Wind Uplift Design For Steel Joist and Steel Deck Roofs

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Webinar Description

This webinar will provide a comprehensive review of wind forces on steel joist and steel deck roof systems, including wind load determination, wind load combinations, and wind load application. Specification, analysis, and design to resist uplift loads will be a primary focus, but load paths and connections will also be touched on.

Learning Objectives

- Learn how to apply ASCE 7 to determine which wind pressures to use when designing joists and deck.
- Learn the ways that steel deck is designed for both strength and anchorage to resist wind uplift.
- Learn the main considerations in designing an efficient joist system to resist wind uplift.
- Learn how to integrate steel deck and steel joists into a system that resists uplift efficiently.

Outline

- Selection and specification of wind pressures
- Design and installation of steel roof deck to resist wind uplift
- Design considerations for joists subject to net uplift
  - Load combinations
  - End anchorage
  - Bridging

Wind Uplift on Joists and Deck

- Even if the system is robust, it must stay on the building!

Standards and Codes

- Code of Standard Practice for Steel Deck (2023)
- Code of Standard Practice for Steel Joists and Joist Girders (2020)
- Provisions from ASCE 7-22

ASCE 7-22 Wind Loads

- Many steel joist and steel deck structures will use the following parts of ASCE 7-22 for wind load determination:
  - Chapter 28 for Main Wind Force Resisting System (MWFRS)
  - Chapter 30 Part 1 for Components and Cladding (C&C)

- Note: the simplified method provided in ASCE 7-16 has been removed in ASCE 7-22

ASCE 7-22 Wind Loads

Table 28.2-1. Steps to Determine Wind Loads on MWFRS Low-Rise Buildings.

Step 1: Determine risk category of building; see Table 1.5-1.
Step 2: Determine the basic wind speed, V, for applicable risk category; see Figure 26.5-1.
Step 3: Determine wind load parameters:

- Wind directionality factor, K_d; see Section 26.6 and Table 26.6-1.
- Exposure Category (B, C, or D); see Section 26.7.
- Topographic factor, K_{zt}; see Section 26.8 and Figure 26.8-1.
- Ground elevation factor, K_e; see Section 26.9 and Table 26.9-1.
- Enclosure classification; see Section 26.12.
- Internal pressure coefficient, (GC_{pi}); see Section 26.13 and Table 26.13-1.

Step 4: Determine velocity pressure exposure coefficient, K_z or K_h; see Table 26.10-1.
Step 5: Determine velocity pressure, q_z or q_h, from Equation (26.10-1).
Step 6: Determine external pressure coefficient, (GC_{pf}), for each load case using Section 28.3.2 for flat and gable roofs.

> **User Note:** See Commentary Figure C28.3-2 for guidance on hip roofs.

Step 7: Calculate wind pressure, p, from Equation (28.3-1).

Table 30.3-1. Steps to Determine C&C Wind Loads for Enclosed, Partially Enclosed, and Partially Open Low-Rise Buildings.

Step 1: Determine risk category; see Table 1.5-1.
Step 2: Determine the basic wind speed, V, for applicable risk category; see Figure. 26.5-1.
Step 3: Determine the wind load parameters:

- Wind directionality factor, K_d; see Section 26.6 and Table 26.6-1.
- Exposure Category B, C, or D; see Section 26.7.
- Topographic factor, K_{zt}; see Section 26.8 and Figure 26.8-1.
- Ground elevation factor, K_e; Section 26.9 and Table 26.9-1.
- Enclosure classification; see Section 26.12.
- Internal pressure coefficient, (GC_{pi}); see Section 26.13 and Table 26.13-1.

Step 4: Determine velocity pressure exposure coefficient, K_h; see Table 26.10-1.
Step 5: Determine velocity pressure, q_h, Equation (26.10-1).
Step 6: Determine external pressure coefficient, (GC_p):

- Walls; see Figure 30.3-1.
- Flat roofs, gable roofs, hip roofs; see Figure 30.3-2.
- Stepped roofs; see Figure 30.3-3.
- Multispan gable roofs; see Figure 30.3-4.
- Monoslope roofs; see Figure 30.3-5.
- Sawtooth roofs; see Figure 30.3-6.
- Domed roofs; see Figure 30.3-7.
- Arched roofs; see Figure 30.3-8.
- Bottom horizontal surface of elevated buildings; see Section 30.3.2.1.

Step 7: Calculate wind pressure, p; Equation (30.3-1).

Determining Wind Loads for Joists

- Steel Joist Institute (SJI) Code of Standard Practice

2.4 SPECIFYING DESIGN LOADS

Neither the Steel Joist Institute nor the joist manufacturer establishes the loading requirements for which structures are designed.

The *specifying professional* shall provide the nominal loads and load combinations as stipulated by the applicable code under which the structure is designed and shall provide the design basis (ASD or LRFD).

The *specifying professional* shall calculate and provide the magnitude and location of ALL JOIST and JOIST GIRDER LOADS. This includes all special loads (drift loads, mechanical units, net uplift, axial loads, moments, structural bracing loads, or other applied loads) which are to be incorporated into the joist or Joist Girder design. For Joist Girders, reactions from supported members shall be clearly denoted as point loads on the Joist Girder. When necessary to clearly convey the information, a load diagram or load schedule shall be provided.

Determining Wind Loads for Joists

- ASCE provides formulas for design wind pressures and net design wind pressures. These are NOT the same as the NET uplift required by SJI.

$$p = q_h[(GC_{pf}) - (GC_{pi})] \text{ (lb/ft}^2\text{) (N/m}^2\text{)} \quad (28.4\text{-}1)$$

$$p_{\text{net}} = \lambda K_{zt}\, p_{net30} \quad (30.5\text{-}1)$$

- ASCE net is the sum of internal and external pressures.
- SJI net uplift, is the final resultant pressure less appropriate dead load – result of the load combination

ASCE 7-22 Load Combinations

- 2.3 COMBINING FACTORED LOADS USING STRENGTH DESIGN
  - 2.3.1 Basic Combinations

1. $1.4D$
2. $1.2D + 1.6L + (0.5L_r$ or $0.3S$ or $0.5R)$
3. $1.2D + (1.6L_r$ or $1.0S$ or $1.6R) + (L$ or $0.5W)$
4. $1.2D + 1.0W + L + (0.5L_r$ or $0.3S$ or $0.5R)$
5. ***$0.9D + 1.0W$***
6. $1.2D + E_v + E_h + L + 0.15S$
7. $0.9D - E_v + E_h$

ASCE 7-22 Load Combinations

- 2.4 COMBINING NOMINAL LOADS ALLOWABLE STRESS DESIGN
  - 2.4.1 Basic Combinations

1. D
2. $D + L$
3. $D + (L_r \text{ or } 0.7S \text{ or } R)$
4. $D + 0.75L + 0.75(L_r \text{ or } 0.7S \text{ or } R)$
5. $D + 0.6W$
6. $D + 0.75L + 0.75(0.6W) + 0.75(L_r \text{ or } 0.7S \text{ or } R)$
7. ***$0.6D + 0.6W$***
8. $1.0D + 0.7E_v + 0.7E_h$
9. $1.0D + 0.525E_v + 0.525E_h + 0.75L + 0.1S$
10. $0.6D - 0.7E_v + 0.7E_h$

Determining Wind Loads for Joists

- When wind uplift is a design consideration, it should be specified as <u>net</u> uplift on the steel joists and joist girders.
- The chart on the following slide is a typical components and cladding roof wind pressures chart provided on the contract documents.

Determining Wind Loads for Joists

Roof Wind Uplift Pressures (PSF)					
Zone	**Effective Wind Area (Sq. Ft.)**				
	10	**20**	**50**	**100**	**500**
1’	-70.5	-70.5	-70.5	-70.5	-47.7
1	-122.7	-112.9	-103.1	-96.0	-77.0
2	-161.9	-152.1	-139	-126	-103.1
3	-220.6	-197.8	-171.7	-152.1	-103.1

- This alone is not enough information
  - Ultimate (LRFD) or Service (ASD) pressures?
  - Dead load available to resist uplift?

Determining Wind Loads for Joists

- Roof pressure needs to be converted to net uplift, or more correctly, the result of the appropriate load combination for wind forces acting upward.
- The specifying professional knows the design dead load and if there are collateral dead loads that should not be deducted from the gross uplift.
  - Maximum Dead Load (for gravity loading)
  - Minimum Dead Load (for wind uplift)
    - $DL_{min} = DL_{max}$ - Collateral Load

Determining Wind Loads for Joists

- Joists are considered components and cladding (C&C).
- Per the ASCE definition of Effective Width, the width need not be less than one third the span.
- Based on this, the following table can be used to determine joist Effective Wind Area based on span.

Determining Wind Loads for Joists

Joist Span (ft)	Effective Wind Area (Sq. Ft.)
L < 8’-0”	10
8-0”≤ L < 13’-0”	20
13’-0”≤ L < 18’-0”	50
18-0”≤ L < 25’-0”	100
25-0”≤ L < 39’-0”	200
L ≥ 39’-0”	500

- Use the largest Effective Wind Area possible for most efficient design

Determining Wind Loads for Joists

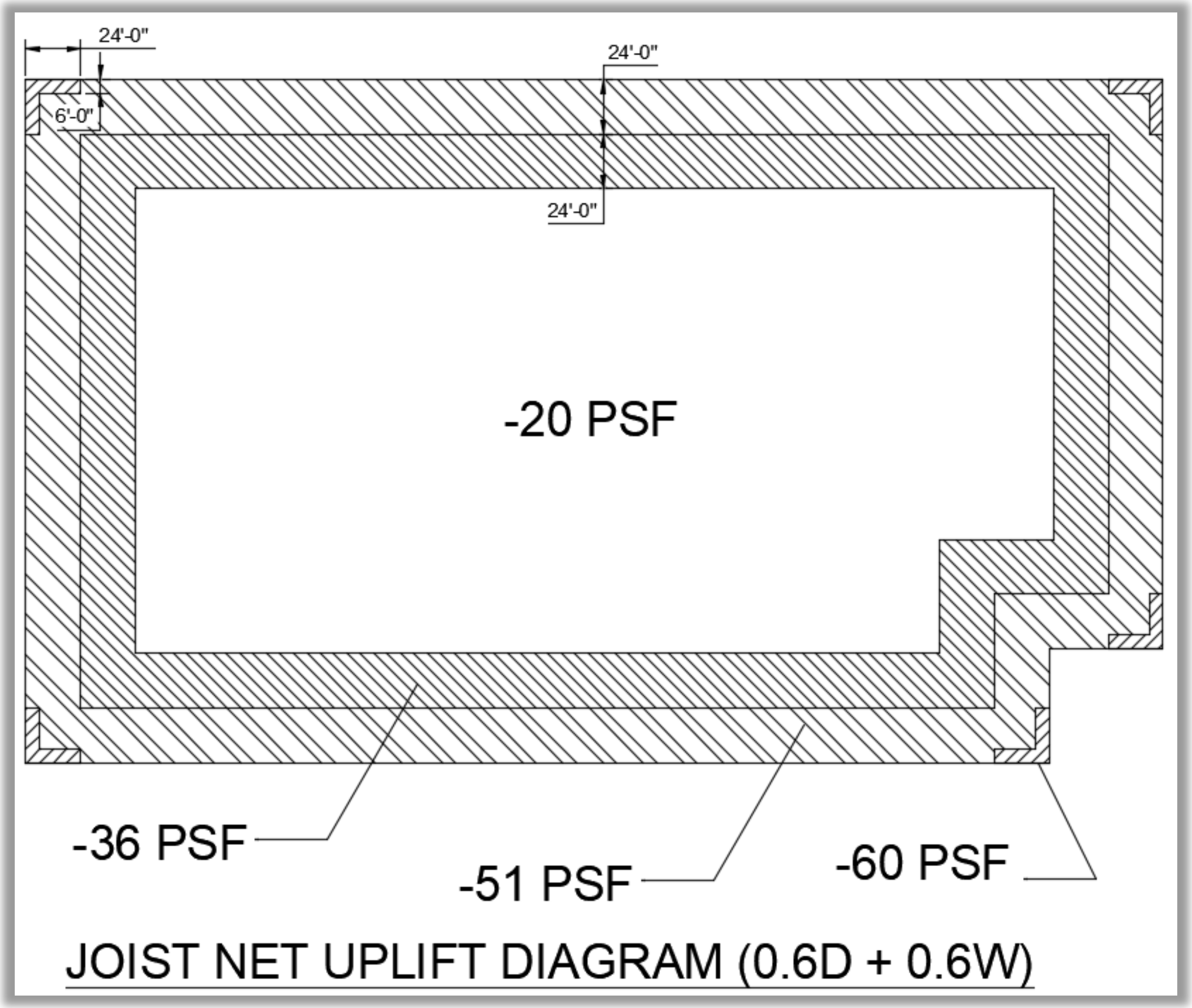
- Joist girders can be considered part of the main wind force-resisting system (MWFRS).
  - Typically, separate MWFRS pressure values are not provided for the joist girders, and the joist designer applies the C&C net uplift forces from the joists to the joist girders.

- Joist girder tension webs must be designed to resist, in compression, 25 percent of their axial force.

- Uplift loads on a Joist Girder of less than 25 percent of the gravity loads have minimal or no effect on the girder design.

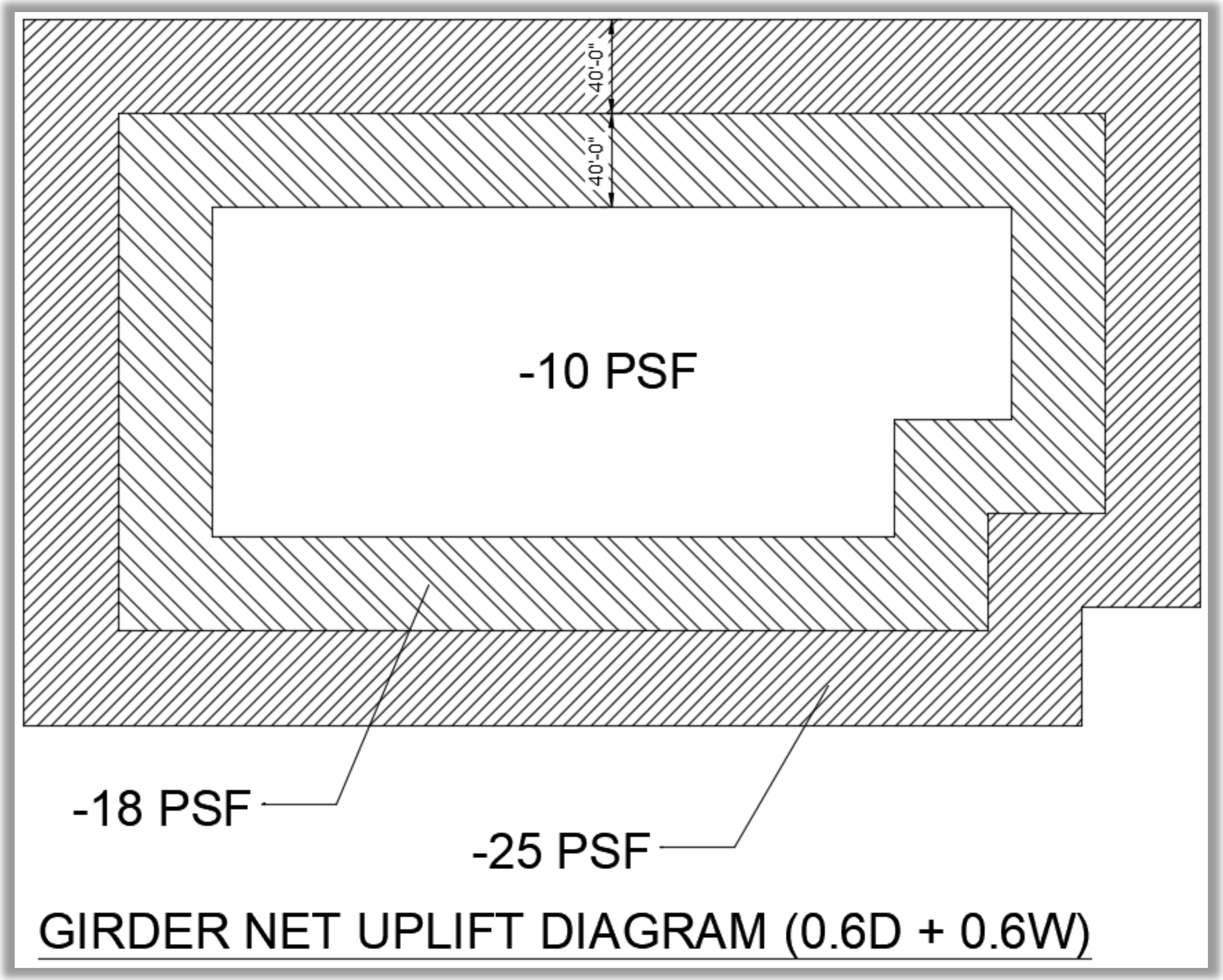
Presentation of Uplift Design

- Use a ***Net Uplift*** plan



Presentation of Uplift Design

- Use a ***Net Uplift*** plan



Presentation of Uplift Design

- Let’s compromise

ROOF WIND UPLIFT PRESSURES

ZONE	UPLIFT PRESSURE < 10 SQ. FT.	UPLIFT PRESSURE < 20 SQ. FT.	UPLIFT PRESSURE < 50 SQ. FT.	UPLIFT PRESSURE < 100 SQ. FT.	UPLIFT PRESSURE < 500 SQ. FT.
1'	70.5	70.5	70.5	70.5	47.7
1	122.7	112.9	103.1	96.6	77.0
2	161.9	152.1	139.0	126.0	103.1
3	220.6	197.8	171.7	152.1	103.1

1. Wind pressures shown are ultimate and can be converted to service by multiplying by 0.6
2. Joist net uplift load combination is 0.6D + 0.6W. “D” = 12 PSF.
3. 0.2h = 6’-0”, 0.6h = 24’-0”

Polling Question #1

If a net uplift diagram is not provided, which of the following are required for joist and girder net uplift design?

A. Main Wind Force Resisting System Pressures

B. Components and Cladding Pressures

C. Dead Load Available to Resist Uplift

D. All of the Above

Design Example

Chapter 30

WIND LOADS – COMPONENTS AND CLADDING (C&C)

Table 30.3-1 Steps to Determine C&C Wind Loads for Enclosed and Partially Enclosed Low-Rise Buildings

Step 1: Determine risk category; see Table 1.5-1.
Step 2: Determine the basic wind speed, V, for applicable risk category; see Figs. 26.5-1 and 26.5-2.
Step 3: Determine wind load parameters:

- Wind directionality factor, K_d; see Section 26.6 and Table 26.6-1.
- Exposure category B, C, or D; see Section 26.7.
- Topographic factor, K_{zt}; see Section 26.8 and Fig. 26.8-1.
- Ground elevation factor, K_e; Section 26.9 and Table 26.9-1
- Enclosure classification; see Section 26.12.
- Internal pressure coefficient, (GC_{pi}); see Section 26.13 and Table 26.13-1.

Step 4: Determine velocity pressure exposure coefficient, K_h; see Table 26.10-1.
Step 5: Determine velocity pressure, q_h, Eq. (26.10-1).
Step 6: Determine external pressure coefficient, (GC_p):

- Walls; see Fig. 30.3-1.
- Flat roofs, gable roofs, hip roofs; see Fig. 30.3-2.
- Stepped roofs; see Fig. 30.3-3.
- Multispan gable roofs; see Fig. 30.3-4.
- Monoslope roofs; see Fig. 30.3-5.
- Sawtooth roofs; see Fig. 30.3-6.
- Domed roofs; see Fig. 30.3-7.
- Arched roofs; see Fig. 27.3-3, Note 4.

Step 7: Calculate wind pressure, p; Eq. (30.3-1).

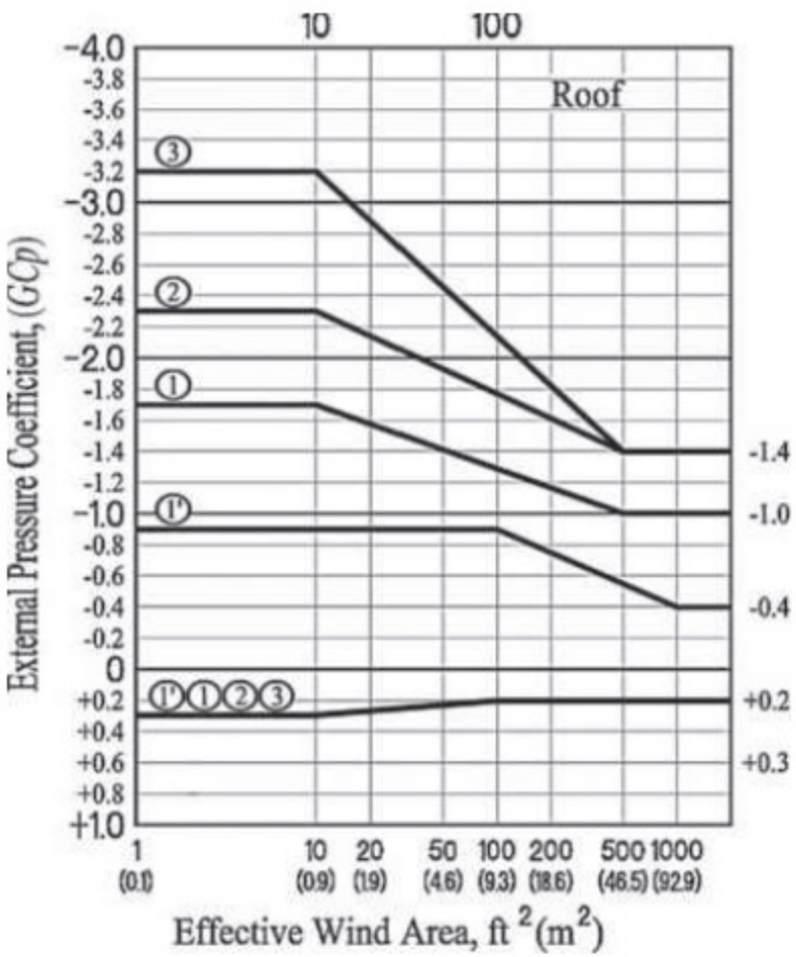
Design Example

- Rectangular building with height = 40', and flat roof
- Risk category II
- V = 140 mph
- Exposure C
- $K_d = 0.85$; $K_{zt} = 1.0$; $K_e = 1.0$; $K_z = 1.04$
- Enclosed Building, GC_{pi} = +/- 0.18

$$q_z = 0.00256 K_z K_{zt} K_e V^2 (\mathrm{lb/ft^2});\ V,\ \mathrm{mi/h} \qquad (26.10\text{-}1)$$

Design Example

- Effective Wind Area – effective width need not be less than 1/3 the span.
- Provide all relevant pressures for most economical design.
- Joists spanning over 39’ can be considered in the 500 sq. ft zone.



Design Example

- Calculate *p* for 100 sf and 500 sf effective wind areas

$$p = q_h[(GC_p) - (GC_{pi})](\text{lb/ft}^2) \qquad (30.3\text{-}1)$$

Ultimate Components and Cladding Pressures (psf)		
A_e (sq. ft)	**100**	**500**
Zone 1'	-47.9	-32.4
Zone 1	-65.6	-52.3
Zone 2	-85.6	-70.1
Zone 3	-103.3	-70.1

D_{min} for net uplift = 10 psf (1.0D)

Design Example

- Joists placed at 6’-0” on center and spanning 50’
- DL = 15 psf, LL = 20 psf, WL+ = 16 PSF
- Use ASD
- Controlling load combination is (DL + 0.75LL + 0.45WL)
- Total load = 224 plf
- Uniform live load = 120 plf
- Select 30K8 (225 plf total load, W_{360} = 130 plf)
- Joist weight is approximately 450 pounds

Design Example

- 500 square foot Zone 1’
  - Net uplift = 0.6D + 0.6W = 0.6*10 + 0.6*(-32.4) = -13.5 psf

- @ 6’-0” spacing = 81 plf net uplift
  ~36% of downward loading of 225 plf

- Joist weight is approximately 470 pounds. 5% more than no uplift. Note that uplift bridging is required.

Design Example

- Let's assume plans are not clear and the joist supplier uses the *p* = -32.4 psf as the net uplift.

- @ 6'-0" spacing = 195 plf net uplift
  Now ~87% of downward loading of 225 plf

- 30K8 with 193 plf net uplift weights about 540 pounds.
  15% heavier than 30K8 supporting required net uplift and requires an additional row of bridging.

Design Example

- Now, let's consider a scenario where only 100 sf pressures are given and the same joist completely in Zone 2
- Net uplift Zone 2 100 sf = 45.4 psf
- Net uplift Zone 2 500 sf = 36.1 psf
- @ 6'-0" spacing NU_{100} = 273 plf & NU_{500} = 217 plf
- 30K8 with 273 plf net uplift is 17% heavier than 30K8 supporting required net uplift

Wind – Not to be Taken Lightly!

Applying Wind Uplift to Joists

- Connections are a critical part of the load path
  - Design of joist seat
  - Capacity of attachment
    - Welds
    - Bolts

Connection Design for Uplift

- Anchorage failure example

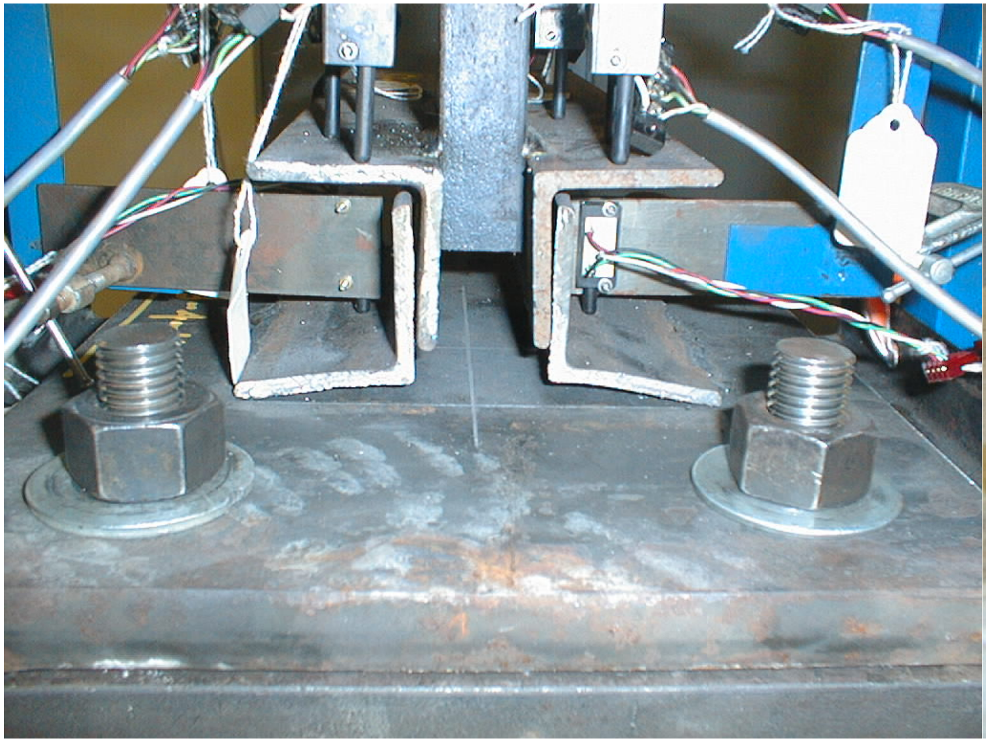
Connection Design for Uplift

- Division of Responsibility
  - SJI Specification and Code of Standard Practice
    - “The joist manufacturer will provide a seat of sufficient thickness and strength to resist the uplift end reaction resulting from the specified uplift.”
    - “The adequacy of the end anchorage connection (bolted or welded) between the joist or Joist Girder bearing seat and the supporting structure is the responsibility of the *specifying professional*. The contract documents shall clearly illustrate the end anchorage connection.”

Welded End Anchorage

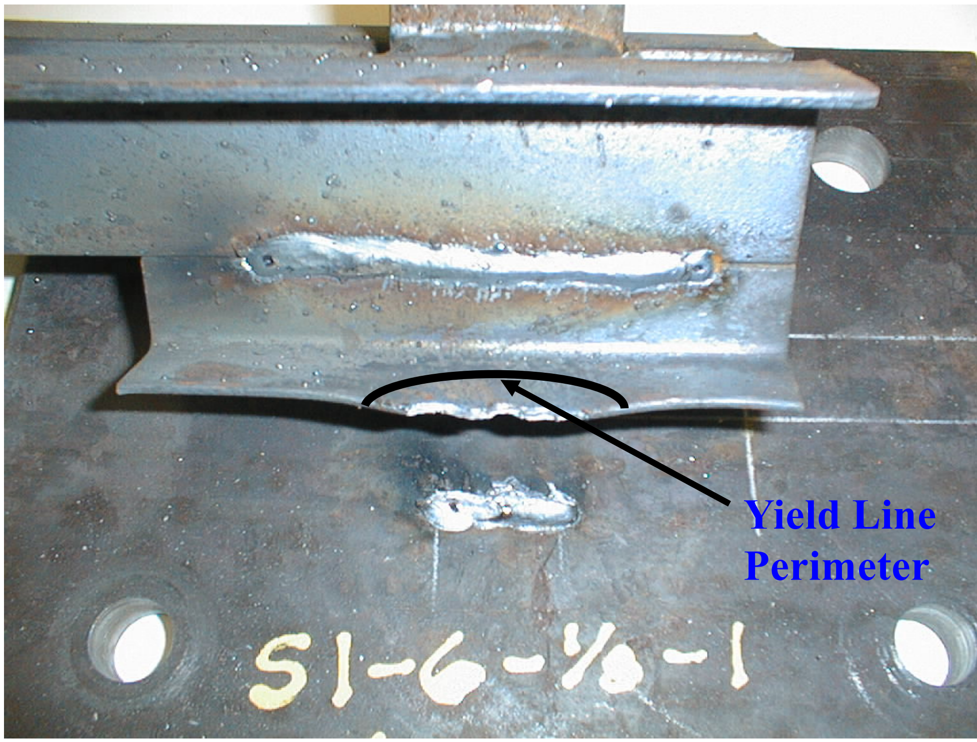
- The strength of the joist bearing seat for an uplift loading combination is a function of both the joist seat thickness and length of the end anchorage welds.
- The minimum anchorage welds from the SJI Specification may not develop the full capacity of the joist seat assembly for uplift.
- Longer end anchorage weld length aids the joist manufacturer in providing an economical design of the joist bearing seat.

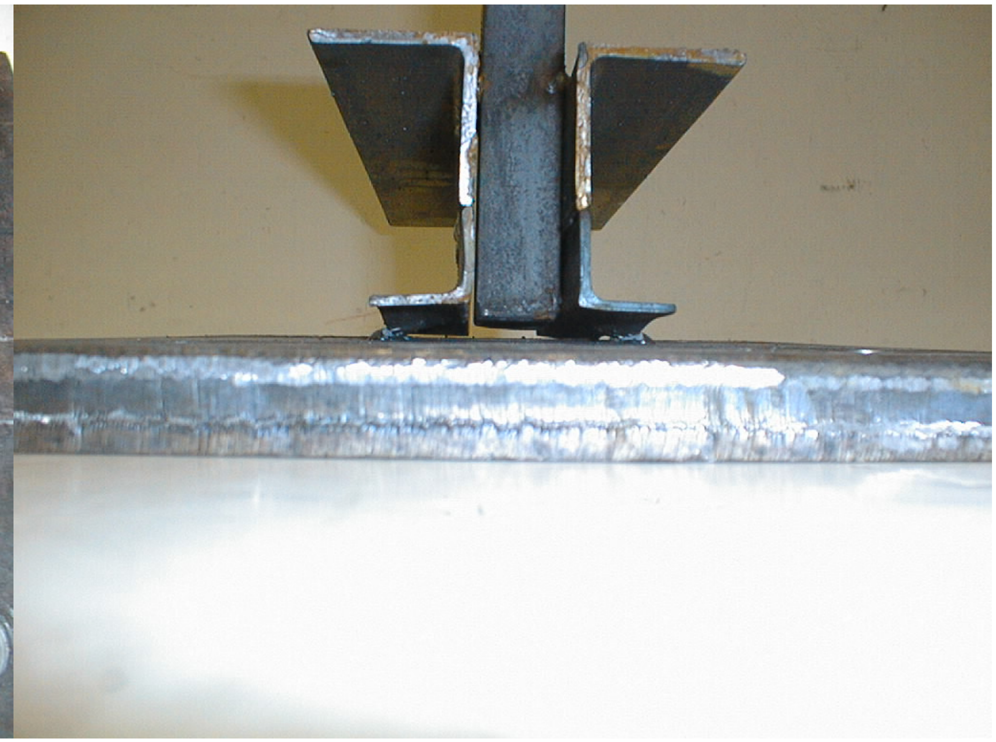
Welded Seat Testing



Failure Mechanism

Welded Seat Testing





Minimum End Anchorage

TABLE 5.7-1

JOIST SECTION NUMBER [1]	MINIMUM FILLET WELD	MINIMUM BEARING SEAT BOLTS FOR ERECTION
K1-12	2– 1/8" x 2 1/2" (3 x 64 mm)	2– 1/2" (13 mm) A307
LH02-06	2– 3/16" x 2 1/2" (5 x 64 mm)	
LH07-17, DLH10-17, JG	2– 1/4" x 2 1/2" (6 x 64 mm)	2– 3/4" (19 mm) A307
LH/ DLH18-25, JG[2]	2– 1/4" x 4" (6 x 102 mm)	2– 3/4" (19 mm) A325

(1) Last digit(s) of joist designation shown in load table.

(2) Joist Girders with a self weight greater than 50 plf (0.73 kN/m).

Bolted End Anchorage

- Final welding is typical for stability (lateral support)
- Only bolts are considered anchorage for uplift
  - Type and diameter by **specifying professional**
  - Provide sufficient tensile strength for uplift reaction
  - Higher strength than minimums per SJI may be required

Bolted Connection Design for Uplift

- The bearing seat design is a check of prying action
  - AISC design procedure is followed
  - An uplift reaction equal to the full tensile capacity of the bolts may not be achieved with maximum practical seat thicknesses and without stiffeners.

Typical Prying Action Capacity

Connection Type to Supporting Member	LRFD Strength Kips	ASD Strength Kips
(2) ½" A307 bolts (1/4" thick steel)	10.5	7.0
(2) ½" A325 bolts (1/4" thick steel)	10.5	7.0
(2) ¾" A307 bolts (1/2" thick steel)	26.4	17.6
(2) ¾" A325 bolts (1/2" thick steel)	36.0	24.0
(2) 1" A325 bolts (1" thick steel)	106.0	70.7

Typical Prying Action Capacity

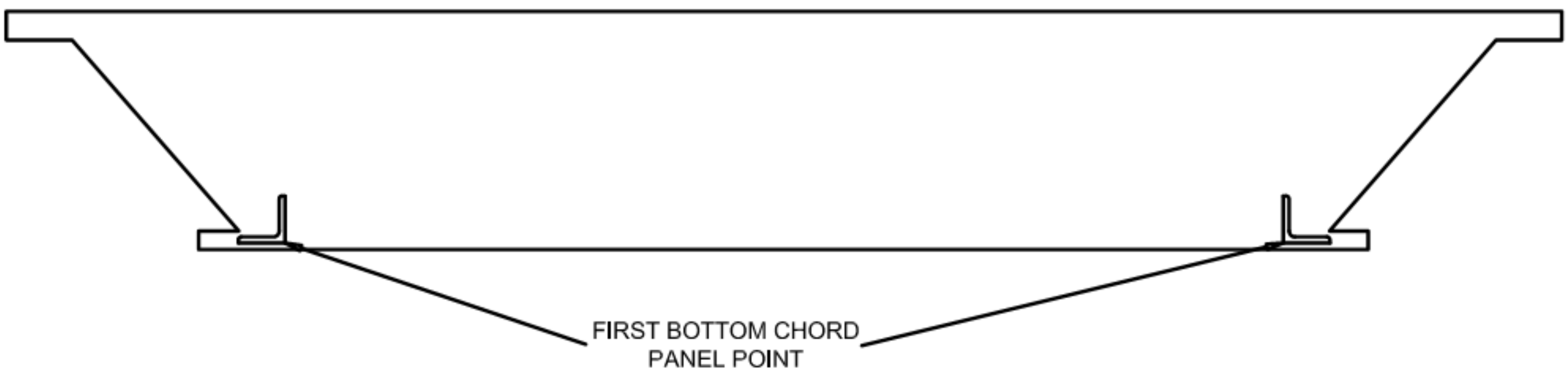
- Capacities on the prior slide were between 51 % and 100 % of the full tensile bolt strength, depending on the thickness of the bearing seat leg.
- A rule of thumb would be to size the bolt diameter, grade, and quantity of bolts based upon using 75 % of the full tensile strength.

End Anchorage

- For more on End Anchorage and joist design for uplift, refer to the Steel Joist Institute Technical Digest #6, *Design of Steel Joist Roofs to Resist Uplift Loads*

Bottom Chord Bridging for Uplift

Bottom Chord Bridging for Uplift

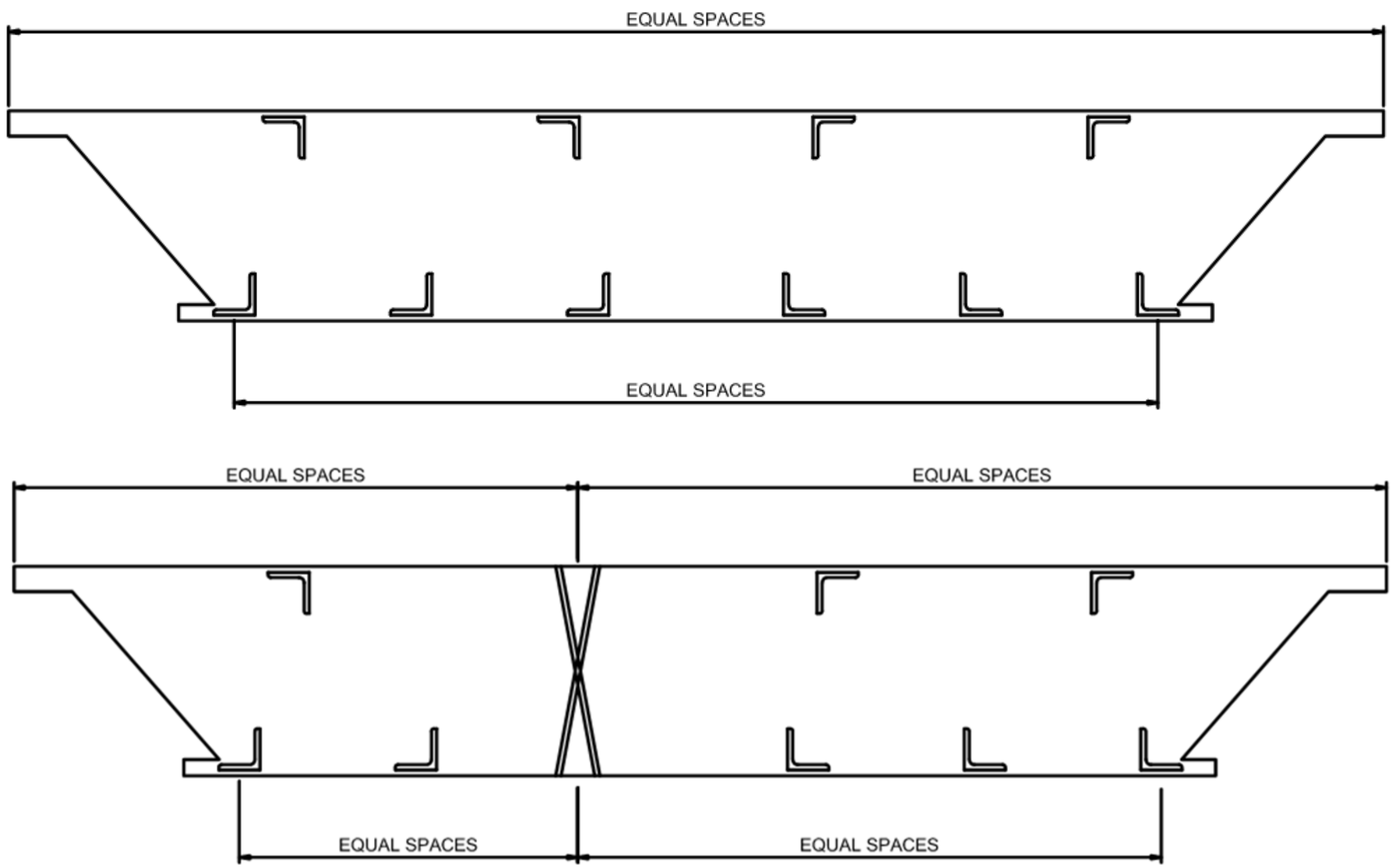


Bottom Chord Bridging for Uplift

- SJI Standard Specifications, Uplift Bridging
  - Bottom chord bridging need not align with top chord bridging
  - Total number of bottom chord rows shall not be less than the number of top chord rows
  - Can be advantageous to space rows more closely near center of span
  - Commonly equal spacing on bottom chord

Bottom Chord Bridging Spacing

- Typical details used – equally space between first bottom chord panel points



Bottom Chord Bridging for Uplift

- Bridging Load Requirements
  - Bridging axial load is based on bottom chord compressive axial load
    - $P_{br} = 0.005\ P_c$
    - Where P_c is the bottom chord compressive axial load
  - Bridging design force for number of joists, n, does not accumulate linearly
  - Randomness of initial lateral out-of-straightness

Bottom Chord Bridging for Uplift

- Bridging Load Requirements
  - The following equation can be used for the bridging force:
    - $P_{br} = 0.001\, n\, P_c + 0.004\, P_c \sqrt{n}$
    - P_c is the bottom chord compressive axial load
  - For small to moderate net uplift and reasonable number of joists, n, P_{br} at bottom chord is no larger than at top chord
  - For more severe uplift, P_{br} at bottom chord can be computed and may determine bridging size, or require a limit on the value of n.

Polling Question #2

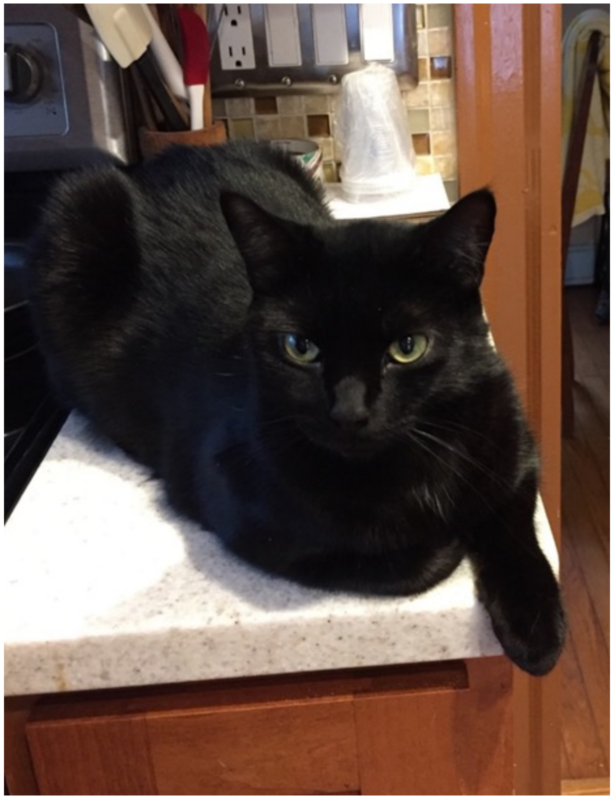
When erection bolts are required, they are also considered for uplift anchorage.

A. True

B. False

Talking 'bout Deck

Mickey
Official Spokes-Cat of
the
Steel Deck Institute



What Wind Pressure Should Be Used for Deck Design?

Technical Note - No. 1

C&C OR MWFRS PRESSURES FOR STEEL ROOF DECK DESIGN:
CLARIFICATION FOR THE ENGINEER OF RECORD:

What Wind Pressure Should Be Used for Deck Design?

Roof deck performs 2 functions:

As Roof SHEATHING, carrying gravity and wind uplift (or downward) loads

As a DIAPHRAGM, transferring lateral loads into the Lateral Force Resisting System

What Wind Pressure Should Be Used for Deck Design?

ASCE 7

C26.2 DEFINITIONS: COMPONENTS AND CLADDING:

… Cladding receives wind loads directly. Examples of components include fasteners, … **roof decking** … Components can be part of the MWFRS when they act as … roof diaphragms, but they may also be loaded as individual components.

What Wind Pressure Should Be Used for Deck Design?

ASCE 7

C26.2 DEFINITIONS: MAIN WIND-FORCE RESISTING SYSTEM (MWFRS)

Can consist of … an assemblage of structural elements that work together to transfer wind loads acting on the entire structure to the ground. Structural elements such as … **roof diaphragms** are part of the Main Wind-Force Resisting System (MWFRS) …

What Wind Pressure Should Be Used for Deck Design?

ROOF DECK AS SHEATHING

Roof Dead, Roof Live, and C&C Wind Pressures (uplift or downward)

ROOF DECK AS DIAPHRAGM

Roof Dead, Roof Live, and MWFRS Wind Pressures (uplift or downward) and MWFRS Wind Diaphragm Shear

Resource for Roof Deck

Uplift Resistance of Roof Deck

TABLE 2.2
1.5 WR ASD Superimposed Uniform Upward Loads (psf)

Span Cond.	Gage Number	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"
Single	22	116	96	81	69	60	53
	20	145	120	101	86	75	65
	18	191	158	133	114	99	86
	16	242	201	169	145	125	110
Double	22	111	92	77	66	57	50
	20	137	114	96	82	71	62
	18	186	154	130	111	96	84
	16	237	197	166	142	123	107
Triple	22	138	114	96	82	71	62
	20	171	142	120	102	88	77
	18	232	192	162	138	120	104
	16	296	245	206	176	152	133

Span Cond.	Gage Number	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"
Single	22	46	41	37	33	30	28
	20	58	51	46	41	38	34
	18	76	68	61	55	50	45
	16	97	86	77	70	63	58
Double	22	44	39	35	32	29	26
	20	55	49	44	40	36	33
	18	74	66	59	53	48	44
	16	95	84	75	68	62	56
Triple	22	55	49	44	39	36	33
	20	68	61	54	49	44	40
	18	92	82	73	66	60	55
	16	117	104	93	84	76	70

Span Cond.	Gage Number	1'-6"	2'-0"	2'-6"	3'-0"	3'-6"	4'-0"
Cantilever	22	305	172	111	77	57	44
	20	378	214	137	96	71	55
	18	512	289	186	130	96	74
	16	653	369	237	166	123	95

TABLE 3.2
3 DR ASD Superimposed Uniform Upward Loads (psf)

Span Cond.	Gage Number	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"
Single	22	65	59	54	50	46	42
	20	83	75	69	63	58	54
	18	113	103	94	86	80	74
	16	146	133	121	111	102	95
Double	22	58	53	48	44	41	38
	20	76	69	63	58	53	49
	18	105	96	87	80	74	68
	16	139	126	115	106	97	90
Triple	22	72	66	60	55	51	47
	20	95	86	79	72	66	61
	18	131	119	109	100	92	85
	16	172	157	143	131	121	111

Span Cond.	Gage Number	13'-0"	13'-6"	14'-0"	14'-6"	15'-0"	15'-6"
Single	22	39	36	34	32	30	28
	20	50	46	43	40	38	36
	18	68	63	59	55	52	49
	16	88	82	76	71	67	63
Double	22	35	33	30	28	27	25
	20	46	43	40	37	35	33
	18	63	59	55	51	48	45
	16	83	77	72	68	63	60
Triple	22	43	40	38	35	33	31
	20	57	53	49	46	43	41
	18	79	73	68	64	60	56
	16	103	96	90	84	78	74

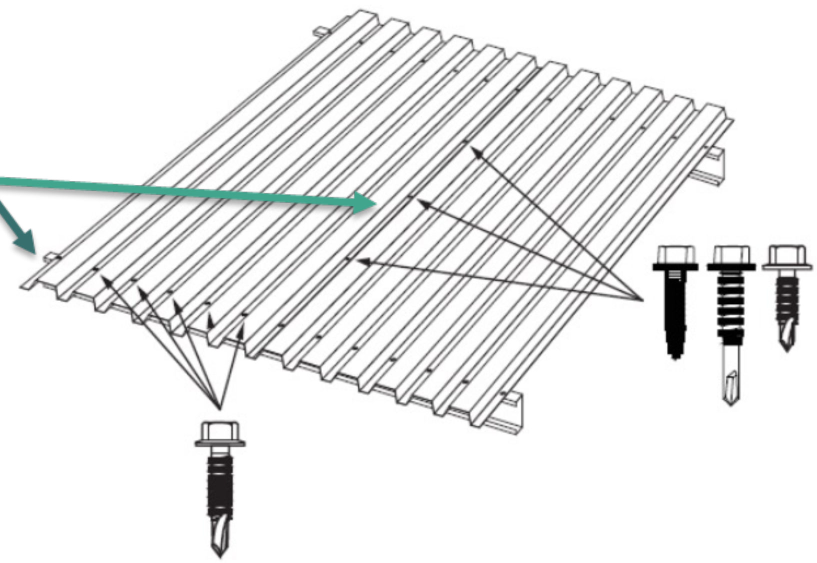
Span Cond.	Gage Number	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"
Cantilever	22	71	58	48	41	35	30
	20	93	76	63	53	46	40
	18	129	105	87	74	63	55
	16	170	139	115	97	83	72

What Fasteners are Used to Attach Deck?

By Position / Function:

(1) Support attachment

(2) Side-lap fastening

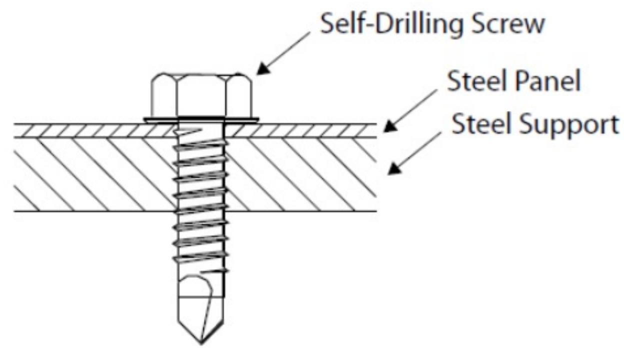


Methods:

(1) Welding

(2) Mechanical (various flavors)

Self-Drilling Screw



Screws are both proprietary and generic

Generally #12 or #14 screw, with drill point per support thickness

Self-Drilling Screw - Tension

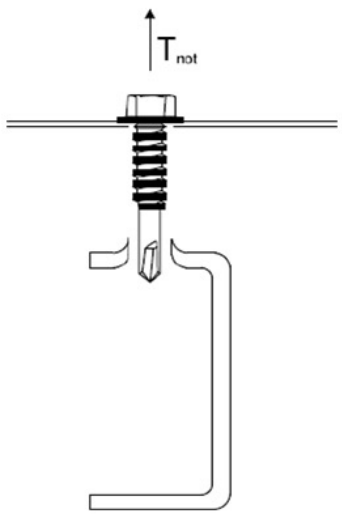
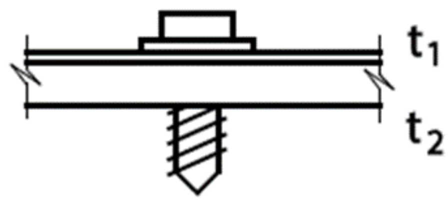


Figure 4.7 – Screw Pull-Out



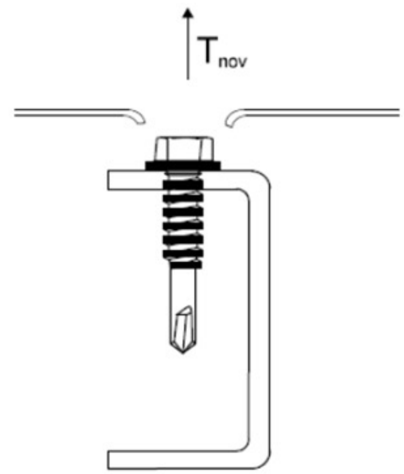


Figure 4.8 – Screw Pull-Over

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

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

$$\Omega = 3.00 \quad (ASD)$$

Self-Drilling Screw - Tension

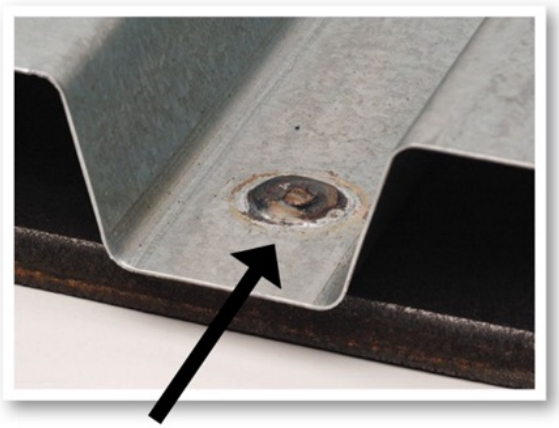
TABLE 8.2
Screw Pull-Out Strength (lbs) (F_u = 50 ksi)

	Pull-Out - lbs (ASD) Ω = 3.00									
Base Sheet Steel Gage	**1/4"**	**3/16"**	**10**	**1/8"**	**12**	**14**	**16**	**18**	**20**	**22**
Steel Thickness (inches)	**0.2500**	**0.1875**	**0.1345**	**0.1250**	**0.1046**	**0.0747**	**0.0598**	**0.0474**	**0.0358**	**0.0295**
#10	673	505	362	336	282	201	161	128	96	79
#12	765	574	412	383	320	229	183	145	110	90
#14	850	638	457	425	356	254	203	161	122	100
1/4"	885	664	476	443	370	265	212	168	127	104

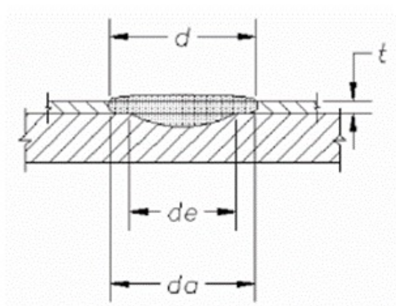
TABLE 8.3
Screw Pull-Over Strength (lbs)

Top Sheet Steel Gage	**16**	**18**	**20**	**22**	**24**	**26**	**28**
Steel Thickness (inches)	**0.0598**	**0.0474**	**0.0358**	**0.0295**	**0.0238**	**0.0179**	**0.0149**
Steel F_u (ksi)	**50**	**50**	**50**	**50**	**62**	**62**	**62**
Screw Washer or Head d_w	**Pull-Over - lbs (ASD) Ω = 3.00**						
0.400”	598	474	358	295	295	222	185
0.415”	620	492	371	306	306	230	192
0.430”	643	510	385	317	317	239	199
0.480”	718	569	430	354	354	266	222
0.500”	748	593	448	369	369	277	231

Arc Spot Weld- Tension



Arc Spot (Puddle) Weld



16 ga. Weld washer required for deck thinner than 0.028”
(23 gage and thinner)

$$P_n = \frac{\pi d_e^{\,2}}{4} F_{xx}$$

Pull-over

$$P_n = 0.8(F_u/F_y)^2 t d_a F_u$$

Arc Spot Weld- Tension

Table 7 – Arc Spot Weld Data

TABLE 7.1
Arc Spot Weld Uplift Capacity (lbs)

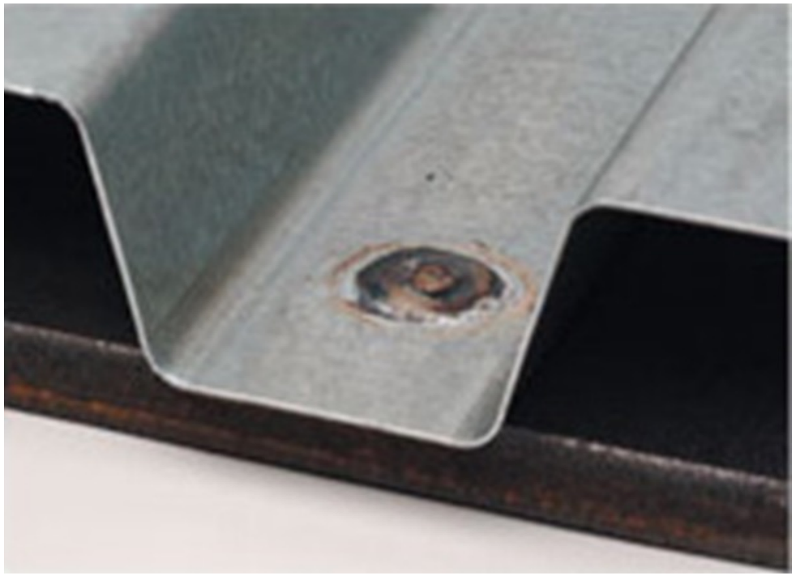
			ASD (lbs) Ω = 2.50			
Case	**Gage Number**	**Design Thickness (inches)**	**Visible Weld Diameter (Inches)**			
			1/2	**5/8**	**3/4**	**1**
1	22	0.0295	347	439	531	716
	20	0.0358	415	527	639	863
	18	0.0474	536	684	833	1129
	16	0.0598	658	845	1032	1406
2	22	0.0295	650	835	1019	1388
	20	0.0358	767	991	1214	1500
	18	0.0474	814	1257	1500	1500
	16	0.0598	549	1256	1500	1500
3	22	0.0295	243	307	372	501
	20	0.0358	291	369	447	604
	18	0.0474	375	479	583	790
	16	0.0598	461	591	722	984

CASE 1
Weld through single sheet thickness

CASE 2
Weld through double sheet thickness

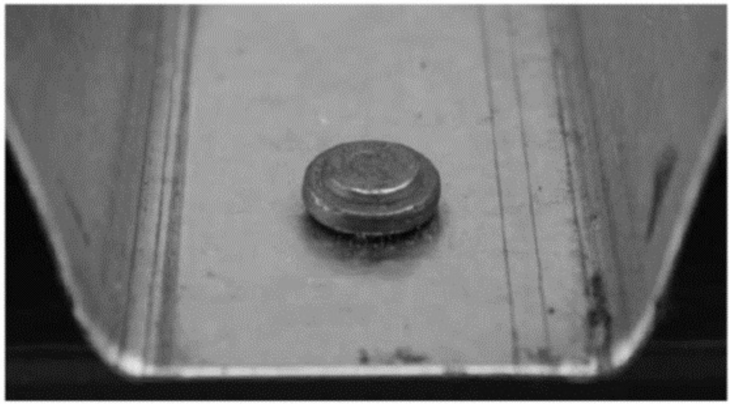
CASE 3
Weld at edge of sheet sidelap

Arc Spot Weld- Quality (or lack thereof)

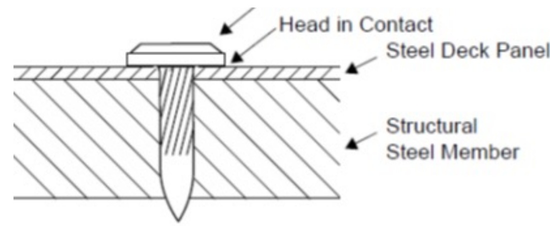


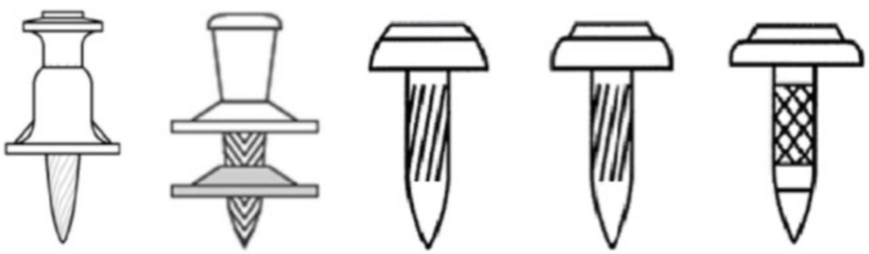
Production rate … 8-15 seconds per weld (not 3 seconds)
Training of welders

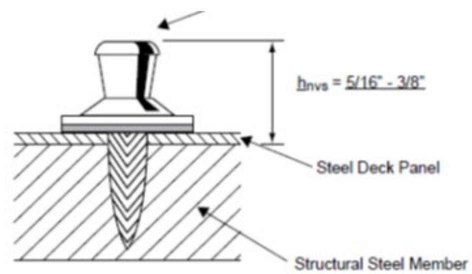
Power Actuated Fastener (PAF) - Tension



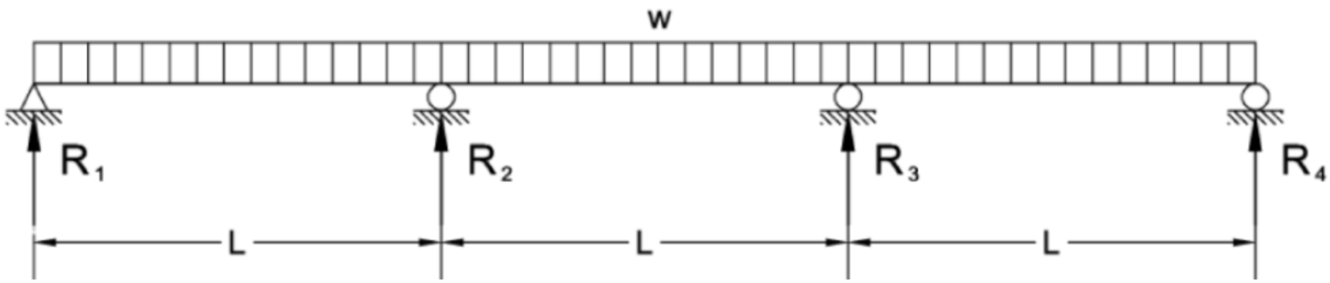
PAF's are proprietary







Beam Reactions or Tributary Area



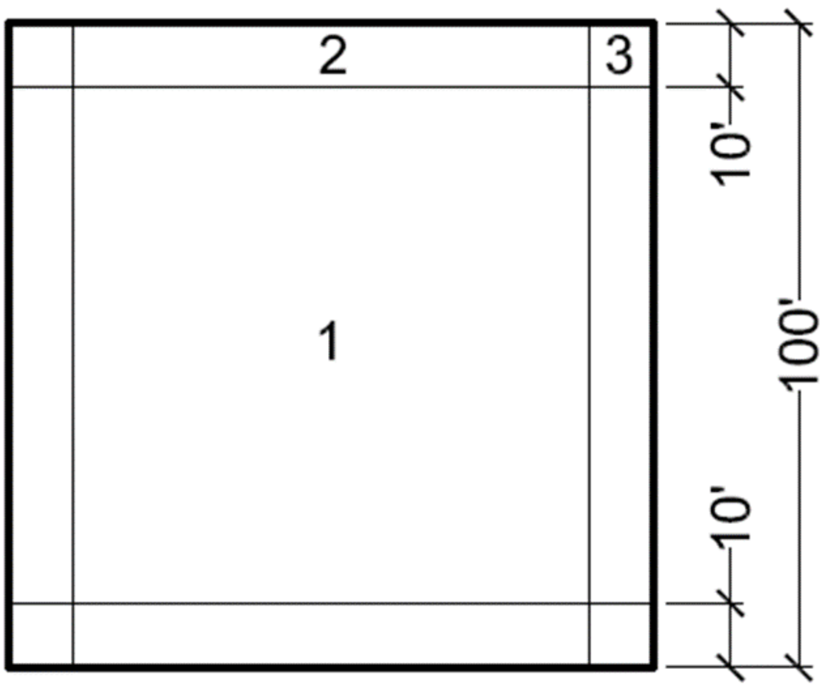
Beam Reactions	1.10 wL	0.40 wL
TA Reactions	1.00 wL	0.50 wL

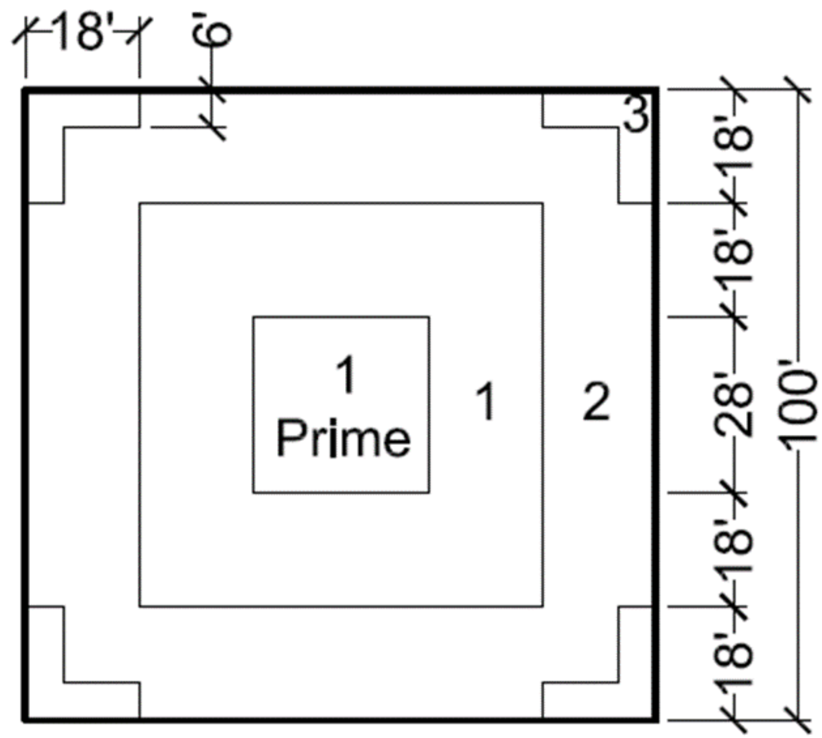
Lapped ends 0.80 wL / 1.00 wL

Zoning Attachment Patterns

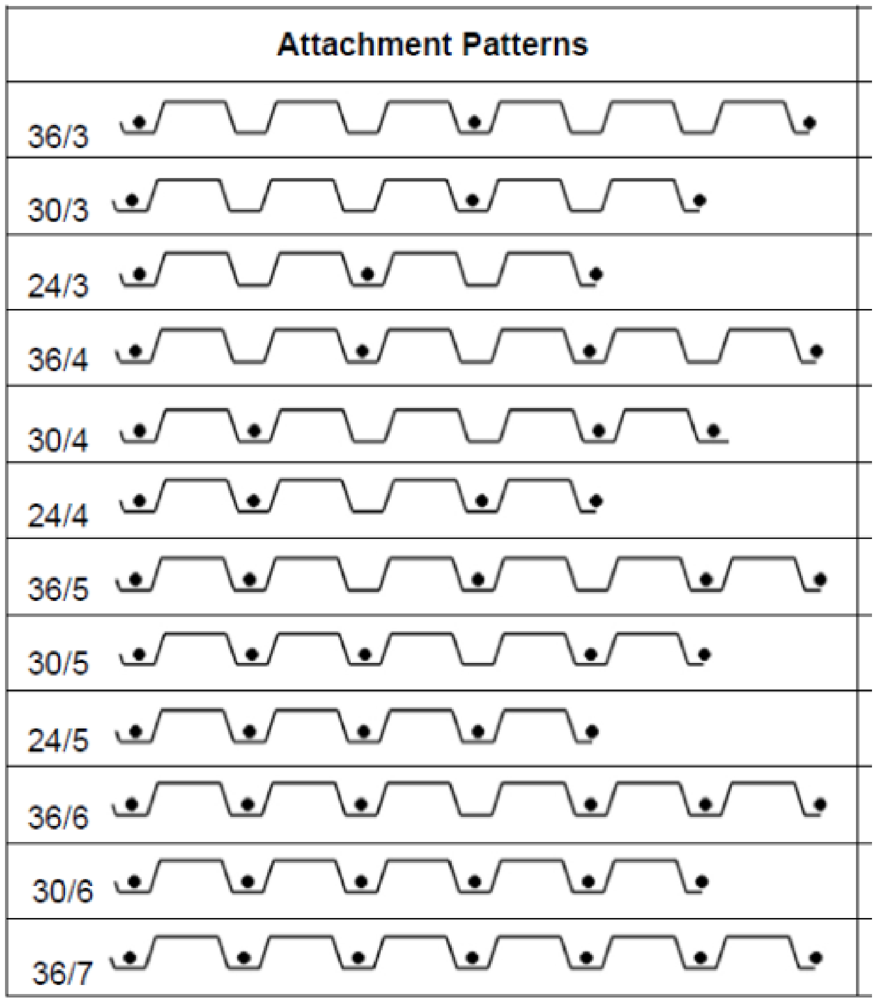
C&C Roof Zones

ASCE 7-10	ASCE 7-16 / 22





Zoning Attachment Patterns



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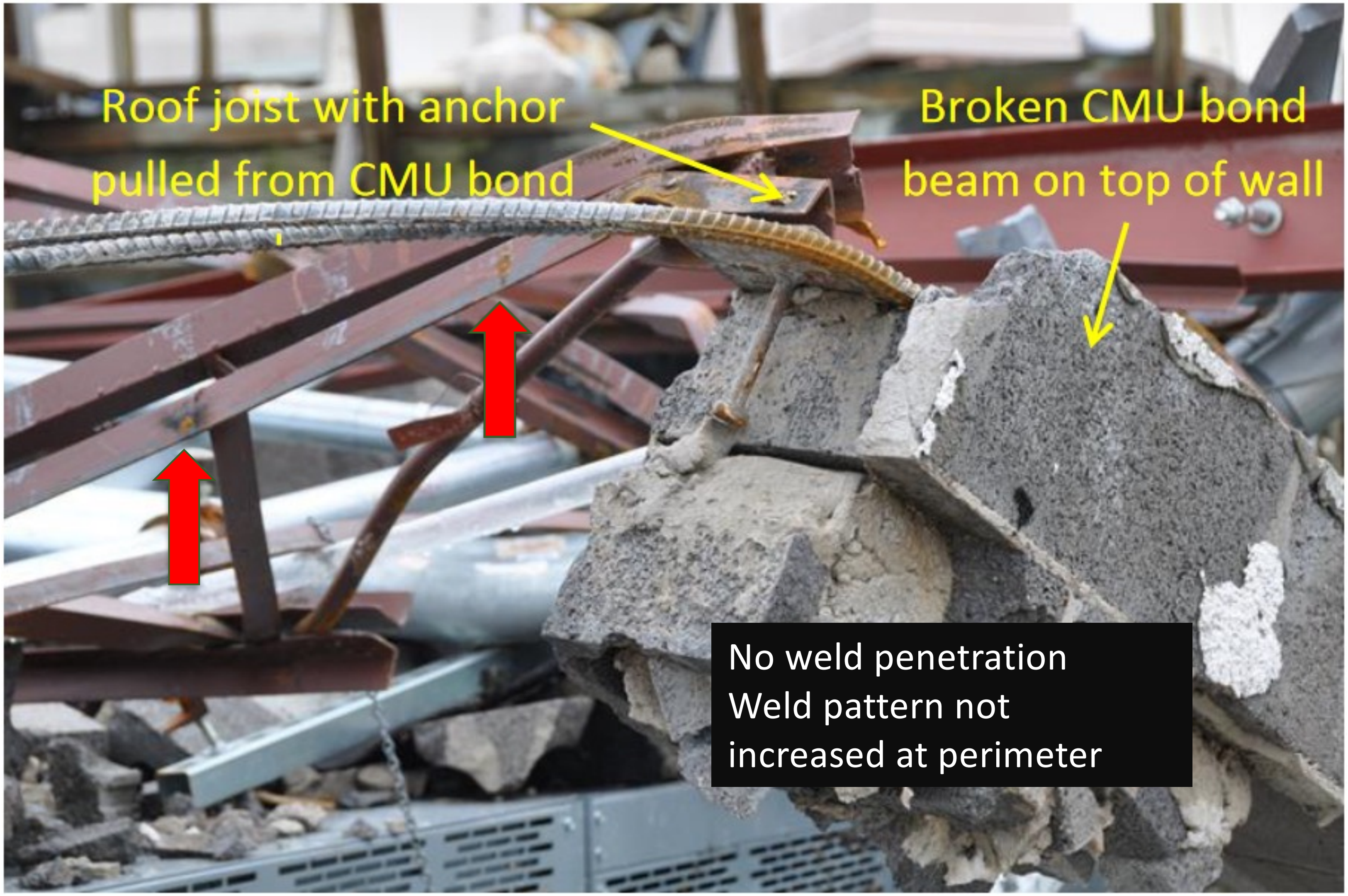

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  - Joist Girder Analysis Tool
  - Joist and Joist Girder Reinforcement Tool
  - Historical Load Tables
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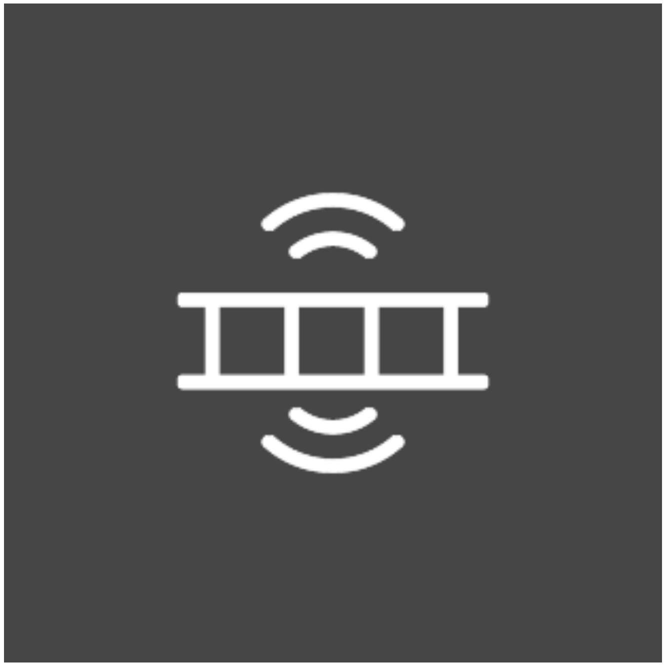
  - Floor Bay Analysis Tool w/ Vibration Analysis
  - Joist Girder Moment Connection Design Tools
  - Virtual Joists
  - Virtual Joist Girders
- Floor Vibration Analysis



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- #4 Guidance for Building Design Using Steel Joists
- #5 Vibration of Steel Joist – Concrete Floors
- #6 Design of Steel Joist Roofs to Resist Uplift Loads
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