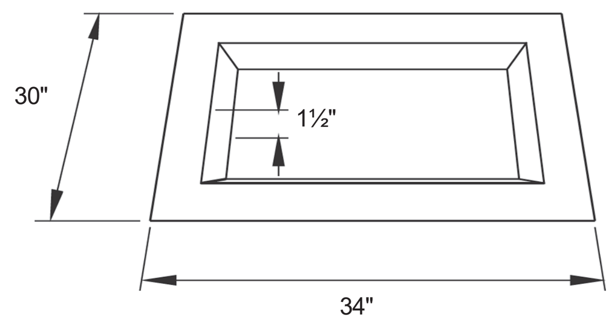


FIGURE 14

Sump pan usage and design guidance for roof deck supporting sump pans can be found in the Steel Deck Institute Manual of Construction with Steel Deck (MOC3). It is available for download at https://www.sdi.org

ACOUSTICAL ROOF DECK

Fluted Acoustical Deck

Verco 1½” and 3” deep fluted, 2” and 3½” deep Dovetail, and 1½” and 3” deep cellular roof decks are available as acoustical decks. Acoustical deck can provide sound attenuation within buildings where the deck is exposed to the interior. Acoustical uses are limited to non-fire-rated assemblies.

PLB-36, HSB-36, PLN3-32 and HSN3-32 fluted decks are available with acoustical perforations in the webs. The webs adjacent to the sidelaps of the PLB-36 and HSB-36 are not perforated as shown in Figure 15. Acoustical perforations are 5/32” in diameter on 7/16” staggered centers. The roofing contractor should install the acoustical insulation batts in fluted acoustical deck as shown in Figure 15, before placement of the roof insulation. The web perforations have some impact on the deck section properties (vertical loads), allowable reactions due to web crippling, and diaphragm shear and flexibility, as shown in Verco’s IAPMO ER-2018 and accounted for in the web-based design tools.

Acoustic Insulation Placement Fluted Deck

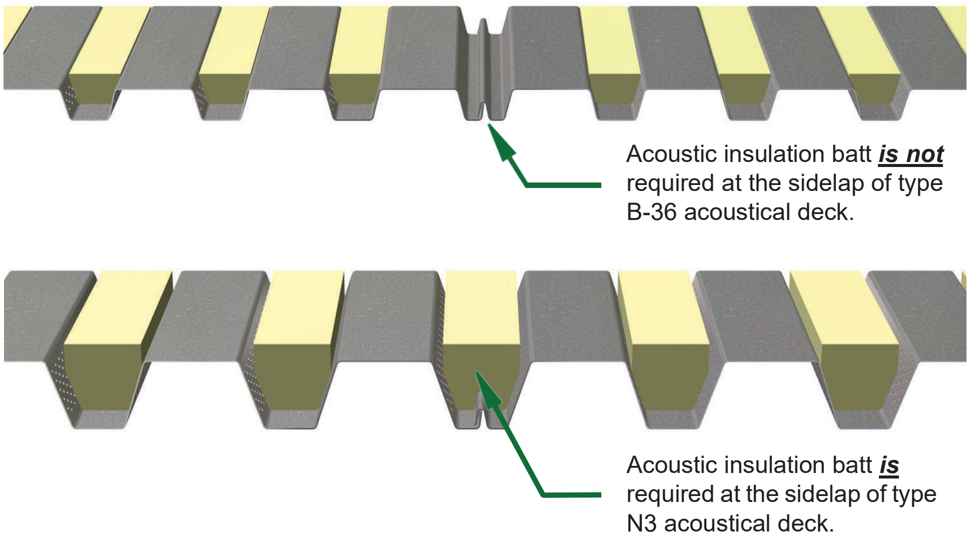


FIGURE 15

Fully Perforated Deck

PLB-36/HSB-36 and PLN3-32/HSN3-32 roof deck profiles are also available fully perforated with the perforations across the entire section except for the sidelaps. Options include approximately 11% open area (FP11) or approximately 21% open area (FP21). The web perforations have some impact on the deck section properties (vertical loads), allowable reactions due to web crippling, and diaphragm shear and flexibility, as shown in Verco’s IAPMO ER-2018 and accounted for in the web-based design tools. Contact your Verco representative for availability.

Cellular Acoustical Deck

PLB-36-CD, HSB-36-CD, PLN3-32-CD, and HSN3-32-CD cellular decks are available with acoustical perforations in the flat bottom plate. Acoustical perforations are 5/32 inch in diameter on 7/16 inch staggered centers in bands centered under the top flanges of the fluted top sections. The insulation batts in acoustical cellular deck are factory installed as shown in Figure 16. The perforations in the flat bottom plates have some impact on the deck section properties (vertical loads) and diaphragm shear and flexibility.

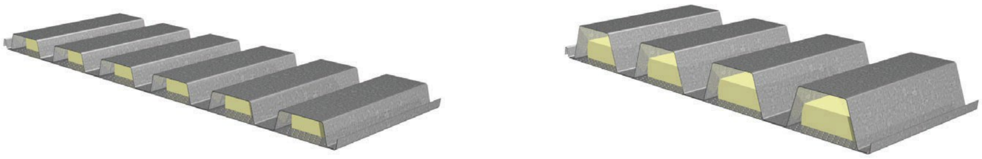


FIGURE 16

Dovetail Acoustical Deck

2.0DA-24.5 and 3.5DA-24 Dovetail Acoustical Decks are available with acoustical perforations in the bottom flange. The roofing contractor should install the acoustical insulation batts in fluted acoustical deck as shown in Figure 17, before placement of the roof insulation. The perforations in the flat bottom flanges have some impact on the deck section properties (vertical loads) and diaphragm shear and flexibility.

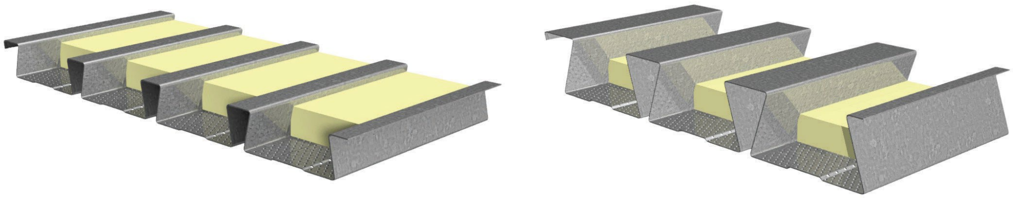


FIGURE 17

Roof Insulation

The performance of acoustical decks may be affected by the type of insulation placed above the deck. Acoustical performance data for fluted decks is shown with the historically used rigid fiberglass insulation board, polyisocyanurate insulation (poly-iso board), and with roof board. The choice of insulation placed above the deck has minimal impact on the acoustical performance of cellular deck therefore only polyisocyanurate insulation is used in the cellular deck assemblies.

Acoustical Insulation

The acoustical insulation batts used in fluted, dovetail or cellular acoustical decks are available encapsulated (wrapped) as a special order. Optional spacers may be installed in cellular acoustical decks between the flat bottom plate and the insulation batts. The acoustical performance of fluted decks with wrapped insulation batts and cellular acoustical decks with spacers are available on the Verco Website.

Noise Reduction Coefficients

The Verco NRC data sheets summarizes the sound absorption coefficients for fluted, dovetail and cellular decks at a number of frequencies. The complete acoustical test reports with the full range of absorption coefficients are available from the Verco website. The noise reduction coefficient (NRC) historically reported is the average of the coefficients at 250, 500, 1000, and 2000 Hz expressed to the nearest multiple of 0.05. The sound absorption average (SAA) is the average of the sound absorption coefficients for the twelve one-third octave bands from 200 through 2500 Hz inclusive, rounded to the nearest 0.01.

Sound Transmission (STC & IIC)

Sound transmission between spaces within a structure or between the exterior and interior of a building is a function of the mass of the floor or roof assembly, and thus is not greatly impacted by the choice of steel roof deck itself, with or without acoustical insulation.

Appearance

Acoustical decks are normally exposed to view, therefore it is appropriate to review the product appearance considerations described on page 14.

FIRE-RATED VERCO ROOF DECK (UL)

Verco roof decks may be used in assemblies which are required to meet hourly fire ratings. Approved hourly fire-rated assemblies are a combination of specific proprietary materials as listed in the individual UL fire-rated assemblies.

See the Verco UL Fire Rated Roof Deck data sheet for a listing of UL fire-rated assemblies utilizing Verco roof deck profiles. Refer to the particular UL assembly being considered for full details of construction, including specific information about fill or fireproofing thicknesses and span limitations.

All Acoustical Roof deck uses are limited to non-fire-rated assemblies. Acoustical cellular composite deck with structural concrete topping is included in a limited number of UL assemblies. . Please see Verco's UL Floor Data Sheet for further information.

FACTORY MUTUAL

FM APPROVED

All Verco 1½", 2", 3" and 3.5" fluted, cellular and dovetail roof deck profiles meet Factory Mutual (FM) Approvals as: STEEL ROOF DECKS; Class I fire; Class I-60, I-75, and I-90 Wind Uplift Rating; Live Load Deflections; and Foot Traffic Resistance of Insulation per FM Standard 4451.

Allowable Spans based upon the most conservative considerations of FM Standard 4451 for live load deflection, and Class I-60, I-75, and I-90 Wind Uplift Rating related to deck bending and fastener pull-over are shown in Table 3 for the specified fluted decks, and Table 4 for cellular decks. (Note: Approved spans are measured center-to-center of support members. FM Standard 4451 limits deflection at L/240 for a 200 lb. point load at mid-span. The specific FM Approved above deck components and selected attachments should also be considered.)

FM Global's RoofNav program, available from their website (www.roofnav.fmglobal.com), may be searched using the company name, Verco, for steel deck. Please note that specific assemblies within RoofNav do not list specific steel decks so as not to unnecessarily restrict what can be used. For a more comprehensive and expanded list of allowable spans based upon FM Standard 4451 for each Wind Uplift Rating Class I-60, I-75 and I-90 for Verco deck with specific FM Approved support connections and connection spacing, see the FM Approval Reports for Verco deck.

Table 3: Simplified FM Approved Spans (c-c) for the most conservative considerations of FM Standard 4451 for live load deflection, and Class I-60, I-75, and I-90 Wind Uplift Rating related to deck bending and fastener pull-over for 1½"and 3" Fluted Roof Decks

Gage	No. of Spans	PLB-36 or HSB-36		PLN3 or HSN3	
		Plain	Acoustic	Plain	Acoustic
22	1	6"-0"	5"-11"	12"-1"	10"-10"
	2+	7"-4"	7"-4"	12"-6"	11"-11"
20	1	6"-8"	6"-8"	13"-6"	12"-1"
	2+	8"-1"	8"-0"	14"-1"	13"-6"
18	1	7"-10"	7"-9"	15"-10"	14"-1"
	2+	9"-4"	9"-3"	17"-3"	16"-6"
16	1	8"-10"	8"-9"	17"-11"	16"-0"
	2+	10"-4"	10"-4"	19"-9"	18"-11"

Note: FM Approved Spans are limited to L/240 deflection due to 200 lb point load at mid-span.

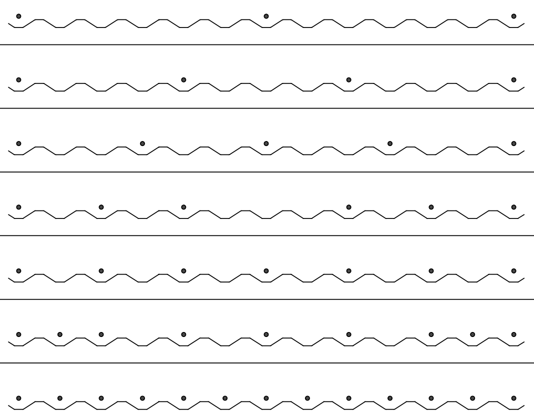
Table 4: Simplified FM Approved Spans (c-c) for the most conservative considerations of FM Standard 4451 for live load deflection, and Class I-60, I-75, and I-90 Wind Uplift Rating related to deck bending and fastener pull-over for 1½"and 3" Cellular Roof Decks

Gage	No. of Spans	PLB-36-CD or HSB-36-CD		PLN3-CD or HSN3-CD	
		Plain	Acoustic	Plain	Acoustic
20/20	1	9"-3"	9"-1"	17"-9"	17"-8"
	2	10"-10"	10"-9"	15"-0"	14"-11"
	3+	10"-10"	10"-9"	***10'-8"***	***10'-8"***
20/18	1	9"-7"	9"-6"	18"-9"	18"-6"
	2	11"-3"	11"-1"	14"-11"	14"-10"
	3+	11"-4"	11"-1"	***10'-8"***	***10'-8"***
18/20	1	10"-6"	10"-4"	19"-8"	19"-8"
	2	12"-4"	12"-1"	***16'-0"***	***16'-0"***
	3+	12"-4"	12"-1"	***10'-8"***	***10'-8"***
18/18	1	10"-11"	10"-9"	21"-2"	20"-9"
	2	12"-11"	12"-9"	***16'-0"***	***16'-0"***
	3+	12"-11"	12"-9"	***10'-8"***	***10'-8"***
18/16	1	11"-4"	11"-1"	21"-9"	21"-6"
	2	13"-4"	13"-1"	***16'-0"***	***16'-0"***
	3+	13"-4"	13"-1"	***10'-8"***	***10'-8"***
16/18	1	12"-0"	11"-10"	23"-2"	22"-11"
	2	14"-1"	13"-11"	***16'-0"***	***16'-0"***
	3+	***10'-8"***	***10'-8"***	***10'-8"***	***10'-8"***
16/16	1	12"-6"	12"-3"	24"-0"	23"-9"
	2	14"-7"	14"-6"	***16'-0"***	***16'-0"***
	3+	***10'-8"***	***10'-8"***	***10'-8"***	***10'-8"***

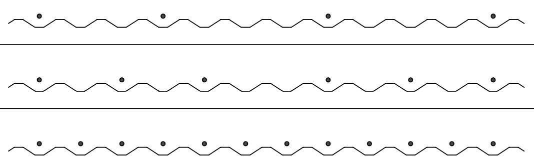
Note: FM Approved Spans are limited to L/240 deflection due to 200 lb point load at mid-span.

Appendix A.1 - Attachment Patterns

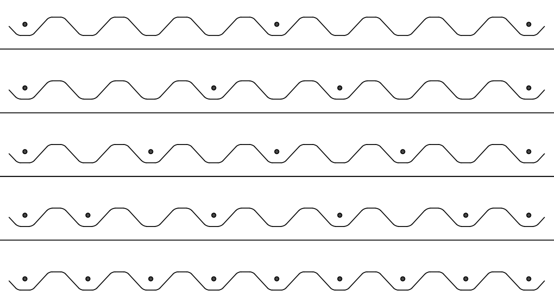
SV-36 (Shallow VERCOR)
36/3
36/4
36/5
36/6
36/7
36/9
36/13



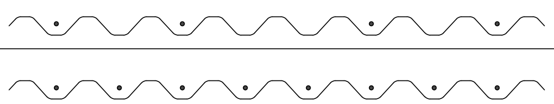
SVR-36 (Shallow VERCOR Inverted)
36/4
36/6
36/12



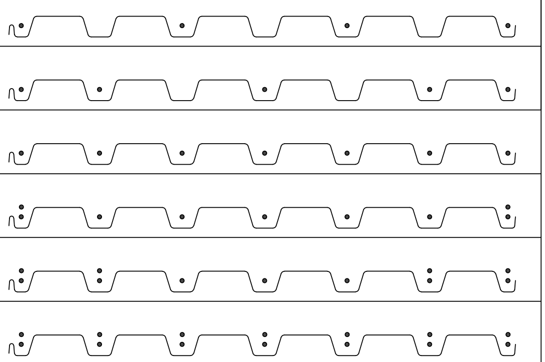
DV-36 (Deep VERCOR)
36/3
36/4
36/5
36/6
36/9



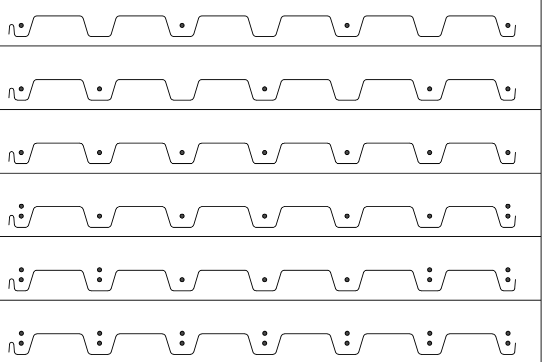
DVR-36 (Deep VERCOR Inverted)
36/4
36/8



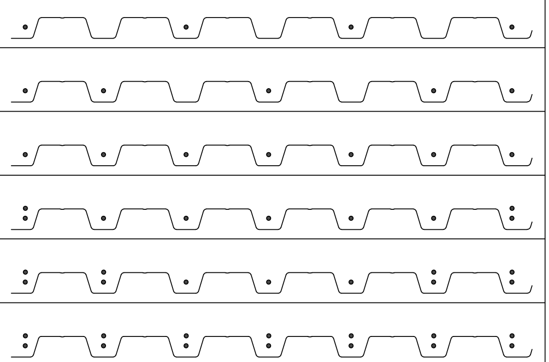
PLB-36, HSB-36, HSB-36-SS
36/4
36/5
36/7
36/9
36/11
36/14



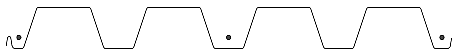
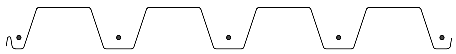
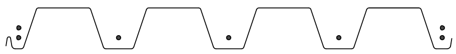
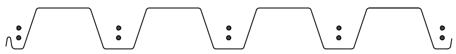
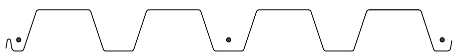
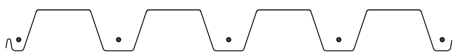
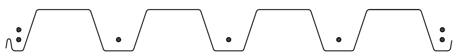
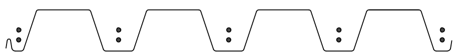
PLB-36 AC, HSB-36 AC, HSB-36-SS AC, PLB-36 FP11, HSB-36 FP11, HSB-36-SS FP11, PLB-36 FP21, HSB-36 FP21, HSB-36-SS FP21
36/4
36/5
36/7
36/9
36/11
36/14

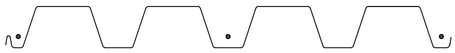
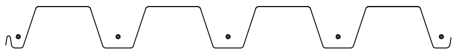
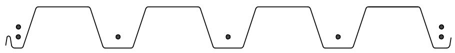
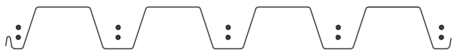
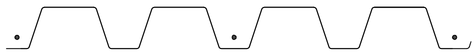
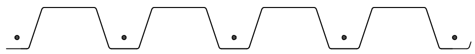
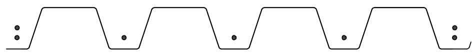
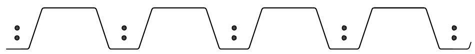
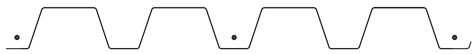
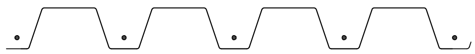
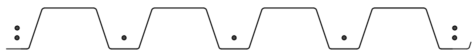
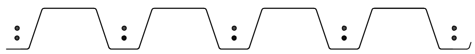
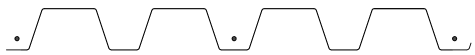
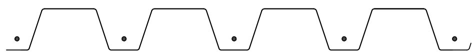
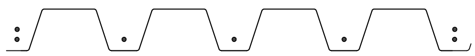
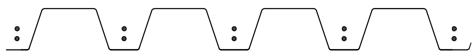
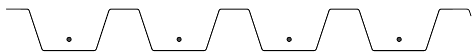


NSB-36, XTB-36, HSB-36-NS-FP21
36/4
36/5
36/7
36/9
36/11
36/14

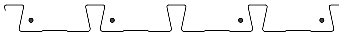
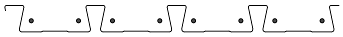
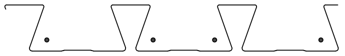
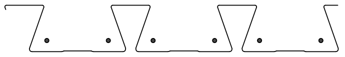
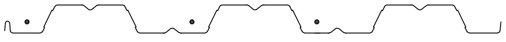
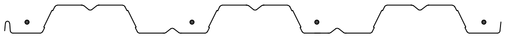
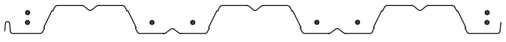


Appendix A.1 - Attachment Patterns

PLB-36 FormLok, B-36 FormLok, B-36-SS FormLok	
36/4	
36/5	
36/7	
36/9	
36/11	
36/14	
HSBR-36, HSBR-36-SS, BR-36 FormLok	
36/4	
36/6	
PLN3-32, HSN3-32, HSN3-32-SS	
32/3	
32/5	
32/7	
32/10	
PLN3-32 AC, HSN3-32 AC, HSN3-32-SS AC, PLN3-32 FP11, HSN3-32 FP11, HSN3-32-SS FP11, PLN3-32 FP21, HSN3-32 FP21, HSN3-32-SS FP21	
32/3	
32/5	
32/7	
32/10	

PLN3-32 FormLok , N3-32 FormLok, N3-32-SS FormLok	
32/3	
32/5	
32/7	
32/10	
HSN3-32-NS	
32/3	
32/5	
32/7	
32/10	
HSN3-32-NS AC, HSN3-32-NS FP11, HSN3-32-NS FP21	
32/3	
32/5	
32/7	
32/10	
N3-32-NS FormLok	
32/3	
32/5	
32/7	
32/10	
HSN3R-32-NS	
32/4	

Appendix A.1 - Attachment Patterns

2.0D-24.5, 2.0DA-24.5, 2.0D-24.5 FormLok	
24.5/4	
24.5/8	
3.5D-24, 3.5DA-24, 3.5D-24 FormLok	
24/3	
24/4	
24/6	
PLW2-36 FormLok, W2-36 FormLok, W2-36-SS FormLok	
36/3	
36/4	
36/6	
36/8	
PLW3-36 FormLok, W3-36 FormLok, W3-36-SS FormLok	
36/3	
36/4	
36/6	
36/8	

VERCO DECKING, INC.

a NUCOR company

SECTION 053100

STEEL DECKING

PART 1 - GENERAL

1.1 SUMMARY

A. This section pertains to steel deck for floors and roofs.

B. Requirements for field painting, fireproofing, roof sumps, roof flashings, drains, collars, gutters, downspouts, insulation, and other miscellaneous items are specified elsewhere.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of steel deck specified including dimensions and finishes.

B. Approval Drawings:

1. Include layout and types of deck panels, deck attachment details, accessories specified on the contract documents and other information required for a thorough review.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates: If field welding is performed, welder certificates signed by the Contractor certifying that welders comply with requirements specified under "Quality Assurance" Article 1.4.

B. Test and Evaluation Reports:

1. Steel Deck: Product Evaluation Reports from IAPMO showing compliance with the specified requirements.
2. Product Test Reports or Evaluation Reports: Reports from a qualified testing or evaluation agency, indicating that each of the following complies with specified requirements:
   a. Mechanical fasteners: If mechanical fasteners are used, independent test reports or evaluation reports shall be provided by the fastener manufacturer.
   b. Acoustical deck performance.

c. Approval reports by Factory Mutual demonstrating that the products provided meet the loss-prevention requirements if specified.

1.4 QUALITY ASSURANCE

A. Codes and Standards: Comply with applicable provisions of the following specifications:

1. ANSI/AISI S100-16 w/S2-20, North American Specification for the Design of Cold-Formed Steel Structural Members

2. ANSI/AISI S310-20, North America Standard for the Design of Profiled Steel Diaphragm Panels

3. ANSI/SDI RD-2017 Standard for Roof Deck

4. ANSI/SDI C-2017 Standard for Composite Steel Floor Deck-Slabs

5. ANSI/SDI NC-2017 Standard for Non-Composite Steel Floor Deck

B. Welding Qualifications: Qualify procedures and personnel in accordance with and the following welding codes:

1. AWS D1.3/D1.3M:2018, Structural Welding Code – Sheet Steel.

C. Mechanical Fasteners: If required by the fastener manufacturer, certify that each mechanical fastener installer has satisfactorily passed certification tests as required by the fastener manufacturer.

D. Fire Resistance Assemblies: Provide steel deck units classified by Underwriters Laboratories (UL) in the "Fire Resistance Directory" if a fire rated assembly is required. Identify steel deck bundles with labels bearing the UL mark.

1.5 SUSTAINABILITY

A. Environmental Product Declarations (EPD): Submit steel floor or roof deck manufacturer's EPD per the following:

1. 1. All EPDs are to be third-party verified in accordance with the current version of ISO 14025 (validated by a date that has not yet expired) and indicate the following Impact Categories:

   a. Global Warming Potential (GWP): All GWP information submitted shall be in the form of kgCO2eq/kg.
   b. Ozone Depletion Potential (ODP): All ODP information shall be in the form of kgCFC-11/kg.
   c. Acidification Potential (AP): All AP information shall be submitted in the form of kgSO2/kg.

d. Eutrophication Potential (EP): All EP information submitted shall be in the form of kgN/kg.

e. Smog Formation Potential (SFP): All SFP information shall be submitted in the form of kgO3/kg.

f. Energy Consumption: All energy consumption information shall be submitted in the form of MJ.

2. Manufacturer-specific GWP information will be one of the decision criteria when awarding this scope. The manufacturer EPD must indicate GWP information from the specific mill or plant facility from which the material is procured. EPDs including GWP information for more than one facility are acceptable as long as each facility's GWP information is reported separately. EPDs reporting GWP values as averages from multiple facilities only or industry-wide EPDs are not acceptable.

3. EPDs must clearly indicate the Product Flow Diagram disclosing if product fabrication is included within the "cradle-to-gate" life cycle scope (product stages A1-A3) of the EPD.

B. Recycled Content of Steel Products: Provide documentation in accordance with the current version of ISO 14021 from the manufacturer of steel floor and roof decking products. For each product, both the post-consumer and pre-consumer recycled content percentage by weight must be indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products with bundle tag bearing the brand name and manufacturer's identification until ready for installation.

B. Store products in accordance with SDI MOC3 in a clean, dry, sheltered area off the ground until ready for use including the following:

1. Protect steel deck from exposure to sunlight and rain. Store steel deck on the jobsite off the ground and covered with waterproof material to prevent exposure to rain or condensation.

2. Protect and ventilate acoustical insulation to maintain insulation free of moisture.

C. Handle materials to avoid damage.

PART 2 - PRODUCTS

2.1 STEEL DECKS

A. A manufacturer offering deck products to be incorporated into the work must have an evaluation report from an accredited 3rd party evaluation agency such as IAPMO and be a member of the Steel Deck Institute.

B. A manufacturer offering deck products to be incorporated into the work must have product EPDs in accordance with the sustainability requirement listed in this specification.

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Verco Decking
2. Vulcraft

D. Fabrication:

1. Steel Deck Panels: Fabricate panels to comply with ANSI/SDI RD-2017, C-2017, or NC-2017. Deck profile, design uncoated-steel thickness, steel grade and finish, and side-lap configuration as indicated on the structural drawings:

2. Acoustical Steel Deck:

   a. Provide deck units with manufacturer's standard perforations.
   b. Non-cellular steel deck: Provide manufacturer's standard glass or mineral fiber sound-absorbing insulation. Provide pre-molded strips or rolls for field installation by the roofing installer.
   c. Cellular steel deck: Provide factory installed acoustical insulation and optional spacers (if indicated in structural drawings).

3. Composite Steel Deck: Fabricate composite deck panels with integral embossments or configurations to comply with ANSI/SDI C-2017.

E. Materials

1. Sheet Steel:

   a. Uncoated Steel Sheet Shop Primed: ASTM A1008, Structural Steel (SS), Grade 40, 50, or 80 as indicated on structural drawings.
   b. Galvanized-Steel Sheet: ASTM A653/A653M, Structural Steel (SS), Grade 40, 50, or 80, and G30, G60, or G90 zinc coating as indicated on structural drawings.

F. Finishes

1. Shop applied primer: Apply manufacturer's standard baked-on, rust-inhibitive primer to top and/or bottom side(s) as indicated on structural drawings. Do not prime top side of composite decks.

   a. Color: Manufacturer's standard gray or white as indicated.

2.2 ACCESSORIES

A. Provide manufacturer's standard accessory materials for deck that comply with requirements indicated.

B. Mechanical Support Fasteners: Corrosion-resistant, low-velocity, power-actuated or pneumatically driven carbon-steel fasteners; or self-drilling, self-threading screws. Size and fastening pattern as indicated.

C. Screws for Side-Lap Fastening: Corrosion-resistant, hexagonal washer head; self-drilling, carbon-steel screws, diameter and spacing or quantity as indicated on structural drawings.

D. Flexible Closure Strips: synthetic rubber.

E. Column Closures, End Closures, Z-Closures, Cover Plates, and other Miscellaneous Sheet Metal Deck Accessories: Galvanized steel sheet, minimum yield strength of 33,000 psi, not less than 0.0358-inch (20 gage) design uncoated thickness of profile indicated or required for application.

F. Pour Stops and Girder Fillers: Galvanized Steel sheet, minimum yield strength of 33,000 psi, and of thickness and profile recommended by SDI for overhang and slab depth.

H. Weld Washers: Uncoated steel sheet, shaped to fit deck rib, 0.0598 inch (16 gauge) thick, with factory-punched hole of 3/8-inch minimum diameter.

I. Sump Pans: Single-piece steel sheet, 0.0747 inch (14 gauge) thick galvanized steel sheet. For drains, cut holes in the field.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine supporting frame and field conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF DECKS

A. Install deck panels and accessories in accordance with ANSI/SDI RD-2017, C-2017, or NC-2017, SDI MOC, structural drawings, installation drawings marked for field use, and requirements in this section.

B. Place deck panels on structural supports and adjust to final position with ends aligned. Bring deck into contact with the bearing surface as required by the fastening system and attach firmly to the supports immediately after placement to form a safe working platform.

C. Install temporary shoring before pouring concrete if required to meet strength or deflection limitations.

D. Fasten deck panels to steel supporting members, side-laps between supports, and at perimeter edges by the means indicated.

1. Locate welds as indicated and comply with AWS requirements and procedures for manual shielded metal arc welding, appearance and quality of welds, and methods used for correcting welding work.

2. Locate mechanical fasteners as indicated and install in accordance with fastener manufacturer's written instructions.

3. Install PunchLok II side-lap connections using the PunchLok II tool as indicated.

E. End Bearing: Install deck ends over supports with a minimum end bearing of 2 inches, or as indicated on the approved installation drawings with end joints as follows:

F. End Joints: Lapped or butted per the approved installation drawings. Laps shall be 3 inches minimum at open-web steel joists or 2" at other structural supports.

G. Cut and neatly fit deck panels and accessories around openings and other work projecting through or adjacent to deck.

H. Install additional reinforcement and closure pieces as specified on the structural drawings.

3.3 INSTALLATION OF ACCESSORIES

A. Deck Accessories: Install and fasten steel sheet accessories in accordance with ANSI/SDI RD-2017, C-2017, NC-2017, or SDI MOC the approved installation drawings.

B. Roof Sump Pans: Install where indicated in architectural details in openings cut in roof deck and mechanically fasten flanges to top of deck. Space mechanical fasteners not more than 12 inches apart with at least one fastener at each corner.

1. Install reinforcing members as indicated to span between supports and weld or mechanically fasten.

C. Flexible Closure Strips: Install flexible closure strips over partitions, walls, where indicated. Install with adhesive in accordance with closure manufacturer's written instructions to ensure complete closure.

D. Sound-Absorbing Insulation for non-cellular acoustical decks: Install into topside ribs of deck before roofing insulation is applied.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Special inspections and qualification of welding special inspectors for cold-formed steel floor and roof deck in accordance with quality-assurance inspection requirements of ANSI/SDI QA/QC.

a. Perform inspection of field welds and other inspections as indicated on structural drawings.

b. Perform inspection of PunchLok II connections to ensure that the sidelap material has been sheared and offset so the sheared surface of the male leg is visible in the cut.

c. Perform inspection of the sidelap screw connections to ensure that the proper size and number of screw attachments per span have been installed between supports.

d. Perform inspection of the support connections to ensure that the proper size and number of attachments per deck sheet have been installed. Ensure that the fasteners are installed per the manufacturer’s instructions and quality assurance requirements.

e. Inspect other attachments of deck and accessories according to manufacturer’s instructions and quality assurance requirements, or per industry standards.

END OF SECTION 053100

EXAMPLE BASIC GENERAL NOTES

These notes are intended as an example only. They give a Designer or specifier the basic information to build on to create a complete set of general notes for incorporation into their design. These notes are only a starting point not an end point.

STEEL ROOF DECK

GENERAL REQUIREMENTS:

1. DESIGN CODE: 2018 INTERNATIONAL BUILDING CODE (IBC)
2. RISK CATEGORY: II
3. SEISMIC:
    a. SEISMIC DESIGN CATEGORY: D
    b. SITE CLASS: D

    S_S= 1 .5 S_{DS} = 1 .0
    S_1 = 0.6 S_{D1} = 0.68
4. WIND:
    DESIGN WIND SPEED: 95 MPH (3 SECOND GUST)
    WIND EXPOSURE: C

STRUCTURAL STEEL GENERAL NOTES:

1. ALL MATERIALS AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE LATEST EDITION OF THE AISC STEEL CONSTRUCTION MANUAL (AISC 360), INCLUDING THE "SPECIFICATION FOR STRUCTURAL STEEL BUILDINGS" AND THE CODE OF STANDARD PRACTICE.
2. MATERIAL:
    a. ANGLES, BARS, PLATES, C, S,& M: ASTM A36 (UNLESS OTHERWISE NOTED)
    b. RECTANGULAR AND SQUARE TUBE MEMBERS (HSS): ASTM A500 GRADE B Fy = 46KSI
3. SUBMIT STRUCTURAL STEEL SHOP DRAWINGS TO STRUCTURAL ENGINEER FOR REVIEW AND APPROVAL PRIOR TO FABRICATION.
4. BOLTS TO BE ASTM A307 UNLESS OTHERWISE NOTED.

STEEL DECK GENERAL NOTES:

1. STEEL DECK SHALL BE MANUFACTURED BY VERCO DECKING, INC. IN ACCORDANCE WITH IBC SECTION 2210.1.1 AND IAPMO PRODUCT EVALUATION REPORT ER-2018 OR IAPMO ER-0423
2. STEEL DECK SHALL BE FORMED FROM STEEL SHEETS CONFORMING TO ASTM A653 SS GRADE 50 [G60 or 90] GALVANIZED.
3. DOVETAIL STEEL DECK SHALL BE FORMED FROM STEEL SHEETS CONFORMING TO ASTM A653 SS GRADE 40 G90 GALVANIZED.
4. SEE ARCHITECTURAL PLANS FOR AREAS WHERE BOTTOM OR TOP OF DECK IS TO BE PRIMER PAINTED AND PRIMER COLOR (WHERE REQUIRED).
5. SEE "STEEL ROOF DECK ATTACHMENT DIAGRAM" & "STEEL ROOF DECK GAGE AND ATTACHMENT SCHEDULE" FOR DECK TYPE, GAGE, AND ATTACHMENT.

Appendix A.3 - General Notes

6. SUBMIT STEEL DECK SHOP DRAWINGS TO ARCHITECT AND STRUCTURAL ENGINEER FOR REVIEW AND APPROVAL. SHOP DRAWINGS SHALL SHOW TYPE OF DECK, LAYOUT OF DECK, AND ATTACHMENT. THE SIZE AND LOCATION OF ANY OPENINGS WITH A WIDTH GREATER THAN 1 '-0" SHALL BE SHOWN.

COMMON STEEL DECK OPTIONS: (ALTERNATE TO NOTE 2)*

1. STEEL DECK SHALL BE FORMED FROM STEEL SHEETS CONFORMING TO ASTM A1008 SS GRADE 50 GRAY PRIMER PAINTED TOP AND BOTTOM.
2. STEEL DECK SHALL BE FORMED FROM STEEL SHEETS CONFORMING TO ASTM A653 SS GRADE 50 G30 GALVANIZED WITH PRIMER PAINTED BOTTOM SURFACE.
3. STEEL DECK SHALL BE FORMED FROM STEEL SHEETS CONFORMING TO ASTM A653 SS GRADE 50 G90 GALVANIZED.

* WHITE OR GRAY PRIMER PAINT MAY BE SPECIFIED ON ANY GALVANIZED OR BARE STEEL DECK. ONLY GRAY PRIMER IS UL APPROVED.

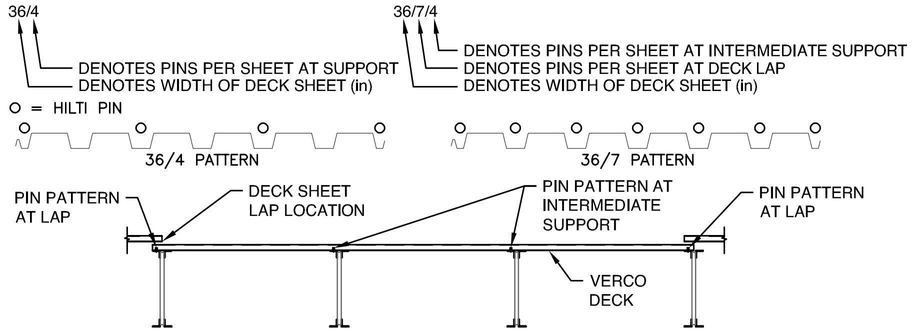
EXAMPLE BASIC DECK SCHEDULE FOR GENERAL NOTES

STEEL ROOF DECK GAGE AND ATTACHMENT SCHEDULE

ZONE	VERCO PLB-36 DECK GAGE (1)	PIN ATTACHMENT PATTERN AT PERPENDICULAR SUPPORT (2)(4)	BOUNDARY PIN SPACING WHERE DECK IS PARALLEL TO WALL/SUPPORT (2)	DECK SIDE LAP CONNECTION AND SPACING EACH SHEET (3)
I	22	36/4	16" o.c.	VSC2 @ 24" o.c.
II	22	36/7/4	12" o.c.	VSC2 @ 18" o.c.
III	22	36/7/4	8" o.c.	VSC2 @ 8" o.c.
IV	20	36/7/4	7" o.c.	VSC2 @ 8" o.c.

(1) DECK TO BE VERCO DECK GRADE 50 PER IAPMO ER 2018. SUBSTITUTION OF ANOTHER MANUFACTURER'S DECK IS NOT ACCEPTABLE.
(2) PINS TO BE HILTI POWDER ACTUATED FASTENERS (PAF) PER ICC ESR 2776. USE HILTI X-HSN 24 PINS FOR SUPPORTS 1/8" THICK TO 3/8" THICK. HILTI X-ENP-19 PINS MAY BE USED FOR SUPPORTS 1/4" OR THICKER. WELDING OF DECK IS NOT PERMITTED.
(3) ATTACHMENT OF THE DECK SIDE LAPS TO BE WITH VERCO PUNCHLOK II TOOL (VSC2 CONNECTION).

(4) SEE DIAGRAMS BELOW FOR ILLUSTRATION OF FASTENER PATTERNS PER SHEET OF PLB DECK.



(3 SPAN DECK CONDITIONS SHOWN, ACTUAL SHEET SPANS TO BE DETERMINED BY CONTRACTOR)

An approach to Modeling Based on Equivalent Modulus

Generally, programs use either equivalent thickness or equivalent modulus to model a flat plate to perform like a deck diaphragm. This requires a calculation to determine the equivalent modulus of a flat plate for any given deck diaphragm condition (combination of deck profile, gage, span and attachments). Any formula used only provides a reasonable approximation and further work may be required to “dial in” the appropriate equivalence by comparing deflection of a flat plate unbound element with a hand calculation of the deck diaphragm, then adjusting the equivalent modulus in the program until the deflections match.

For most diaphragms the depth, *b*, is large compared to the length, *L*. Thus, when *L* : *b* < 3 : 1, Slender Beam Deflection Theory is not applicable.

Equivalent Modulus for Diaphragms < 3:1

Beam Theory Shear Deflection	Diaphragm Theory Shear Deflection
$\Delta = \frac{wL^2}{8GA_s}$ $A_s = \frac{2A}{3} = \frac{2bt}{3}$ $G = \frac{E'}{2\,(1+v)}$	$\Delta = \frac{wL^2}{8bG'}$

Equating

$$\frac{wL^2}{8\left(\frac{E'}{2\,(1+v)}\right)\left(\frac{2bt}{3}\right)} = \frac{wL^2}{8bG'}$$

$$E' = \frac{3G'(1+v)}{t}$$

$$\boxed{E' = \frac{3.84G'}{t}}$$

Where:

- Δ = shear deflection (in.)
- G' = Diaphragm shear stiffness (kip/in)
- E' = Effective elastic modulus
- v = Poisson’s ratio = 0.28
- t = Thickness of plate (in.)
- b = Depth of diaphragm (ft.)
- L = Length of diaphragm (ft.)
- w = Uniform load (lbs./ft.)
- G = Shear Modulus
- A_s = Area Steel
- A = Area

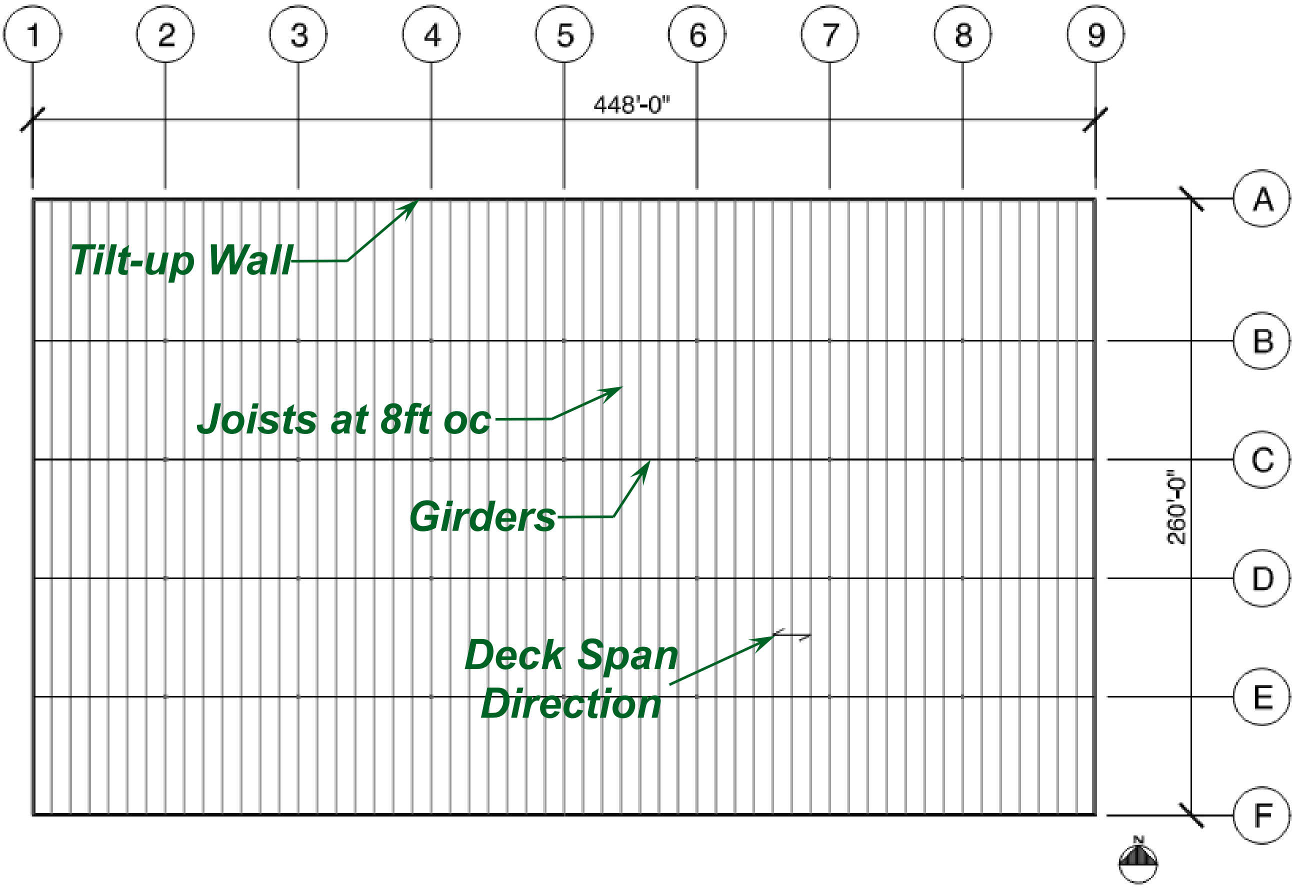
Multi-Zone Diaphragm Deflection: North-South Direction

Building Description:

- 8.5” Thick Concrete Tilt-up Panels (Intermediate Precast Shear Walls).
- Joists at 8ft on center.
- 35ft roof height at North & South walls.
- 38ft top of wall at North & South walls.
- Diaphragm Load: $1.0E = F_{px} = 0.25W_p$
- Roof Dead Load = 14 psf (includes Joist & Joist Girder weights)
- $S_{DS} = 1.0$

Roof Deck:

- Verco PLB Deck (1.5” tall)
- 22 gage deck minimum required for vertical loads, including wind.
- 36/4 pattern required for vertical and uplift loading.



Appendix B.2 - Diaphragm Deflection Example

Diaphragm Loading:

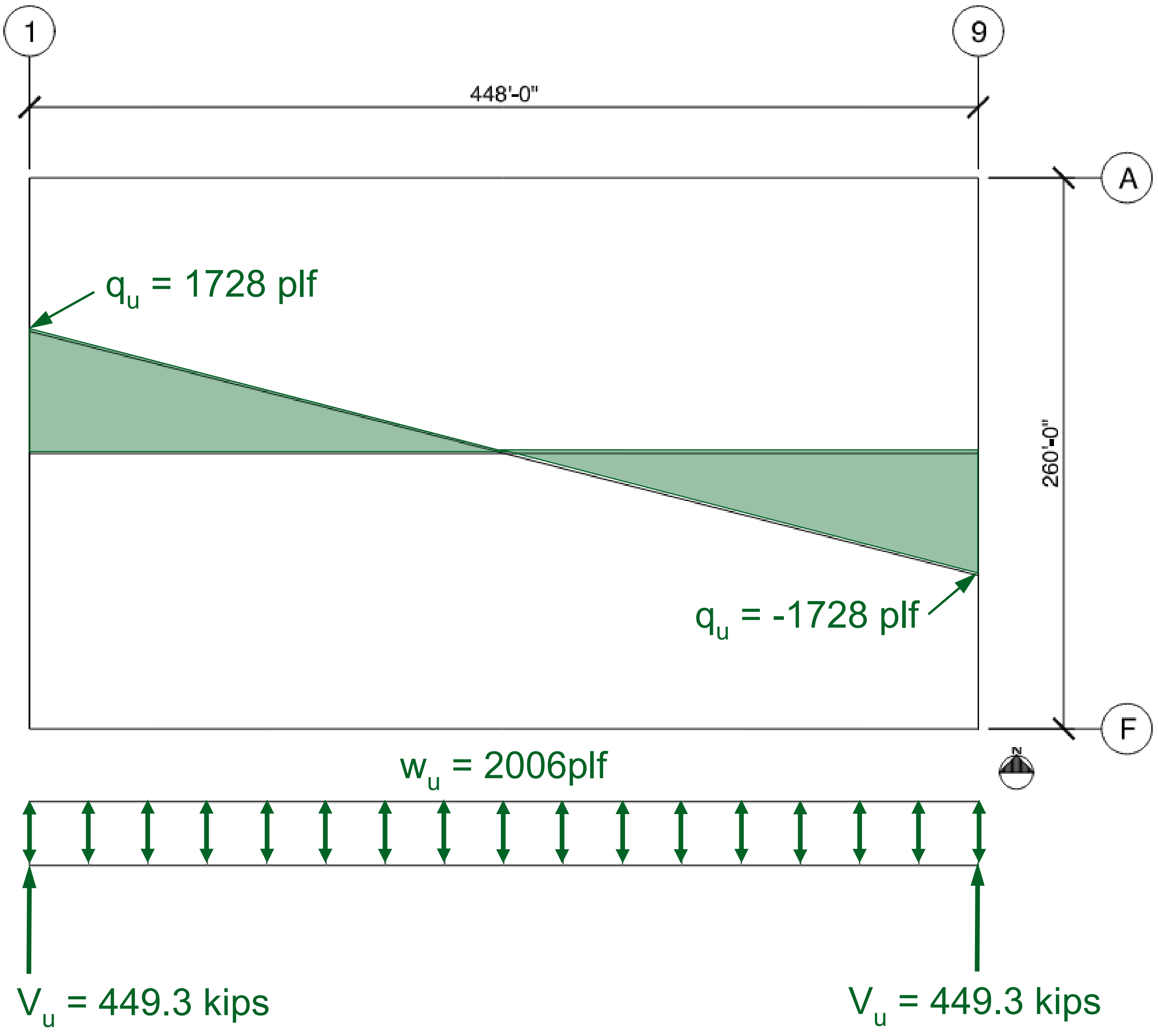
$1.0E = F_{px} = 0.25W_p \Rightarrow\ w_u = 2006$ plf

Reaction to Shear Wall:

$V_u = w_u\ (448ft/2) = 449.3$ kips

Diaphragm Shear at Shear Wall:

$q_u = V_u\ /\ 260ft = 1728$ plf



Appendix B.2 - Diaphragm Deflection Example

Diaphragm Shear Capacity:

Max diaphragm shear was 1728plf, so attachment pattern needs to be determined which exceed the shear demand.

This building is wide enough that it is worth reducing the attachment pattern as the shear decreases toward the middle of the building.

Use the Verco Deck Diaphragm Capacity Tool to determine attachment patterns and their resulting shear capacity.

Roof Deck Inputs:

- LRFD design Method.
- Verco PLB Deck (1.5" tall).
- Start with 22 gage deck (minimum gage required for vertical loads).
- Grade 50 deck.
- 3 Span Condition (for diaphragm capacity).
- Both Ends Lapped.
- Hilti X-HSN24 PAF pins for attachment to supports.
- A572 GR 50 with 0.13 in. min. thickness for supports.
- 2 in. min bearing on supports.
- Start with 36/7 pattern at end connection.
- Start with 36/4 pattern at interior connection.
- Punchlok II mechanical sidelap connections (VSC2).
- Sidelap Connection Spacing in inches.
- Supports at 8ft on center.

Design Note:

1. Number of Spans: the Diaphragm Capacity of 1 or 2 spans will be the same or higher than 3 Span Condition. It is recommended to determining shear capacity based on 3 spans. On the Structural Plans, fewer than 3 spans can be allowed, based on number of spans required for vertical capacity.
2. For Diaphragm Capacities for Wind Loading: input the MWFRS uplift load for the combined uplift and shear capacity interaction. May need to run design tool for shear capacity for uplift at ends of building and a second run for the uplift in the interior of the building.
3. For Larger buildings, using a different pin pattern at the end connections verses the interior connections (i.e. 36/7/4 pattern) can significantly reduce pin quantity with very little reduction in diaphragm capacity.
4. In the middle of the building, it may be advantageous on some projects to use 36/4 pattern for both the end connection and the interior connection in order to reduce number of pins.

Diaphragm Shear Capacities: Verco Online Design Tool (Strength)

22 ga PLB™-36 Grade 50 Roof Deck

Seismic Diaphragm Shear

For Both Ends Lapped Deck

Hilti X-HSN24 PAF Connections to Supports
36 / 7 / 4 Perpendicular Connection Pattern to Supports
PunchLok II Connection (VSC2) Sidelap Connections

A572 GR50 Support Member or Equivalent
0.13 ≤ Support Thickness (in.) ≤ 0.375
2 in. Minimum Deck End Bearing Length

LRFD Design Seismic Diaphragm Shear Strength ΦSn (plf) — Generic 3 Span Condition

Sidelap Connection Spacing (in.)	Span 7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"
4	2111	2111	1902	1684	1503	1349	1217	1104	1006
6	1951	1947	1902	1684	1503	1349	1217	1104	1006
8	1777	1785	1729	1684	1503	1349	1217	1104	1006
12	1414	1457	1396	1436	1382	1349	1217	1104	1006
18	1154	1093	1168	1114	1064	1130	1085	1043	1006
24	1002	945	894	986	939	897	857	935	899
36	834	785	740	700	664	768	733	701	671

Average Connection Spacing to Supports at Parallel Chords & Collectors (in.)

Sidelap Connection Spacing (in.)	Span 7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"
4	7	6	7	7	7	7	7	7	7
6	7	7	7	8	9	10	11	11	11
8	8	8	8	8	9	10	11	13	13
12	9	9	10	9	10	10	11	13	13
18	12	13	12	13	14	13	12	13	13
24	14	15	16	15	15	16	17	14	15
36	17	18	19	20	22	19	20	21	22

Seismic or Wind Diaphragm Shear Stiffness, G' (kip/in.) — Generic 3 Span Condition

Sidelap Connection Spacing (in.)	Span 7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"
4	183	184	183	183	182	183	182	183	182
6	165	165	164	164	164	164	163	163	163
8	154	154	150	151	151	152	149	149	150
12	132	134	131	133	129	131	128	130	127
18	117	113	117	113	110	114	111	108	111
24	108	104	100	105	102	99	96	101	98
36	97	93	89	86	83	90	87	84	82

Appendix B.2 - Diaphragm Deflection Example

Diaphragm Zones:

Based on the results from the Verco design tool, the following attachment patterns will be used:

Zone 1:

- 22 GA PLB deck, Hilti X-HSN24 pins to supports.
- 36/7/4 attachment to perpendicular supports.
- VSC2 at 24 in. o.c. at Sidelap connection.
- Pins at 16 in. o.c. to parallel supports.
- ΦS_n = 894 plf
- G’ = 100 kip/in

Zone 2:

- 22 GA PLB deck, Hilti X-HSN24 pins to supports.
- 36/7/4 attachment to perpendicular supports.
- VSC2 at 18 in. o.c. at sidelap connection.
- Pins at 12 in. o.c. to parallel supports.
- ΦS_n = 1168 plf
- G’ = 117 kip/in.

Zone 3:

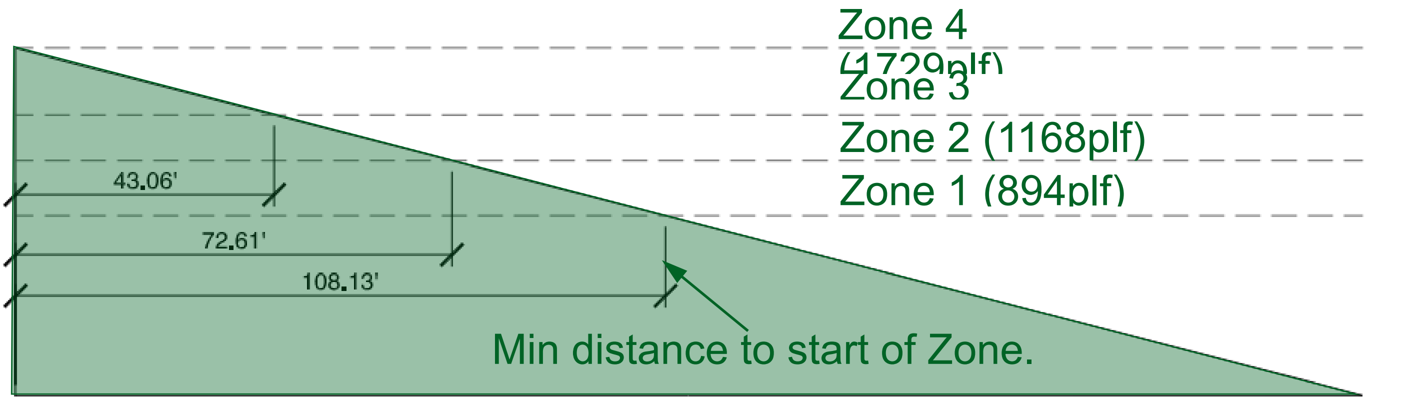
- 22 GA PLB deck, Hilti X-HSN24 pins to supports.
- 36/7/4 attachment to perpendicular supports.
- VSC2 at 12 in. o.c. at sidelap connection.
- Pins at 10 in. o.c. to parallel supports.
- ΦS_n = 1396 plf
- G’ = 131 kip/in.

Zone 4:

- 22 GA PLB deck, Hilti X-HSN24 pins to supports.
- 36/7/4 attachment to perpendicular supports.
- VSC2 at 8 in. o.c. at sidelap connection.
- Pins at 8 in. o.c. to parallel supports.
- ΦS_n = 1729 plf
- G’ = 150 kips/in.

Diaphragm Zones Continued:

This diaphragm has uniform loading, so the shear diagram is the same at both ends of the diaphragm. Determine minimum distance to the start of each zone (i.e. location where shear equals zone capacity). Right end of the diaphragm would be the same.



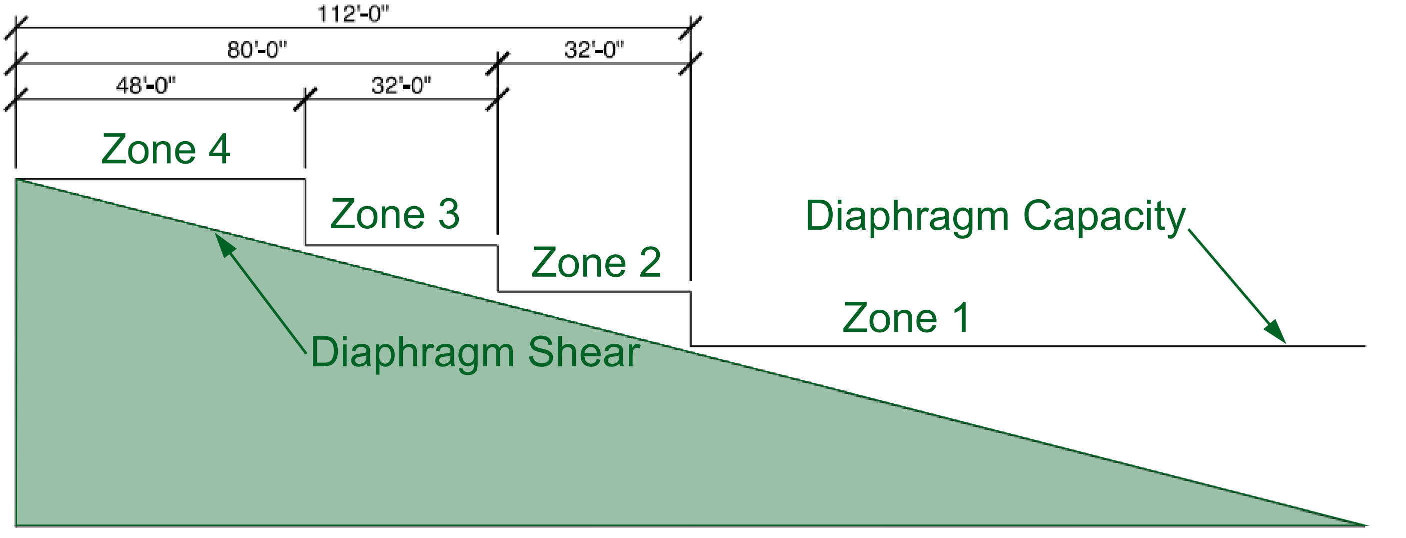
Diaphragm Shear - Left End

Zone Transitions:

- Transitions at 48ft, 80ft, & 112ft.
- North-South diaphragm loads are parallel to the joists, so transition between zones should occur at a joist. Distance to transitions will therefore be a function of the joist spacing, i.e. function of 8ft.

Design Note:

1. East-West diaphragm loads are parallel to the deck span, so transitions between zones should be a function of the deck width. PLB deck is 3ft wide, therefore distance to transitions should be a function of 3ft, when multiple zones required.

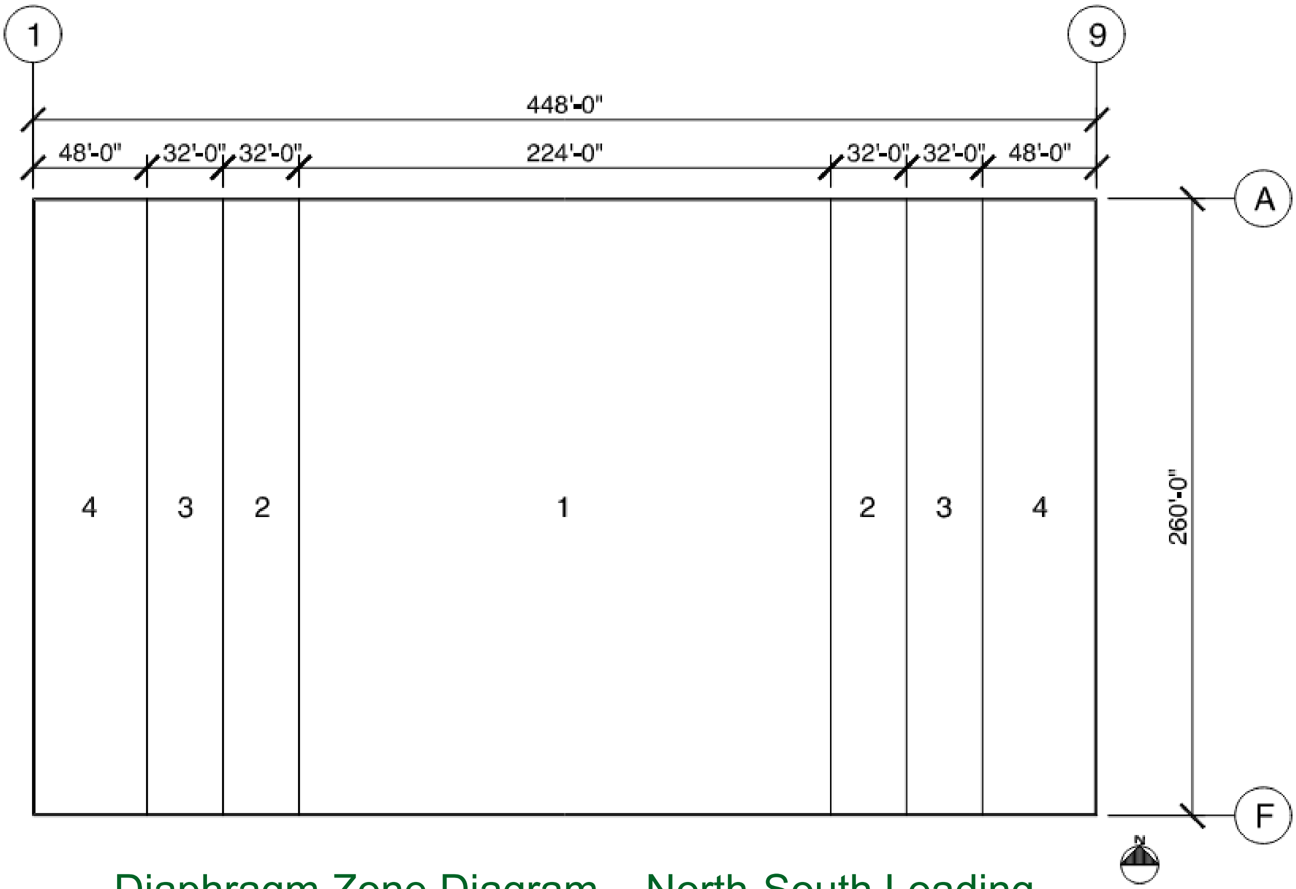


Diaphragm Shear & Diaphragm Capacity - Left End

Appendix B.2 - Diaphragm Deflection Example

Diaphragm Zones Continued:

The diagram below shows the final zones for the North-South loading.



Diaphragm Zone Diagram – North-South Loading

Design Note:

1. From analysis of East-West diaphragm loading (not shown in example), q_u = 740plf, so only Zone 1 is needed for East-West loading. Therefore, the diagram above would be the final diaphragm zone diagram for the building.

Appendix B.2 - Diaphragm Deflection Example

Diaphragm Deflection:

- The aspect ratio of this building is 448ft / 260ft = 1.72 < 3 to 5
- Only Shear Deflection applies to this roof. (See "Roof Structure Design Guide" by Patrick Bodwell, available on Verco website for additional discussion on this topic)

The Maximum Deflection will occur where the shear is equal to zero.

- Since the diaphragm is uniformly loaded, shear will be equal to zero at the center of the diaphragm.
- Use strength level diaphragm shear for seismic deflection.

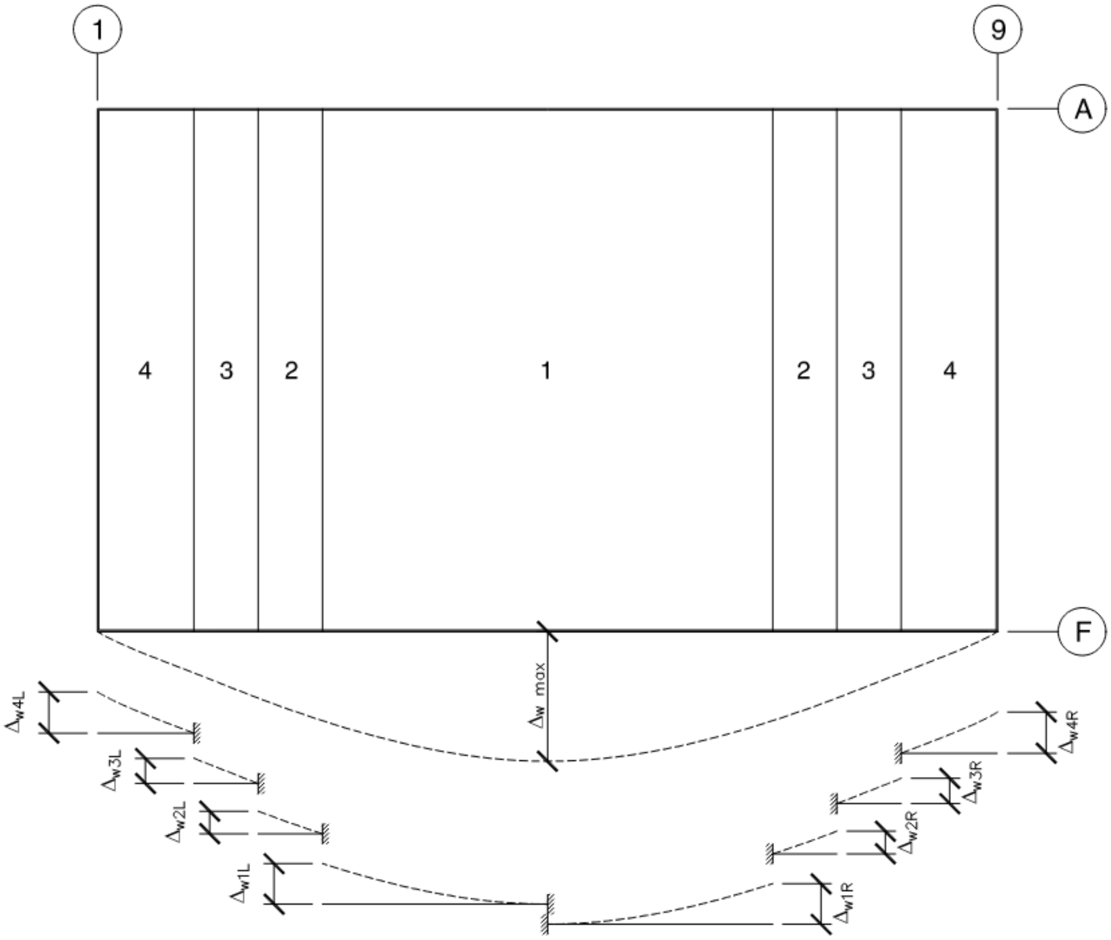
Multi-Zone Diaphragm Deflection

- The diaphragm is idealized as a series of guided cantilevers.

$$\Delta_w = \Sigma\left(\frac{q_{i\,ave}\,L_i}{1000G'}\right)$$

Where:

Δ_w = Diaphragm shear web deflection (in.)
$q_{i\,ave}$ = Average diaphragm shear for cantilever segment (lbs./ft.)
L_i = length of cantilever segment (ft.)
G' = Diaphragm shear stiffness factor (kips/in.)
1000 is to convert G' to lbs./in. due to shear in lbs./ft.



Diaphragm Deflection Continued:

- Maximum Deflection is the sum of the deflection of each segment between the end of the diaphragm and point of zero shear.

$$\Delta_{w\,max} = \Delta_{w4L} + \Delta_{w3L} + \Delta_{w2L} + \Delta_{w1L}$$

$$\Delta_{w\,max} = 0.494 \text{ in.} + 0.301 \text{ in.} + 0.270 \text{ in.} + 0.484 \text{ in.}$$

$$\Delta_{w\,max} = 1.549 \text{ in.}$$ - at strength level deflection

- For Seismic design: to determine if the deflection is acceptable, $\Delta_{w\,max}$ would be used in ASCE 7-16 Eq. 12.8-15 to determine the amplified deflection. The amplified deflection would then be used in ASCE 7-16 Eq. 12.8-16 to determine if $\theta < 0.10$.
- For Wind design: the maximum deflection would need to be checked against acceptable drift limitations for the construction type. See ASCE 7-16 commentary.

Design Note:

1. Each attachment zone needs to have at least one cantilever segment to account for the G' stiffness of each zone.
2. The attachment zone where shear is zero needs to have a cantilever segment each side of the location of zero shear.
3. Attachment zones can be divided into more than one cantilever segment. This is beneficial when the loading to the diaphragm is not uniform. It is recommended to create cantilever segments such that the loading is uniform for each segment. i.e. if Zone 4 had one loading over the first 20ft and then a different loading for the next 28ft, Zone 4 could be divided into a 20ft segment, then a 28ft segment.

Diaphragm Deflection Continued:

- Deflection at any point along the diaphragm can be computed using the formula shown above. Sum the deflection of each cantilever segment from the end of the diaphragm to the desired location.

Design Note:

1. The sign of the shear (positive or negative) needs to be included when calculating the deflection with this formula.

- The table below shows the deflection all the way across the building:

Design Note:

1. By using the sign of the shear (positive or negative) the deflection starts at zero at the left end and comes back to zero at the right end.

Muti-Zone Diaphragm Deflection

Zone	Zone Length L_i (ft)	Diaphragm Shear q_i (strength) in segment (plf)		$q_{i\ ave}$ (plf)	G' (kips/in)	Δ_w of segment (in)	Diaphragm Deflection Δ_S (in) at ends of Zones	
		q_i at left	q_i at right				left end	right end
4	48	1,728	1,358	1543	150	0.494	0.000	0.494
3	32	1,358	1,111	1234	131	0.301	0.494	0.795
2	32	1,111	864	988	117	0.270	0.795	1.065
1	112	864	0	432	100	0.484	1.065	1.549
1	112	0	-864	-432	100	-0.484	1.549	1.065
2	32	-864	-1,111	-988	117	-0.270	1.065	0.795
3	32	-1,111	-1,358	-1234	131	-0.301	0.795	0.494
4	48	-1,358	-1,728	-1543	150	-0.494	0.494	0.000

Σ 448.0 ft

Diaphragm Deflection (in)

Design Note:

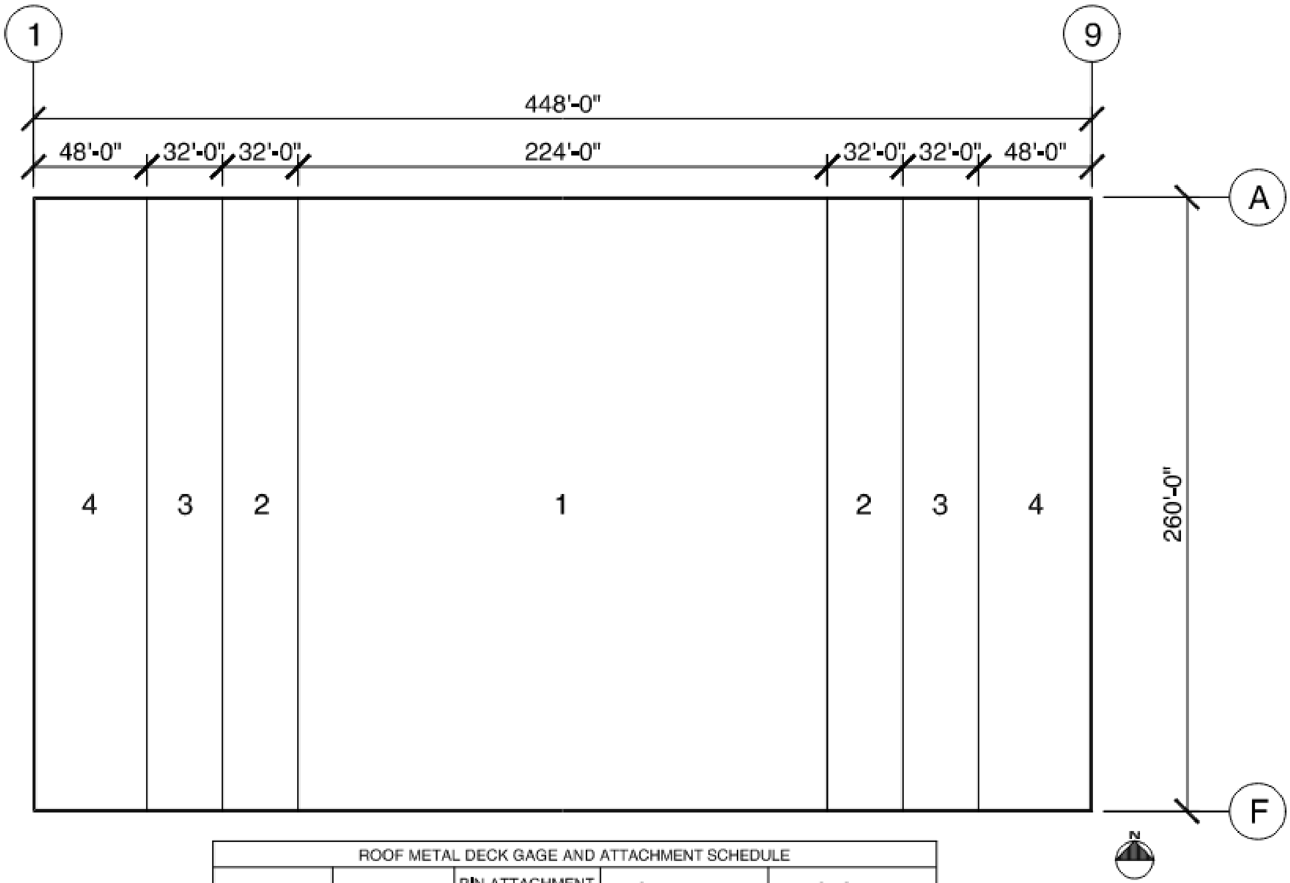
1. The following variation of the deflection formula is used in some design examples:

$$\Delta_w = \Sigma\left(\frac{0.5 q_{i\ \mathrm{ave}}\ L_i}{1000G'}\right)$$

2. With this version of the formula, ½ the deflection from each end of the diaphragm is used.
3. The absolute value of the diaphragm shear is used in this formula.
4. The deflections of all cantilever segments across the diaphragm must be summed to get the maximum deflection of the diaphragm.
5. This formula can only be used to determine the maximum deflection.
6. If the diaphragm loading is not uniform or deflection at a point other than maximum deflection is needed, it is recommended to use the method illustrated in the example above.

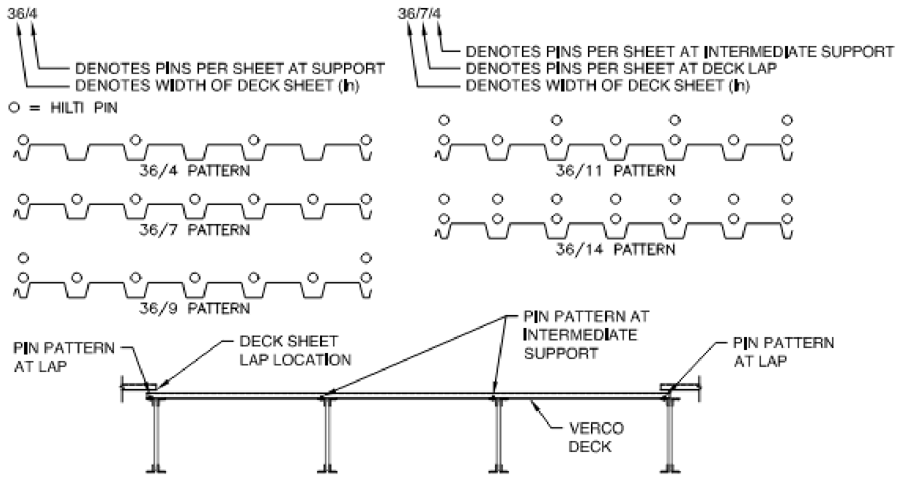
Appendix B.2 - Diaphragm Deflection Example

Diaphragm Attachment Diagram and Schedule:



ROOF METAL DECK GAGE AND ATTACHMENT SCHEDULE				
ZONE	VERCO PLB DECK GAGE (1)	PIN ATTACHMENT PATTERN AT PERPENDICULAR SUPPORT (2)(4)	BOUNDARY PIN SPACING WHERE DECK IS PARALLEL TO WALL/SUPPORT (2)	DECK SIDE LAP CONNECTION AND SPACING EACH SHEET (3)
1	22	36/7/4	16" o.c.	VSC2 @ 24" o.c.
2	22	36/7/4	12" o.c.	VSC2 @ 18" o.c.
3	22	36/7/4	10" o.c.	VSC2 @ 12" o.c.
4	22	36/7/4	8" o.c.	VSC2 @ 8" o.c.

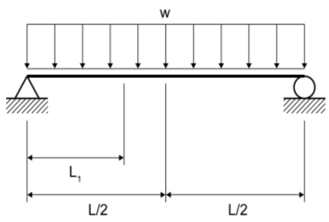
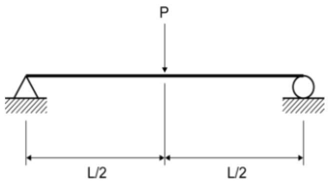
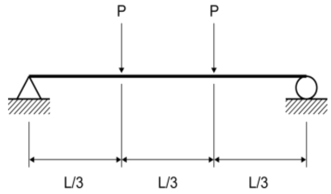
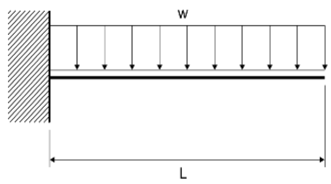
(1) DECK TO BE VERCO PLB-36 DECK GRADE 50 PER IAPMO ER 2018. SUBSTITUTION OF ANOTHER MANUFACTURER'S DECK MUST BE APPROVED BY ENGINEER OF RECORD.
(2) PINS TO BE HILTI POWDER ACTUATED FASTENERS (PAF) PER ICC ESR 2776. USE HILTI X-HSN24 PINS FOR SUPPORTS ⅛" THICK TO ⅜" THICK. HILTI X-ENP-19 PINS MAY BE USED FOR SUPPORTS ¼" OR THICKER. WELDING OF DECK IS NOT ALLOWED.
(3) ATTACHMENT OF THE DECK SIDE LAPS TO BE WITH VERCO PUNCHLOK II TOOL (VSC2 CONNECTION).
(4) SEE DIAGRAMS BELOW FOR ILLUSTRATION OF FASTENER PATTERNS PER SHEET OF PLB DECK.



(3 SPAN DECK CONDITIONS SHOWN, ACTUAL SHEET SPANS TO BE DETERMINED BY CONTRACTOR)

Appendix B.2 - Diaphragm Deflection Example

Diaphragm shear deflection may be determined by the following equations:

Type of Loading	Loading Condition	Shear Deflection	Diagrams
Simple Span Diaphragm, Deflection at L_1	Uniform Load, w	$\Delta_w = \frac{q_{ave} L_1}{G'}$	
Simple Span Diaphragm, Deflection at center	Uniform Load, w	$\Delta_w = \frac{wL^2}{8bG'}$	
Simple Span Diaphragm, Deflection at center	Point Load, P	$\Delta_w = \frac{PL}{4bG'}$	
Simple Span Diaphragm, Deflection at 1/3 points	Point Load, P	$\Delta_w = \frac{PL}{3bG'}$	
Cantilever Diaphragm, Deflection at Free End	Uniform Load, w	$\Delta_w = \frac{WL^2}{2bG'}$	
Cantilever Diaphragm, Deflection at Free End	Point Load, P	$\Delta_w = \frac{PL}{bG'}$	

Where:

Δ_w = Diaphragm shear web deflection (in)
q_{ave} = Average diaphragm shear (lbs/ft)
L_1 = Distance between vertical resisting element (such as shear wall) and the point at which deflection is to be calculated (ft)
G' = Diaphragm shear stiffness factor (kips/in)
b = Depth of diaphragm (ft)
L = Diaphragm Length (ft)
P = Concentrated load (lbs)
w = Uniform load (lbs/ft)

Appendix B.3 - Vertical Load Deck Selection Example

This design example illustrates the process of determining the gage and minimum number of spans for Verco Steel Deck for a Roof. This example uses ASD design for vertical load design.

Building Description:

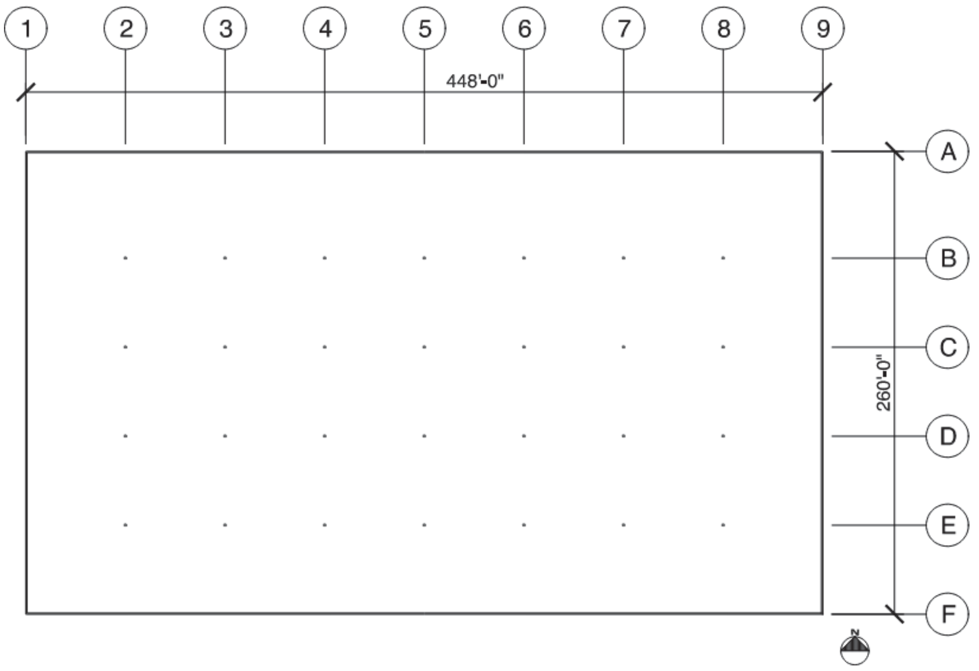
- ¼" per foot min. roof slope. (slope less than 7°)
- 3ft minimum parapets around the building
- 37 ft mean roof height above finish floor. Finish Grade is 1ft below finish floor
- Wind speed = 96mph (ultimate), Exposure C, Risk Category II
- 6" of water on top of roof at drain/scuppers for drainage (2" to bottom of overflow + 4" water required for flow).
- Use Hilti X-HSN 24 pins to attach deck to supports.
- Steel deck supports non-plaster ceiling

Building Loading:

- Dead Load: D_{min} = 5 psf (for resisting uplift), $D_{collateral}$ = 5 psf,

$$D_{total} = D_{min} + D_{collateral} = 10 \text{ psf}$$

- Roof Live Load L_r = 20 psf reducible
- Rain Load R = (6"/12"/ft)(62.4pcf) = 31.2 psf
- No Snow loading



Appendix B.3 - Vertical Load Deck Selection Example

Wind Loading: ASCE 7-16 Component & Cladding Loads

- Mean Roof Height Above Grade = 37 ft + 1 ft = 38 ft
- Roof slope < 7°, use ASCE 7 Figure 30.3-2A for pressure coefficients
  - With 3ft min parapets, per Note 5 in Fig. 30.3-2A, the negative coefficient for Zone 3 shall be the same as Zone 2. The positive coefficients for Zone 2 & 3 are equal to wall Zone 4 & 5 coefficients.
  - This means larger downward loads at the perimeter of the roof.
- Assume 6ft minimum deck span to determine Effective Wind Area (EWA) for Deck
  - Effective Width = max(Span/3, Tributary Width) = max(6ft/3, 3ft deck sheet) = 3 ft
  - EWA = (6ft span)(3ft width) = 18 sq.ft.
- EWA of fasteners is limited to tributary area
  - per ASCE 7 Chapter 26 definition for EWA
  - EWA = (6ft span)(1ft on center) = 6 sq.ft.
  - Coefficients are the same for EWA @ 10 sq.ft.
  - So, if fasteners are closer than 1ft on center, it won't change the wind loads

Designer Note:

1. See "Roof Structure Design Guide" by Patrick Bodwell, available on Verco website, for full example of calculating the wind loads.

- The following table summarizes the wind loads for the deck:

Wind Loading (ultimate)

Zone	Deck		Fastener
	Downward 1.0W (psf)	Uplift 1.0W (psf)	Uplift 1.0W (psf)
1'	16.0	-22.4	-22.4
1	16.0	-36.7	-38.9
2	23.5	-48.5	-51.3
3	23.5	-48.5	-51.3

Designer Note:

1. Parapets: Some projects will have parapets greater than 3ft on only part of the project. Designer may want to consider using the higher downward wind loads at the perimeter of the building, as if there are parapets over 3ft on the entire building. Then use uplift loading based on parapets less than 3ft. This would envelope the worst case of both conditions and be conservative.

Deflection:

- IBC Table 1604.3 provides deflection limits
- Go to Roof member, Supporting non-plaster ceiling row in table
- Roof Live Load $\Delta_{L_r} \leq L/240$
- Wind Loads: per footnote "f", 0.42 times Component & Cladding loads may be used for deflection check.
- Wind Load: $\Delta_{0.42W} \leq L/240$
- $D+L_r$ check:
  - per footnote "d" this check is for creep component of long-term dead load deflection plus short term live load deflection.
  - Steel deck is a steel structural member, per footnote "g", dead load may be taken as zero for creep.
  - $D + L_r = 0 + L_r = L_r \leq L/180$; Therefore, live load deflection column controls.

Next step is to determine the loading to the deck and fasteners. ASD design is being used, so use Basic Load Combinations.

Vertical Loading on the Deck:

- $w = D + L_r$ = 10psf + 20psf = 30psf
- w = D + 0.6W = 10psf + 0.6(23.5)psf = 24.1psf
- $w = D + 0.75(L_r+0.6W)$ = 10psf + 0.75(20psf + 0.6(23.5psf)) = 35.6psf
- w = D + R = 10psf + 31.2psf = 41.2psf
- w = D + 0.75(R+0.6W) = 10psf + 0.75(31.2psf + 0.6(23.5psf)) =
  = 44.0psf ← Controls

Vertical Loading for deflection:

- L_r = 20psf ← Controls
- 0.42W = 0.42(23.5psf) = 9.9psf

Designer Note:

1. Snow Loads: If a project has snow load requirements, load combinations with the uniform Snow Load and the Drift Snow Loads would have to be checked as well.
2. Snow Deflection: ASCE7-16 Commentary Section CC.2 has additional discussion that can be beneficial regarding deflection due to snow loading.

Uplift Loading on the Deck:

- Zone 1': w = 0.6D+0.6W = 0.6(5 psf) + 0.6(-22.4 psf) = -10.4 psf
- Zone 1: w = 0.6D+0.6W = 0.6(5 psf) + 0.6(-36.7 psf) = -19.0 psf
- Zone 2: w = 0.6D+0.6W = 0.6(5 psf) + 0.6(-48.5 psf) = -26.1 psf
- Zone 3: w = 0.6D+0.6W = 0.6(5 psf) + 0.6(-48.5 psf) = -26.1 psf ←

Uplift Loading for deflection:

- Zone 1': w = 0.42W = 0.42(-22.4 psf) = -9.4 psf
- Zone 1: w = 0.42W = 0.42(-36.7 psf) = -15.4 psf
- Zone 2: w = 0.42W = 0.42(-48.5 psf) = -20.4 psf
- Zone 3: w = 0.42W = 0.42(-48.5 psf) = -20.4 psf ← Controls

Uplift Loading for Fasteners:

- Zone 1': w = 0.6D+0.6W = 0.6(5psf) + 0.6(-22.4psf) = -10.4psf
- Zone 1: w = 0.6D+0.6W = 0.6(5psf) + 0.6(-38.9psf) = -20.3psf
- Zone 2: w = 0.6D+0.6W = 0.6(5psf) + 0.6(-51.3psf) = -27.8psf
- Zone 3: w = 0.6D+0.6W = 0.6(5psf) + 0.6(-51.3psf) = -27.8psf ←

For Roof applications: the typical Steel Deck Profiles are B deck (1.5"tall profile) and N deck (3" tall profile).

For this example, PLB deck will be used. PLB is B deck that uses Verco Punchlok II sidelap connections

- "PL" in Verco deck profile name indicates profile with Punchlok II sidelap connection.

Deck Gage: Start with the lightest gage for the deck profile. For PLB, the lightest gage is 22GA.

Deck Fasteners: Start with the lightest attachment pattern. PLB deck is a 36" wide sheet. The lightest fastener pattern is 4 pins per sheet. Pattern is called out as 36/4.

Appendix B.3 - Vertical Load Deck Selection Example

Use the Verco Bare Deck Uniform Load Tool to determine deck capacity.

Roof Deck Inputs:

- ASD design Method
- Verco PLB Deck
- Start with 22 gage deck
- Grade 50 deck
- Deflection Limit: L/240
- Support Member Grade: A572 GR 50
- End Bearing Length: 2"
- Interior Bearing Length: 4"
- End Lapped Deck
- Hilti X-HSN24 PAF pins
- 0.125" min thickness for supports
- Start with 36/4 pattern at end connection
- Start with 36/4 pattern at interior connection
- Starting Span for table: 6ft (min assumed for EWA)
- Span Increments in table: 0.5ft

The following is the output from the Verco Online tool.

Appendix B.3 - Vertical Load Deck Selection Example

Verco Online Design Tool Output:

22 Gage PLB™-36 Grade 50

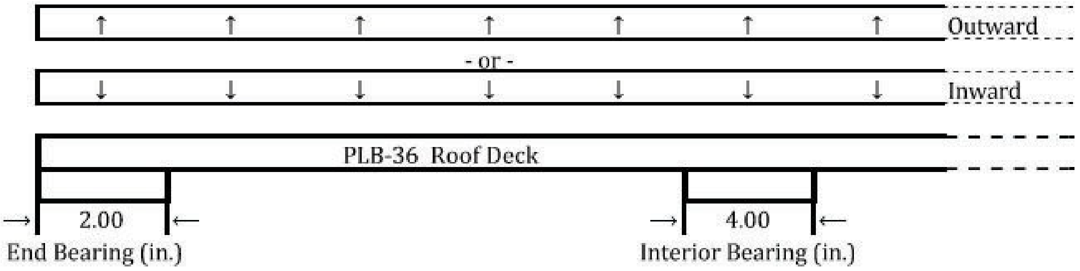
Uniform Allowable Load Table, ASD (psf)

For End Lapped Deck

VERCO DECKING, INC. A NUCOR COMPANY

36/4 Connection Pattern to Supports with
Hilti X-HSN 24 PAF

Support Member A572 GR50
$0.125 \le t_2$ (in.) ≤ 0.375



Inward Uniform Allowable Load Table, ASD (psf)

Span	Span	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"
1	Wn/Ω	98	83	72	62	55	49	43	39
	L/240	54	42	34	28	23	19	16	14
2	Wn/Ω	103	88	76	66	58	52	46	41
	L/240	-	-	-	-	-	49	42	35
3	Wn/Ω	128	110	95	83	73	64	57	52
	L/240	110	87	69	56	46	39	33	28

Outward (Uplift) Uniform Allowable Load Table, ASD (psf)

Span	Span	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"
1	Wn/Ω	104	89	77	67	59	52	46	42
	Rn/Ω	97	89	83	77	73	68	64	61
	L/240	58	46	37	30	25	20	17	15
2	Wn/Ω	97	82	71	62	55	48	43	39
	Rn/Ω	77	71	66	62	58	55	52	49
	L/240	-	-	-	-	-	46	39	33
3	Wn/Ω	120	103	89	77	68	60	54	48
	Rn/Ω	88	81	75	70	66	62	59	56
	L/240	-	80	64	52	43	36	30	26

Steel Deck Properties

t	Fy	wdd	Id+	Id-	Se+	Se-	Mn+/Ω	Mn-/Ω	Vn/Ω
in	ksi	psf	$in.^4$/ft	$in.^4$/ft	$in.^3$/ft	$in.^3$/ft	lbs-ft/ft	lbs-ft/ft	lbs/ft
0.0299	50	1.90	0.178	0.192	0.176	0.188	439	469	2688

Where: $W \le Wn/\Omega$

W = Required strength of the governing ASD load combination
Wn/Ω = Allowable strength governed by the steel deck
Rn/Ω = Allowable strength governed by connection tension

Steel Deck Uniform V1.0.5 in accordance with AISI S100-16 and AISI S310-16. Date: 3/28/2023

Compare the required loads above to the capacities in the table.

- Allowable Uniform Load 2: Required Uniform Load
- Allowable Load for Deck Strength = W_n/Ω.
- Allowable Load for Fasteners = R_n/ Ω.

Check 8ft spacing for the deck supports:

Downward Load on Deck:
- 1 Span: Capacity = 55psf > 44.0psf - OK
- 2 Span: Capacity = 58psf > 44.0psf - OK
- 3 Span: Capacity = 73psf > 44.0psf - OK

Downward Load for Deflection:
- 1 Span: Capacity = 23psf > 20psf - OK
- 2 Span: Capacity = 58psf > 20psf - OK
  (Deflection does not control with 2 Span condition, so strength load used.)
- 3 Span: Capacity = 46psf > 20psf - OK

For Uplift Capacities, Table shows absolute value. Negative sign in required loads indicates uplift direction.

Uplift Load on Deck:
- 1 Span: Capacity = 59psf > 26.1psf - OK
- 2 Span: Capacity = 55psf > 26.1psf - OK
- 3 Span: Capacity = 68psf > 26.1psf - OK

Uplift Load for Deflection:
- 1 Span: Capacity = 25psf > 20.4psf - OK
- 2 Span: Capacity = 55psf > 20.4psf - OK
  (Deflection does not control with 2 Span condition, so strength load used.)
- 3 Span: Capacity = 43psf > 20.4psf - OK

Uplift Load on Fasteners:
- 1 Span: Capacity = 73psf > 27.8psf - OK
- 2 Span: Capacity = 58psf > 27.8psf - OK
- 3 Span: Capacity = 66psf > 27.8psf - OK

Appendix B.3 - Vertical Load Deck Selection Example

Capacities based on supports at 8ft on center exceed required load for 1 Span Condition, 2 Span Condition, & 3 Span Condition - Therefore OK

Designer Note:

1. Where practical, determine required deck gage and support spacing so 1 Span Condition minimum will work. Allows the contractor more flexibility in erection methods. This also simplifies construction at mechanical and other openings in the roof deck.
2. See "Roof Structure Design Guide" by Patrick Bodwell, available on Verco website, for discussion of 300lb maintenance worker load on roof deck.

For Vertical Load Requirements on this Building:
Use 22GA Verco PLB deck with Hilti X-HSN24 PAF at 36/4 pattern, 1 Span minimum. Max Support Spacing = 8ft on center

The result above is the starting point for the lateral analysis for Seismic and Wind. The lateral analysis may require portions of the roof to have heavier attachment patterns and/or heavier gage deck.

Designer Note:

1. Designer needs to use their judgment and experience to balance deck support spacing, deck gage, and minimum number of spans for vertical loads based on all the requirements for the project.

2. This example is a simple case where the same deck gage and span condition worked for the entire roof. For heavier loading requirements, different deck span condition or deck gage may be required for different portions of the roof (ie perimeter and corner wind zones, drift areas, etc).

3. High wind loading: Using 2 Span Condition minimum may allow a lighter gage deck to work in areas where 1 span is not adequate. For example: 2 Span Condition minimum could be used at the Corner Wind Zone 3 in order to allow the same deck gage to be used on the entire roof. Construction documents would then need to specifically show where 2 span condition was required and where 1 span condition was allowed.

4. High wind loading: The lateral analysis may require a heavier gage deck be used near the walls. This may reduce the minimum span condition for vertical loads in those areas. For example: 22GA deck with 2 span min. may be required at Corner Wind Zone 3, but only 1 span min was required for the rest of the building. Lateral analysis required 20GA deck in the corner zones for shear capacity. The 20 GA deck should be analyzed to see if 1 span condition will work at the Corner Wind Zone 3, to simplify construction.

5. Snow Drift Loads parallel to deck span, it may be beneficial to use a heavier gage deck under the snow drift areas and leave the deck support spacing the same as the main portion of the roof. Then transition back to the lower gage deck beyond the drifts.

6. Snow Drift Loads perpendicular to deck span, it may be beneficial to space the deck supports closer together to allow a lighter gage deck under the drift in this direction. For example: main roof has beams/steel joists at 8ft on center. At the snow drifts at the end of the building, the beams/steel joists could be spaced at 6ft on center.

Appendix B.4 - Cantilever Design Example

Overview:
This design example walks through the design of a 20 gage PLB-36 bare deck cantilever starting with basic loads and includes the required information and mechanics for a cantilever check. Included in this example is a discussion of loads cases and typical determinations by an Engineer of Record (EOR) on how to address various issues.

Codes and Reference Documents:
International Building Code (2021 IBC)
American Society of Civil Engineers, Minimum Design Loads for Buildings and Other Structures (ASCE 7-16)
American Iron and Steel Institute North American Specification for the Design of Cold-formed Steel Structural Members (AISI S100-16)
Verco Decking, Inc. IAPMO-UES Evaluation Report (ER-2018)
Steel Deck Institute Standard for Steel Deck (SD-2022)

Steel Deck Use: Bare deck used for a canopy type application

Steel Deck Type: Verco 20 gage PLB-36

Section Properties

M_n-:	0.988 kip-ft/ft	IAPMO ER-2018
V_n:	5.152 kip/ft	IAMPO ER-2018
I_d-:	0.231 in^4/ft	IAPMO ER-2018
Deck Weight:	2.3 psf	IAMPO ER-2018

Web-crippling		Verco Web-Based Design Tools
Interior Bearing 1 Flange:	2339 plf @ 4 in. of bearing	Bare Deck Web Crippling
Interior Bearing 2 Flange:	2946 plf @ 4 in. of bearing	Bare Deck Web Crippling

Note: Interior bearing is used for the web-crippling as the end beam that the deck cantilevers over will be interior to the deck sheet even if there is no end beam on the cantilever.

Modulus of Steel, E: 29,500,000 psi

Supports: A36 W 8 x 10 with flange width of 4" and flange thickness of 0.205 in.

Attachments to support: Hilti HSN-24 on a 36/7 pattern with VSC2 at 24" o.c. for the sidelap

Hilti X-HSN-24		Verco Web-Based Design Tools
Tension Capacity:	0.553 kips (ASD) 553 lbs (ASD)	Bare Deck Uniform Load-Connections

Back span, L: 6'-0"

Cantilever Deflection Requirement: a/30

Note: a/30 comes from the notes in IBC 2021 Table 1604.3 specifically the following: Note (a): For structural roofing and siding made of formed metal sheets, the total load deflection shall not exceed L/60; Note (i): L = Length of the members between supports. For Cantilever members, L shall be taken as twice the length of the cantilever.

Superimposed loads:

20 psf live load

200 lbs point load

Appendix B.4 - Cantilever Design Example

Note: Table 1607.1 - 20 psf is the minimum load required for a roof per IBC 2018/2021 with a 300 lbs point load typically considered across 18 in. width located at the cantilever end. In SDI SD-2022 Eqns 2.2-3 and 2.2-4 a one-foot width which works out to be 200 lbs across a 1' width of deck. This basic load is the same for roofs as it is associated with roof maintenance.

Calculations:

Allowable Negative Flexural Strength: $M_{a-} = M_{n-} / 1.67$ = (0.988 kip-ft/ft * 12 * 1000) / 1.67 = 7099 lb-in/ft

Vertical component of allowable web shear: $V_a = V_n / 1.6$ = (5.152 kip /ft * 1000) / 1.6 = 3220 lb/ft

W_1 =	2.3 psf	Deck weight
W_2 =	20 psf	Superimposed live load
P_1 =	200 lbs	Superimposed concentrated live load

Note: For the cantilever calculations on combined bending and web shear and for the calculations for cantilever based on deflection, a series of iterations will be required, but only 2 iterations are shown for simplification of the example. A spreadsheet will greatly reduce the time requirements of the iterations.

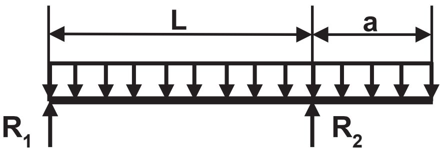
1. **Maximum Cantilever based on Combined Bending and Web Shear:**

$$\sqrt{\left(\frac{M}{M_a}\right)^2 + \left(\frac{V}{V_a}\right)^2} \leq 1.0$$ AISI S100-16 Eq. H2-1

Note: 3 load cases are considered for the below calculations "1A. Beam Overhanging One Support with Uniformly Distributed Load", "1B. Beam Overhanging One Support with Uniformly Distributed Load on Overhang" and "1C. Beam Overhanging One Support with Concentrated Load at End of Support". Typically, the 1C load case will control, but due diligence requires checking of all 3 conditions. These formulas are all derived from the standard beam formulas from engineering mechanics. Examples can be found in the AISC Steel Construction Manual or other resources.

1A. Beam Overhanging One Support with Uniformly Distributed Load

1st Iteration: Overhang, a = 50 in.



$$m_1 = \left(\frac{W_1+W_2}{8L^2}\right)(L+a)^2(L-a)^2$$ = 323 lb-in/ft

$$m_2 = \frac{(W_1+W_2)*a^2}{2}$$ = 2324 lb-in/ft

M_{max} = Max (m_1, m_2) = 2324 lb-in/ft

$V_2 = (W_1+W_2)*a$ = 93 lb/ft

$$V_3 = \frac{(W_1+W_2)}{2L}*(L^2+a^2)$$ = 99 lb/ft

V_{max} = Max [V_2, V_3] = 99 lb/ft

$$\sqrt{\left(\frac{m}{m_a}\right)^2 + \left(\frac{v}{v_a}\right)^2} \leq 1.0 = 0.329$$

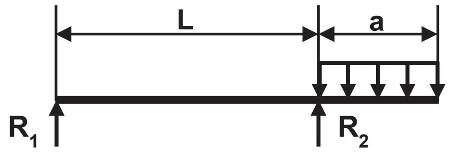
a = 50 in. works but is not optimized – iterate until *a* is the optimum solution as a whole number.

7th Iteration: Overhang, a = 87 in.

$$\sqrt{\left(\frac{m}{m_a}\right)^2 + \left(\frac{v}{v_a}\right)^2} \leq 1.0 = 0.992$$

1B. Beam Overhanging One Support with Uniformly Distributed Load on Overhang

1st Iteration: Overhang, a = 50 in.



$$m_{max} = \frac{(W_1 + W_2) * a^2}{2} = 2334 \text{ lb-in/ft}$$

$$V_1 = \frac{(W_1 + W_2) * a^2}{2L} = 32 \text{ lb/ft}$$

$$V_2 = (W_1 + W_2) * a = 93 \text{ lb/ft}$$

V_{max} = Max [V_1, V_2] = 93 lb/ft

$$\sqrt{\left(\frac{m}{m_a}\right)^2 + \left(\frac{v}{v_a}\right)^2} \leq 1.0 = 0.328$$

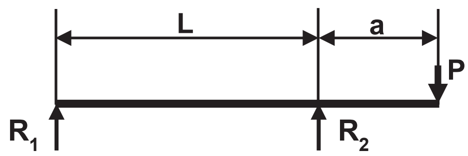
a = 50 in. works but is not optimized – iterate until *a* is the optimum solution as a whole number.

7th Iteration: Overhang, a = 87 in.

$$\sqrt{\left(\frac{m}{m_a}\right)^2 + \left(\frac{v}{v_a}\right)^2} \leq 1.0 = 0.992$$

1C. Beam Overhanging One Support with Concentrated Load at End of Cantilever

1st Iteration: Overhang, a = 25 in.



$$m_{max} = P_1 * a = 5000 \text{ lb-in/ft}$$

$$V_1 = \frac{Pa}{L} = 69 \text{ lb/ft}$$

$$V_2 = P = 200 \text{ lb/ft}$$

V_{max} = Max [V_1, V_2] = 200 lb/ft

$$\sqrt{\left(\frac{m}{m_a}\right)^2 + \left(\frac{v}{v_a}\right)^2} \leq 1.0 \quad = 0.707$$

a = 25 in. works but is not optimized – iterate until *a* is the optimum solution as a whole number.

6th Iteration: Overhang, a = ***35 in. <- Governs*** for combined bending and shear

$$\sqrt{\left(\frac{m}{m_a}\right)^2 + \left(\frac{v}{v_a}\right)^2} \leq 1.0 \quad = 0.988$$

2. Maximum Cantilever Spans Based on Deflection

Note: Deflection is typically limited to a/30 or no more than 0.75 inches whichever is less. These two deflection limits are used for this example. The EOR can choose other deflection criteria depending on design requirements.

2A. Beam Overhanging One Support with Uniformly Distributed Load
1st Iteration: Overhang, a = 50 in.
Deflection Limit, a / Δ = 50/30 = 1.667 in. > 0.75 in. controls

$$\Delta_c = \frac{(W_1 + W_2)a}{24EI_{d-}}\left(4a^2L - L^3 + 3a^3\right) \quad = 0.410 \text{ in.} \leq 0.75 \text{ in.}$$

a = 50 in. works but is not optimized - iterate until a is optimum solution as a whole number.

5th Iteration: Overhang, a = 57 in.
Deflection Limit, a / Δ = 57/30 = 1.9 in. > 0.75 in. controls

$$\Delta_c = \frac{(W_1 + W_2)a}{24EI_{d-}}\left(4a^2L - L^3 + 3a^3\right) \quad = 0.724 \text{ in.} \leq 0.75 \text{ in.}$$

2B. Beam Overhanging One Support with Uniformly Distributed Load on Overhang
1st Iteration: Overhang, a = 50 in.
Deflection Overhang, a / Δ = 50/30 = 1.667 in > 0.75 in. controls

$$\Delta_c = \frac{(W_1 + W_2)a}{24EI_{d-}}\left(4a^2L + 3a^3\right) \quad = 0.622 \text{ in.} \leq 0.75 \text{ in.}$$

a = 50 in. works but is not optimized - iterate until a is optimum solution as a whole number.

4th Iteration: Overhang, a = 52 in.
Deflection Overhang, a / Δ = 50/30 = 1.733 in > 0.75 in. controls

$$\Delta_c = \frac{(W_1 + W_2)a}{24EI_{d-}}(4a^2L + 3a^3)$$ = 0.709 in ≤ 0.75 in.

2C. Beam Overhanging One Support with Concentrated Load at End of Support
1st Iteration: Overhang, a = 50 in.
Deflection Overhang, a / Δ = 50/30 = 1.667 in. > 0.75 in. controls

$$\Delta_c = \frac{Pa}{6EI_{d-}}(2aL + 2a^2)$$ = 2.984 in. > 0.75 in.

a = 50 in. does not work – iterate down until a is optimum solution as a whole number.

7th Iteration: Overhang, a = ***27 in. <- Governs*** for deflection
Deflection Overhang, a / Δ = 27/30 = 0.9 in. > 0.75 in. controls

$$\Delta_c = \frac{Pa}{6EI_{d-}}(2aL + 2a^2)$$ = 0.706 in. ≤ 0.75 in.

3. Maximum Cantilever Spans based on Web Crippling

Note: Web-crippling values can be drawn from Verco's Web-based design tool for bare deck web-crippling or calculated by hand the by the EOR. Web-crippling rarely controls the cantilever span unless very heavy loads with narrow bearing and light gage deck.

Note: R_1, R_2 and R_b reactions at the supports. W_1 and W_2 are the applied uniform loads $w = W_1 + W_2$

A. Web Crippling at Cantilever Support - One Flange Loading with Uniformly Distributed Load

$$a = \sqrt{R_2 \frac{2L}{w}} - L$$ = 29.48 ft. = 353 in.

B. Web Crippling at Cantilever Support - One Flange Loading with Uniformly Distributed Load and Point Load

$$a = \frac{-L(W_1 + W_2) - P + \sqrt{2RL(W_1 + W_2) + P^2}}{(W_1 + W_2)}$$ = 21.62 ft. = ***259 in. <- Governs*** for web-crippling

C. Web Crippling at Cantilever Support - One Flange Loading with Uniformly Distributed Load and Point Load

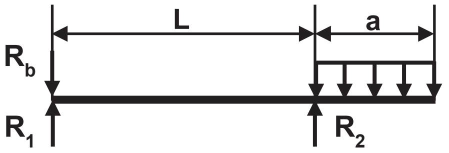
$$a = \sqrt{(R - P)\frac{2L}{w}} - L$$ = 32.44 ft. = 389 in.

4. Required attachment based on Maximum Cantilever

*Note: There are several approaches to calculate the cantilever requirements for attachment. The simplest is to find the maximum cantilever span, **a** as per calculations in Section 3 and then use the cantilever span to calculate the reaction at the inside support to generate the tension per foot required. Then convert the tension per foot into a pattern based on deck and fastener type. In this design example a fastener pattern 36/7 is already given.*

Max Cantilever Span based on previous calculation a = 27 in. = 2.25 ft.

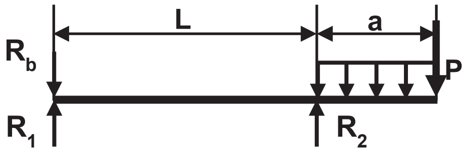
A. Uniform Construction Load on Cantilever:



$$R_b = \frac{w_{dd}L}{2} - \frac{wa^2}{2L}$$ = - 2.508 lbs per foot tension @ 27 in. cantilever

B. Concentrated and Uniform Construction Load on Cantilever:

$$R_b = \frac{w_{dd}L}{2} - \frac{wa^2}{2L} - P\frac{a}{L}$$ = ***-77.508 lbs/ft tension @ 27 in. cantilever <- Governs***



C. Check Required attachment pattern for sufficient Tension capacity:

Hilti X-HSN-24 Tension Capacity: 0.553 kips = 553 lbs ASD per fastener

PLB-36 Deck with 36/7 pattern 36 in. / 12 = 3 ft.

7 pins / 3 ft. = 2.333 pins per foot

2.333 * 553 lbs = 1290 lbs-ft capacity > 77.508 lbs-ft

Tension capacity exceeds load requirement – ***Okay.***

Summary:

a = 35 in. governs for combined bending and shear
a = 27 in. governs for deflection
a = 259 in. governs for web crippling

Therefore, ***a = 27 in. governs overall***

For the above example, the controlling overhang is from "2. Maximum Cantilever Spans Based on Deflection" -> "Load case 2C. Beam Overhanging One Support with Concentrated Load at End of Support" with ***a*** = 27 inches or 2'-3" cantilever. With a 36/7 pattern, the tension capacity of the supports is sufficient to compensate for the uplift on the beam.

Wind Uplift Discussion for bare deck cantilever

In regions with strong winds from hurricanes, tornadoes, microbursts, etc., the question arises regarding how wind uplift should be checked. The same procedure as above can be used with a couple of additional load cases and design information being included.

The following should be considered:

1. Inverted section properties and loads for the deck should be considered including web-crippling.
2. An interior bearing width of 0.75 in. should be the considered on the inverted section properties.
3. Attachment pattern and support attachment type on the end span should be considered for the uplift.

Note: An end support bearing of 0.75 in. should be considered depending on Engineer of Record's judgement, even though there is no support to bear against in the upward condition, because it is the code minimum and can conservatively approximate the localized buckling that can occur as the wind forces the deck back on itself while the deck is restrained by the attachment to the support. This is a case of engineering judgement and should be approached carefully by the EOR.

Other loads and conditions that the Engineer of Record consider appropriate should also be taken into consideration also.

NOTICE: Design defects that could cause injury or death may result from relying on the information in this document without independent verification by a qualified professional. The information in this document is provided "AS IS". Nucor Corporation and its affiliates expressly disclaim: (i) any and all representations, warranties and conditions and (ii) all liability arising out of or related to this document and the information in it.

VERCO DECKING, INC.

a NUCOR® company