Design Considerations for Standing Seam Metal Roofing Systems

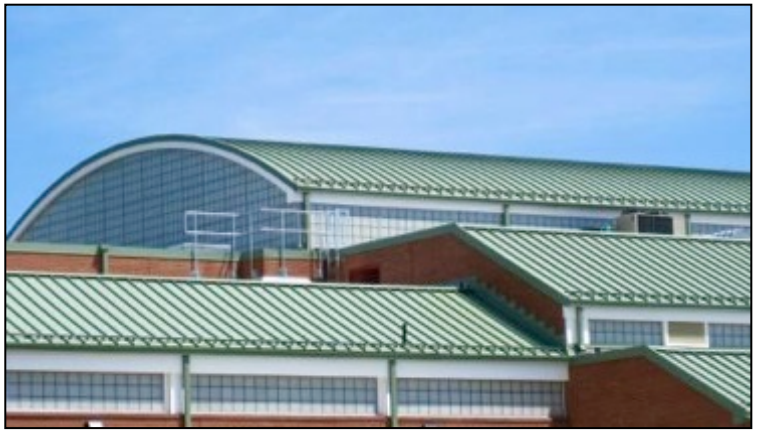
Program #04 SS

GARLAND
since 1895

CONTINUING EDUCATION
AIA

GARLAND OVERVIEW

- Building Envelope / Roofing manufacturer based in Cleveland Ohio.
- Founded in 1895
- 100% employee owned
- 6 to 1 asset to debt ratio
- 27 Subsidiary Companies, Full Building Envelope.



Design of Standing Seam Metal Roofing

- Environmental Design Factors
  - Wind
  - Temperature
  - Rain
  - Snow
  - Fire
- Aesthetics
  - Curving and Tapering Panels
- Metal Applications
  - Long Spans
  - Metal Retrofit Framing

The Risk of Improper Design...

Environmental Factors:
Wind

Wind

Wind

Wind Uplift Testing Required by Code

IBC 2009 1504.3.2 Metal Panel Roof Systems Through Fastened or Standing Seam Shall Be Tested in Accordance With UL 580 or ASTM E1592

- UL 580 is Antiquated
- **ASTM E 1592** Written Specifically for Standing Seam Roofing

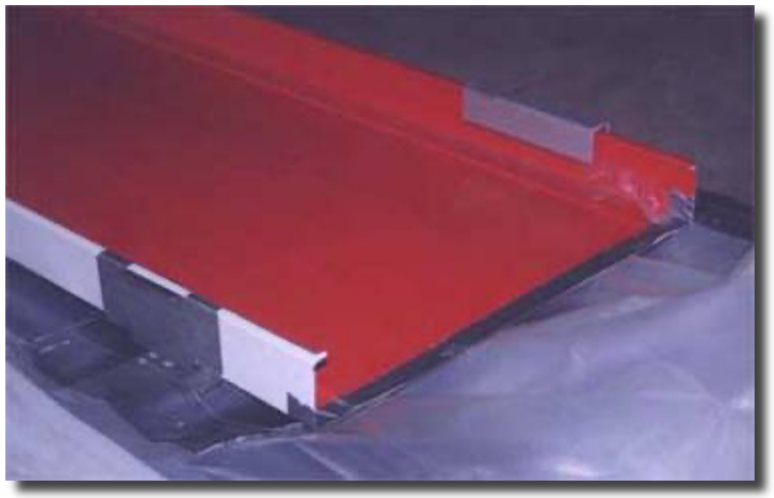
Wind

- **Failure of a Standing Seam Roof Over Open Purlins**

Wind

ASTM E 1592 Test Apparatus

Uses Actual Details



Manufacturer's Actual Rake Detail

Manufacturer's Actual Eave Detail

Wind

UL 580 Testing Apparatus

Wind

Wind Uplift Pressures

1504.1 Wind Resistance Of Roofs. Roof Decks and Roof Coverings Shall be Designed for Wind Loads in Accordance with Chapter 16.

1609.1.1 Determination Of Wind Loads. Wind Loads on Every Building or Structure Shall be Determined in Accordance with Chapter 6 of ASCE 7-16.

Wind

ASCE 7-16

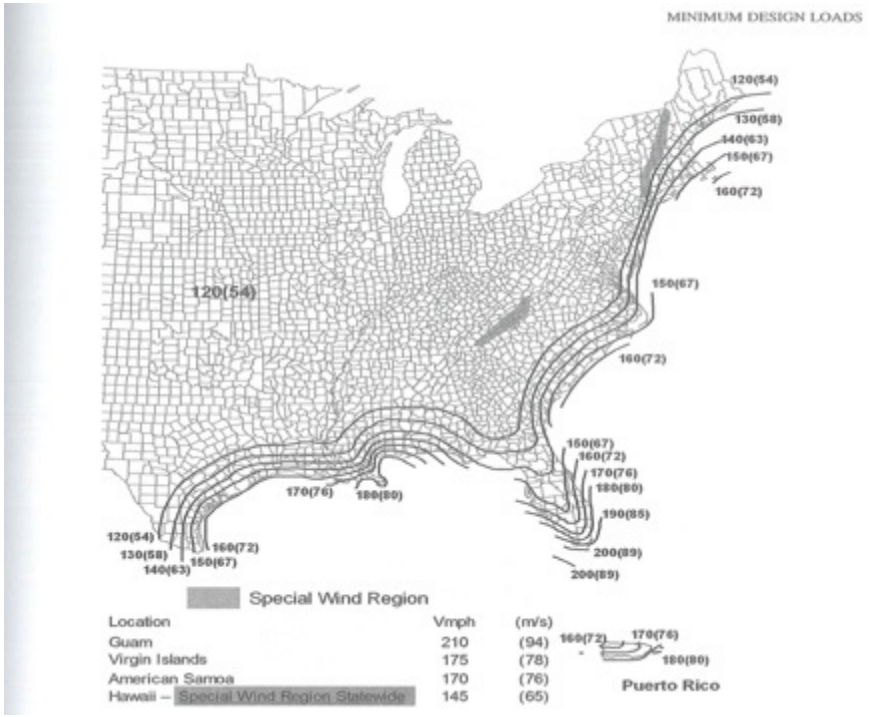
American Society of Civil Engineers 7-16

Minimum Design Loads for Buildings and Other Structures

Provides the Method for Determining the WIND UPLIFT PRESSURES a Building will Experience

Wind

ASCE 7-16 Provides a ***Service Level*** Design with a "Likely" Probability of Occurrence During the Useful Life of the Structure.

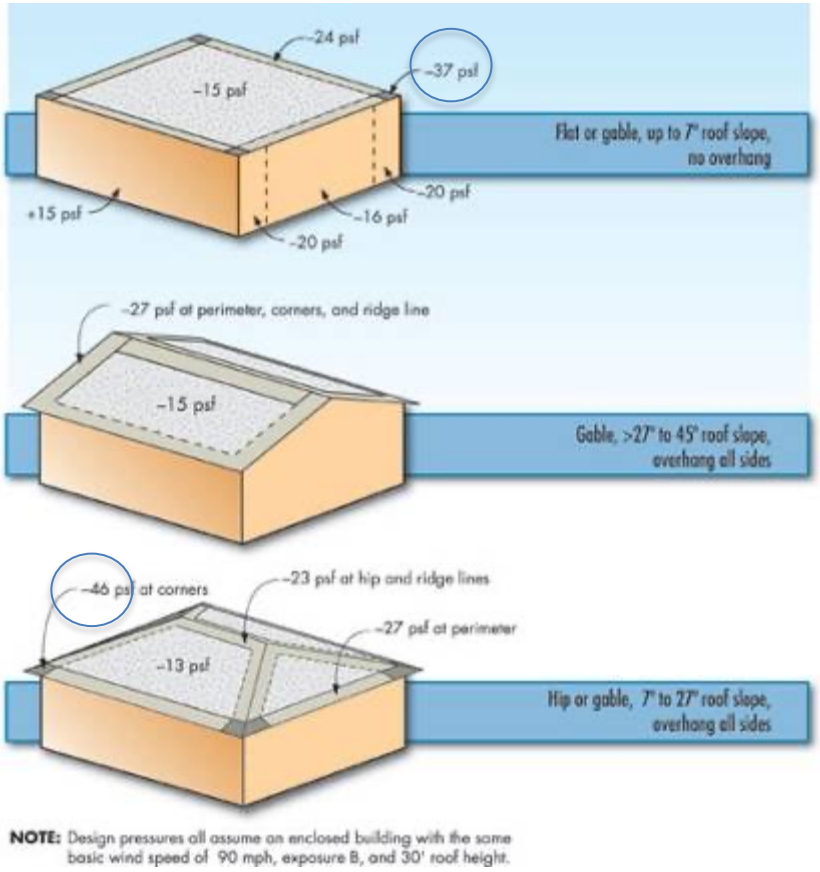


Wind

ASCE 7-16 Criteria for Determining Design Wind Loads

- Geographic Location
  - Determines Historical Maximum Wind Speed
- Mean Roof Height
  - Wind Speed Steadily Increases With Height
- Exposure Condition
  - City Centers and Suburbs Provide More Wind Shielding Than Open Fields or Coastal Locations
- Occupancy Classification
  - Some Occupancies, Such As Schools and Fire Departments, Are Considered More Important Than Others, Such as Agricultural Buildings or Single Family Homes
- Roof Pitch and Geometry
  - the Wind Reacts in Different Manner on a Low Sloped Roof Than on a Steep Roof
- Other Factors
  - Local Topography, Wall Openings, Parapets, and Other Criteria Can Also Play a Role in Determining Wind Loads on a Structure

Wind



ASCE 7-16 +

ASTM E 1592 =

Code Compliant Roof Design!

Wind

Sample Wind Uplift Calculation

PROJECT	High School
ROOF SECTION	Classrooms
DATE	9/7/2011
BASIC VELOCITY PRESSURE	18.28 psf
DESIGN CODE	ASCE 7-05

Panel & Fastener Data

PANEL TYPE	R-MER Span
PANEL WIDTH	18 in
PANEL/CAP MATERIAL	24/24 GA Steel
SUBSTRATE MATERIAL	Steel
SUBSTRATE THICKNESS	22 gauge
FASTENER TYPE	Wood: Concealor #14-13 DP1
FASTENERS PER CLIP	2
FASTENER SAFETY FACTOR	3
CLIP PRY COEFFICIENT	1.65
ULTIMATE FASTENER PULLOUT	1200 lbs/screw
ALLOWABLE CLIP LOAD	485 lbs/clip
PANEL SAFETY FACTOR	1.65

Building & Site Data

BASIC WIND SPEED	90	mph
EXPOSURE CATEGORY	C	
TOPOGRAPHY FACTOR	1.00	
BUILDING TYPE	Enclosed	
ROOF PITCH (X, Y)	2	12
RUN TO RIDGE	50	
EAVE HEIGHT	20	
DESIGN ROOF HEIGHT	20.00	ft
IMPORTANCE CLASS / FACTOR	III	1.15
MIN. BLDG WIDTH	100	ft
WIND-BORNE DEBRIS REGION	No	
PARAPET	No	
ROOF ANGLE	9.46	deg
PROTECTED OPENINGS	No	
ROOF TYPE	Gable	
EXTREME THERMAL RANGE	200	deg F

	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5		
ROOF PRESSURE (psf)	19.7	34.4	50.8	21.4	26.3		
OVERHANG PRESSURE (psf)	16.45	40.22	67.64				
PANEL SPAN (ft)	6.00	5.95	4.62	6.00	6.00	N/A	N/A
FASTENER SPAN (ft)	16.37	9.41	6.36	15.11	12.28		
FM RATING (FMRC 4471)							
EDGE ZONE WIDTH "a" =	8.00	ft					

Wind

Proper Clip Spacing Installed

Wind

Other Wind Resistance Design Criteria

Local Building Code Requirements:

- Miami Dade Notice of Acceptance (NOA)
- Florida Building Code Product Acceptance Criteria
- California DSA Form IR-5 Product Acceptance Requirements
- Texas TWIA Requirements for Coastal Counties

  Storm Shelter Design Requirements
- FEMA 361 and ICC Storm Shelter Design Requirements

Environmental Factors:
Temperature

Temperature

Oil Canning Panels as a Result of Thermal Movement

Temperature

Thermal Expansion and Contraction

THERMAL EXPANSION CHART

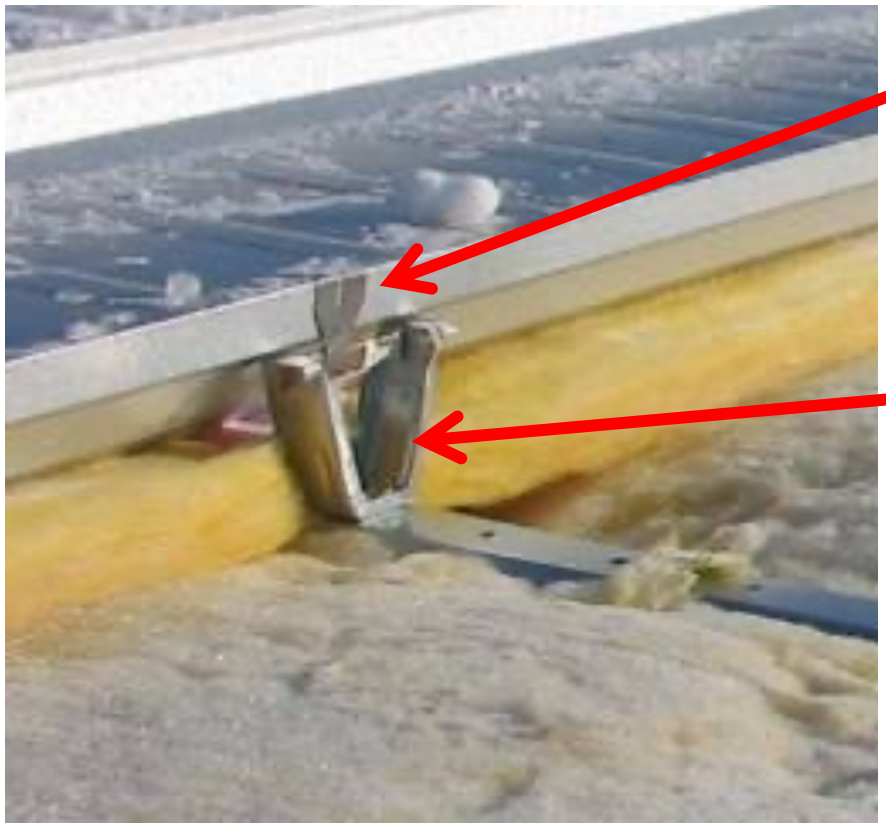
Chart shows panel movement in inches based on 180 Degree F. Temperature Differential

MATERIAL	FACTOR	PANEL LENGTH FROM FIXED POINT (IN FEET)														
		10	20	30	40	50	60	70	80	90	100	120	140	160	180	200
G-90 GAL. STEEL	0.0000067	0.14	0.29	0.43	0.58	0.72	0.87	1.01	1.16	1.30	1.45	1.74	2.03	2.32	2.60	2.89
ALUMINUM	0.0000129	0.28	0.56	0.84	1.11	1.39	1.67	1.95	2.23	2.51	2.79	3.34	3.90	4.46	5.02	5.57
COPPER	0.0000094	0.20	0.41	0.61	0.81	1.02	1.22	1.42	1.62	1.83	2.03	2.44	2.84	3.25	3.65	4.06
ZINC	0.00001222	0.26	0.53	0.79	1.06	1.32	1.58	1.85	2.11	2.38	2.64	3.17	3.70	4.22	4.75	5.28
STAINLESS STEEL	0.0000096	0.21	0.41	0.62	0.83	1.04	1.24	1.45	1.66	1.87	2.07	2.49	2.90	3.32	3.73	4.15

Note: The expansion factor is in inches per inch per degree F.

Temperature

2 Piece Clips Limit Thermal Movement



Top Piece Only Moves 1” to Either Side.

Bottom Piece Anchored to Frame

Installation at Higher Slopes Can Result in No Movement At All!

Temperature

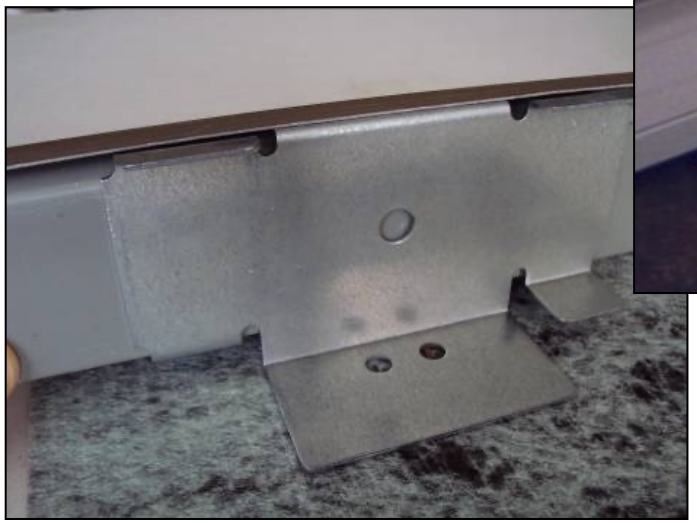
Limited Thermal Movement

Binding of the Panel at a Clip Location

Temperature

Unlimited Thermal Movement

One Piece Clip Allows
Panel to Move Freely

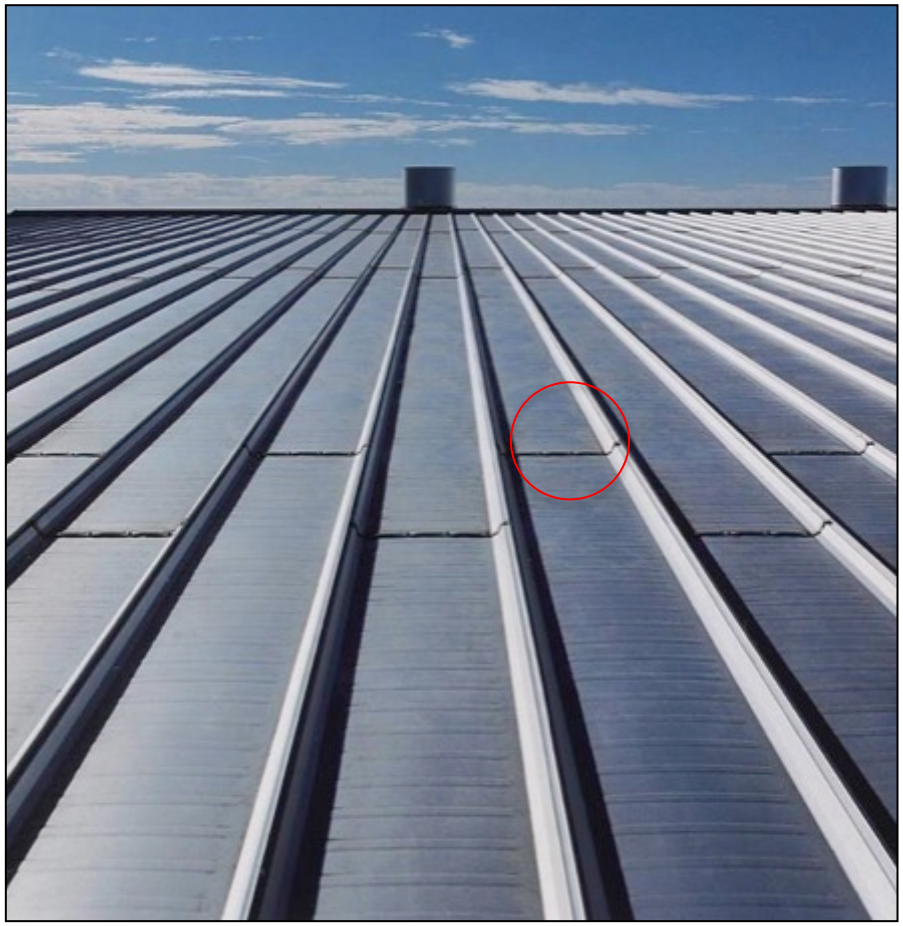


Environmental Factors:
Rain

Rain

How Can a Metal Roof Leak?

Rain



Rain

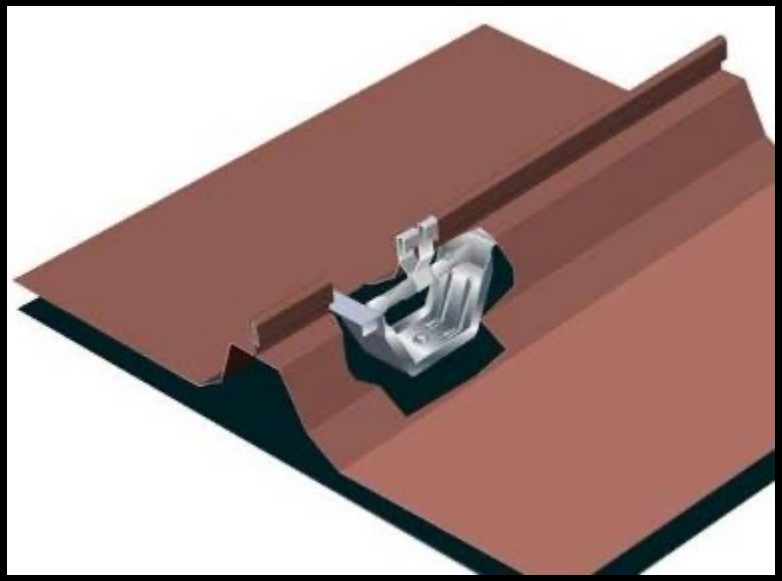
Building Code: Slope

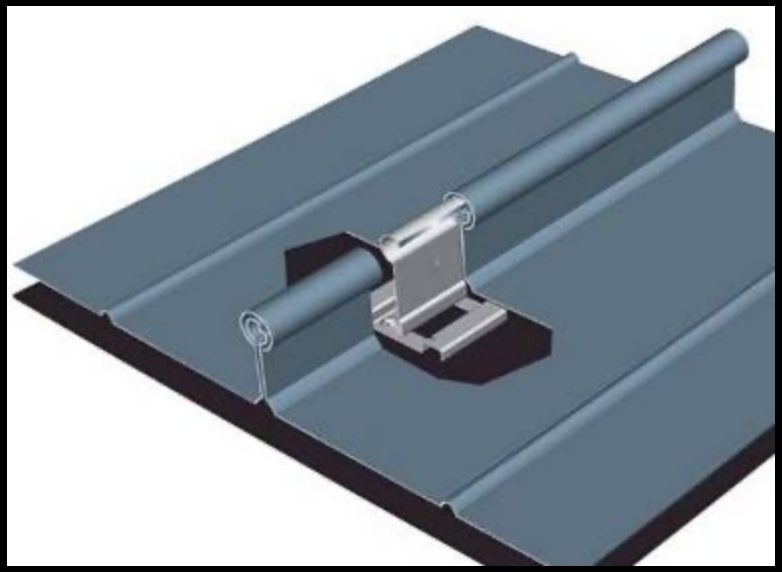
1507.4.2 Deck Slope. Minimum Slopes for Metal Roof Panels Shall Comply with the Following:

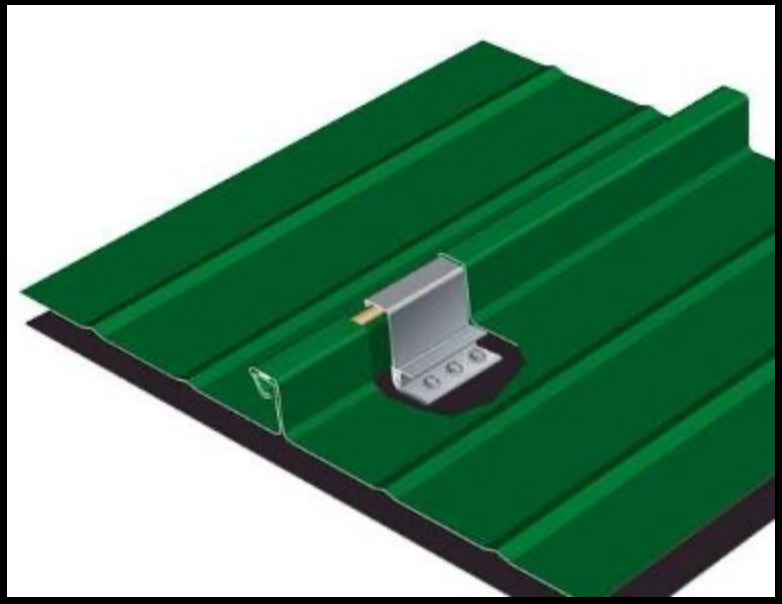
3. The **Minimum Slope** for Standing Seam of Roof Systems Shall be One-quarter Unit Vertical in 12 Units Horizontal (**1/4:12** Or 2-percent Slope).

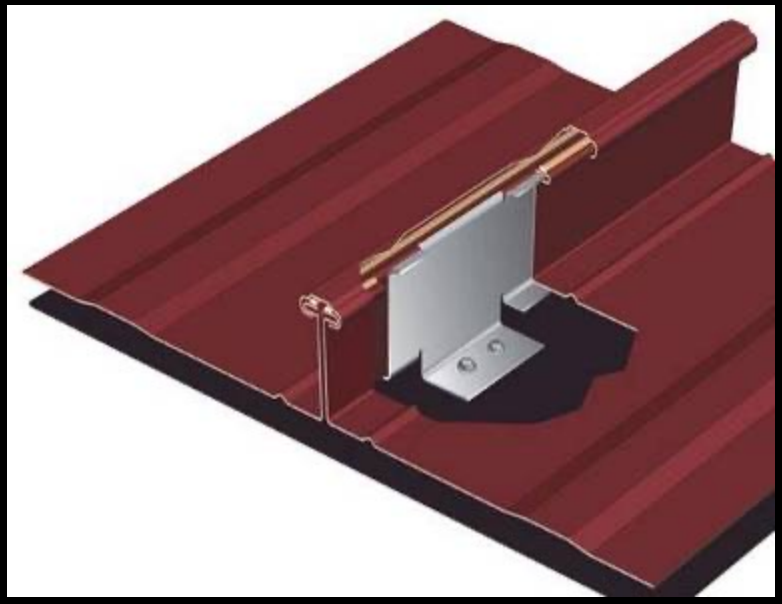
All Metal Roof Systems are not Created Equal

Significant Differences Exist in the Clip, Seam, and Panel Design









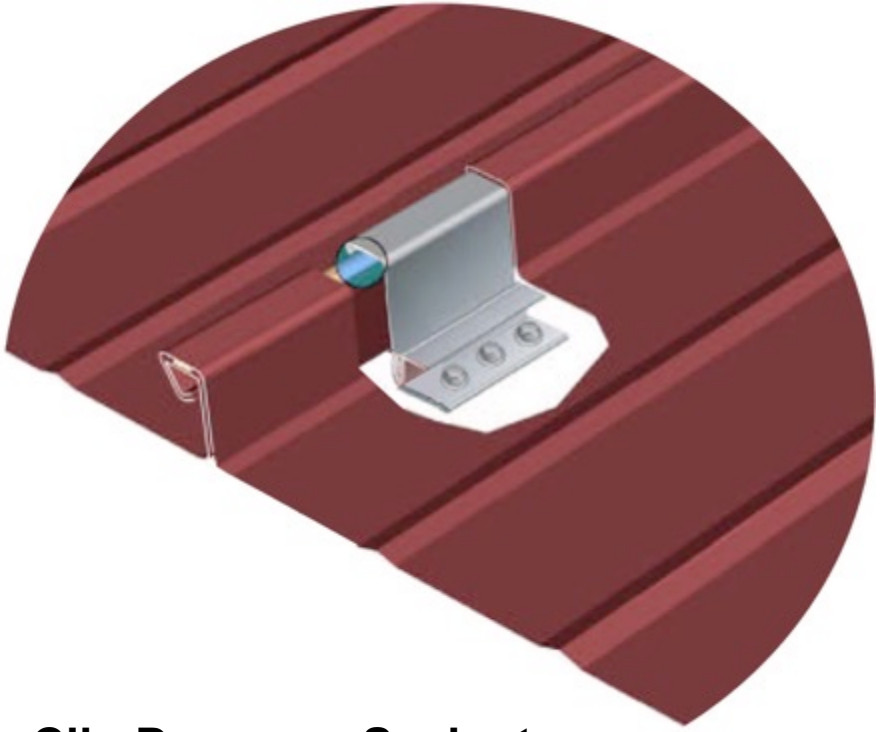
Rain

Important Design Criteria

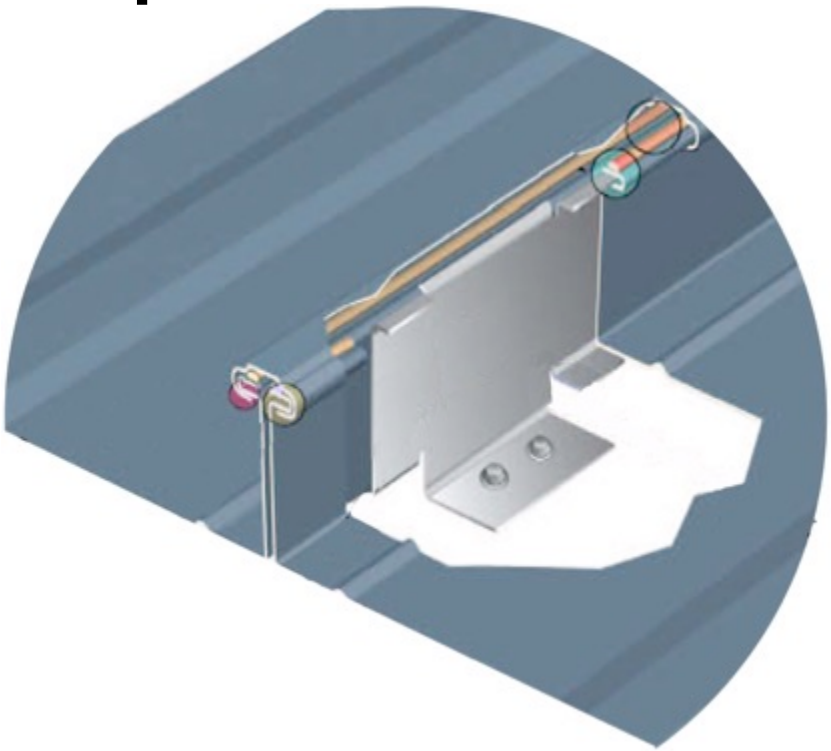
- Isolation of Seam Sealant from Clip
- Avoid Lap Seams and Through Fasteners
- Proper Detailing
- Product Testing

Rain

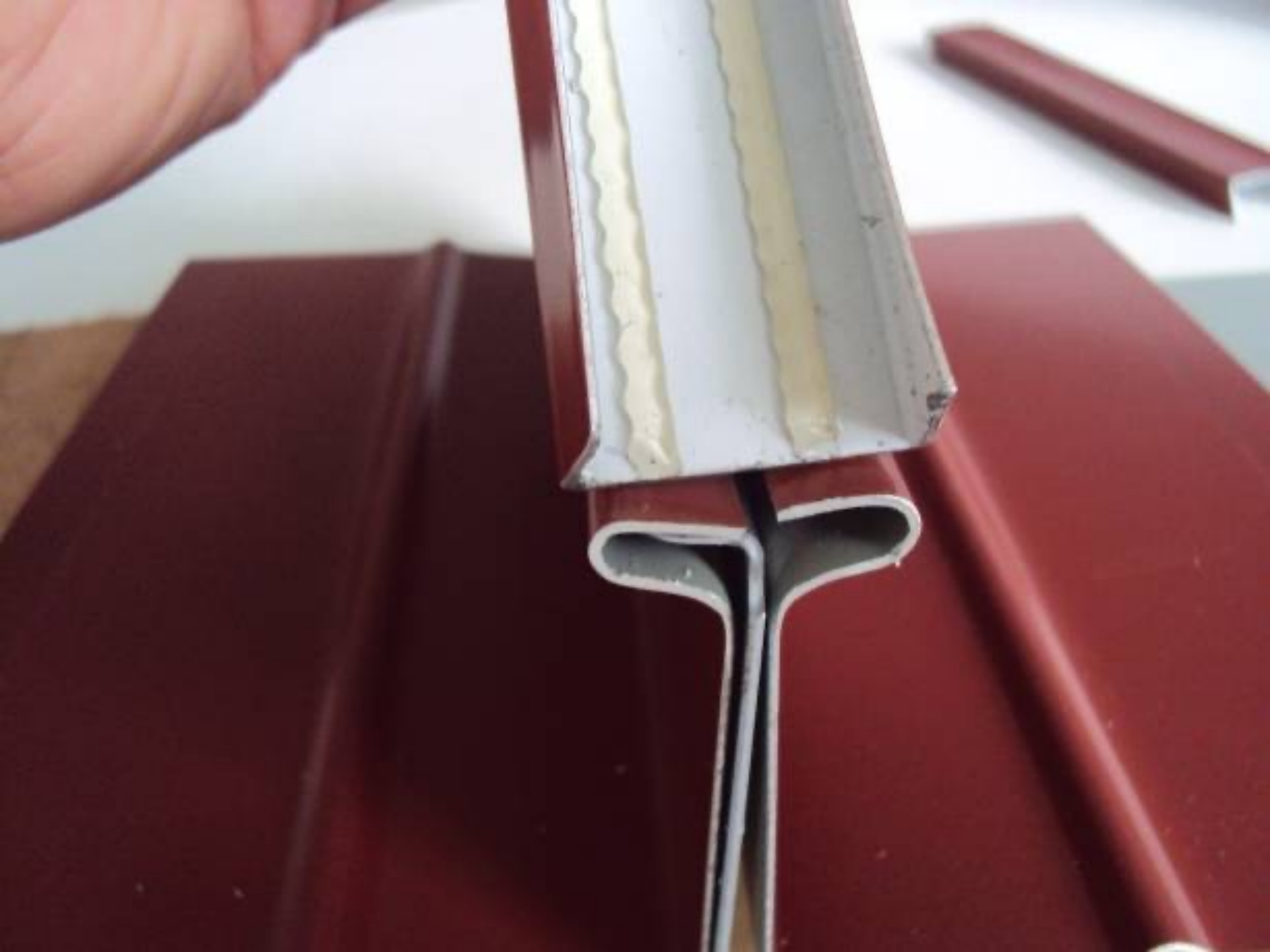
Isolation of Sealant From Clip



Clip Damages Sealant



Proper Isolation of Sealant

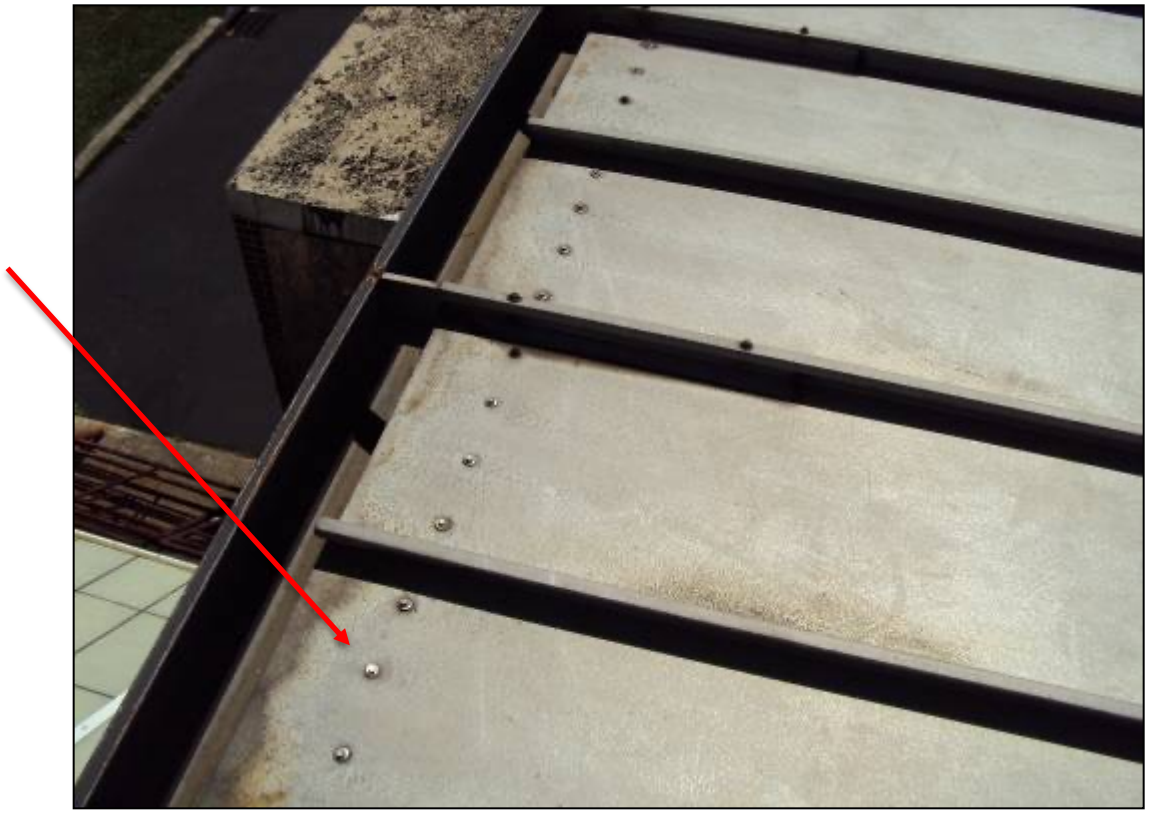


Rain

Avoid Seam Laps

Rain

Avoid Through Fasteners



Rain

Poor Detailing

Failure of
Foam Closure

Rain

Poor Detailing

Failure of
Head Closure

Rain

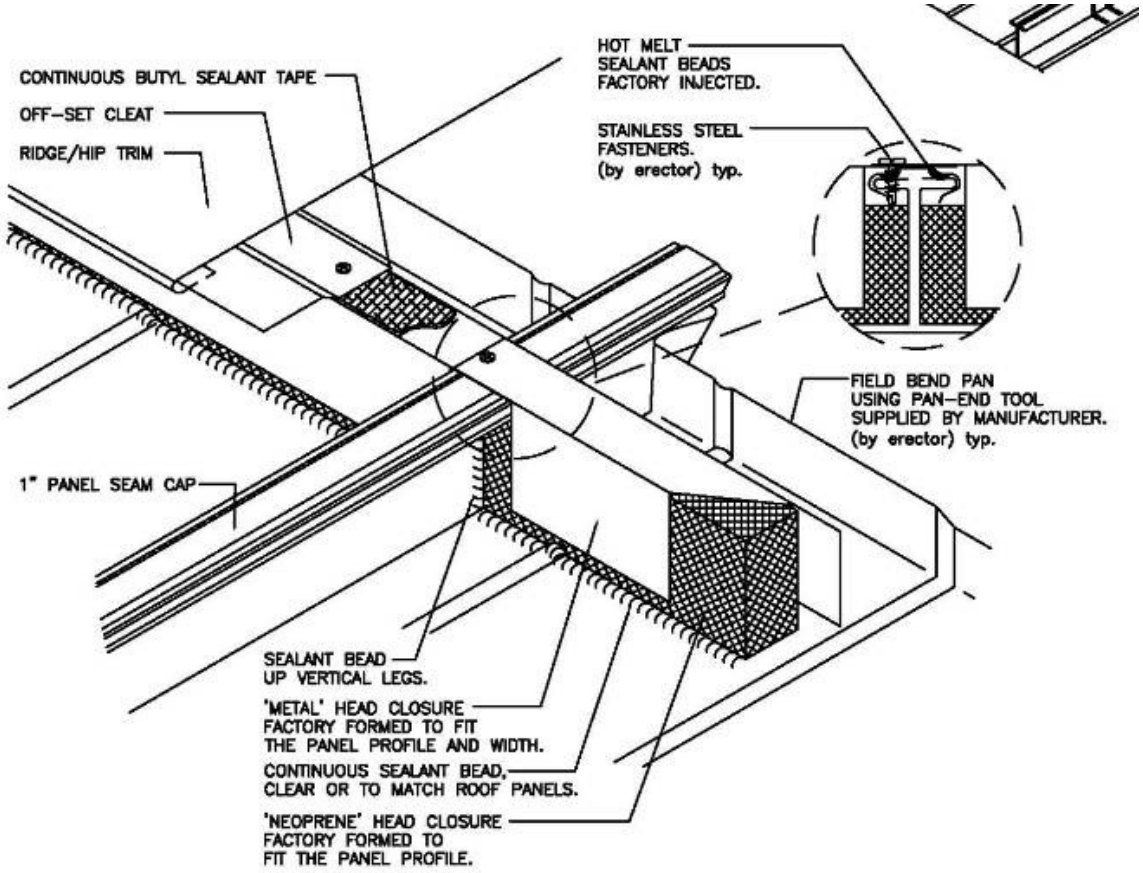
Detailing – Head Closure

Seam Profile – Form Follows Function

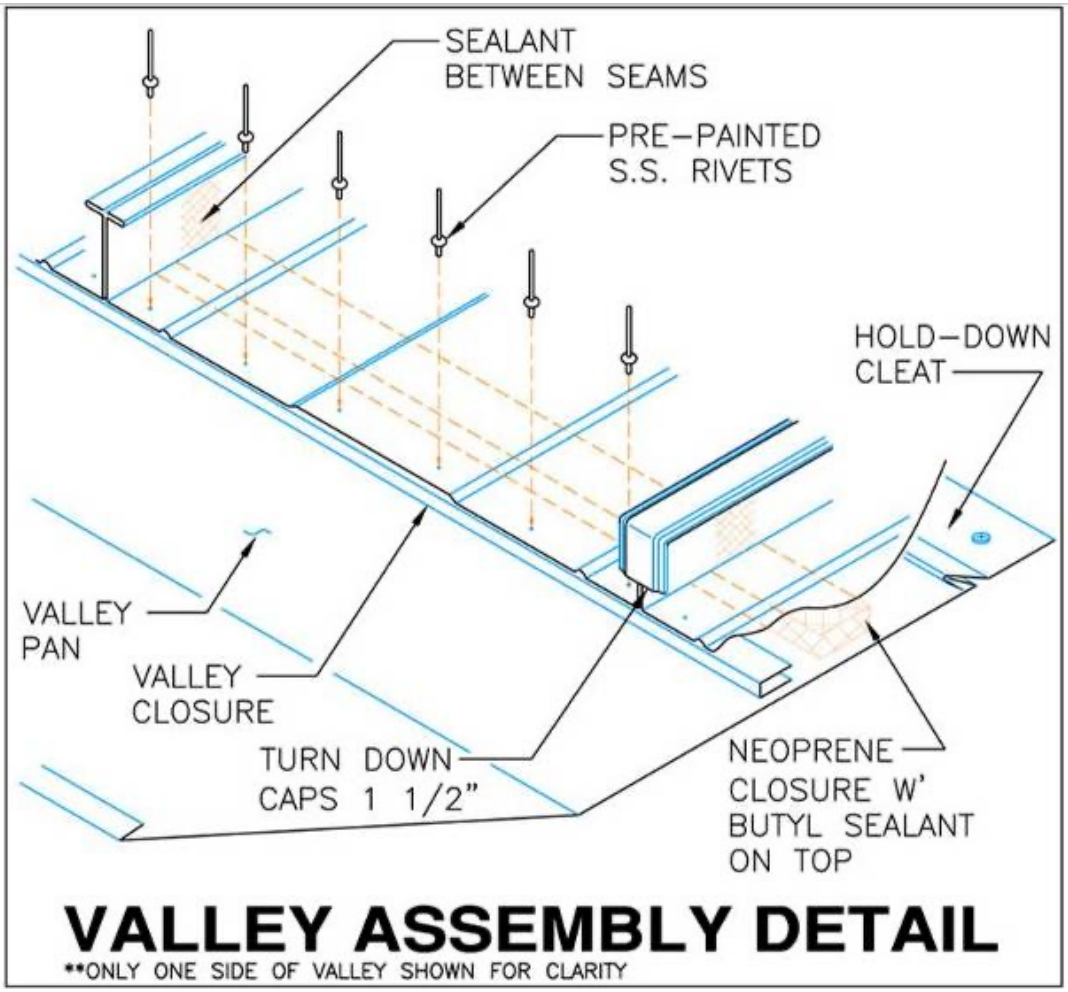
- Closure Pieces Made from Metal and Foam for Longevity

Rain

Head Closure Detail



Rain


SEALANT
BETWEEN SEAMS
PRE-PAINTED
S.S. RIVETS
HOLD-DOWN
CLEAT
VALLEY
PAN
VALLEY
CLOSURE
TURN DOWN
CAPS 1 1/2"
NEOPRENE
CLOSURE W'
BUTYL SEALANT
ON TOP
VALLEY ASSEMBLY DETAIL
**ONLY ONE SIDE OF VALLEY SHOWN FOR CLARITY

Rain

Standing Seam Waterproofing Tests

- **ASTM E 1680** – Standard Test Method for Rate of Air Leakage Through Exterior Metal Roof Panel Systems
- **ASTM E 1646** – Standard Test Method for Water Penetration of Metal Roof Panel Systems
- **AAMA 501.1**– Wind Driven Rain Test
- **ASTM E 2140** – Standard Test Method for Water Penetration of Metal Roof Panel Systems

Rain

ASTM E1680 Air Leakage through Metal Roof System

- Cyclic Test That Measures Long Term Waterproofing
- Results Show
  - Differences In Panel
  - Performance (i.e. Not a “Pass” or “Fail” Test)

Rain

Daily Weather – ASTM E 1646
Water Penetration Metal Roof Panels System

Rain

AAMA 501.1 Wind Driven Rain Test

Rain and Snow

Product Submersion Evaluation
ASTM E 2140 – Static Water Pressure Head

Environmental Factor: Snow

Snow

Concerns

- Weight of Snow
- Fix Point
- Eave detail

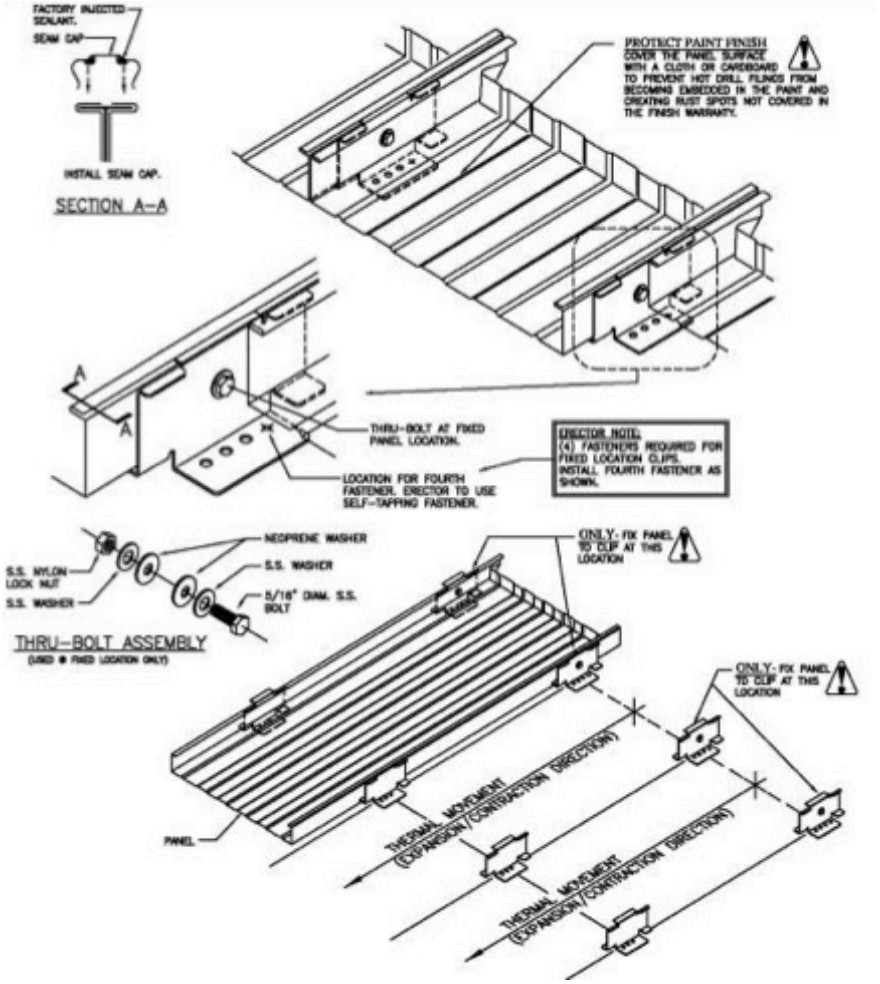
Snow

Ground Snow Load and Snow Drift Load

- Calculations to Determine Drift Loads
- Adding Snow Retention can Increase Loads on Building
- Retrofit Projects Need Special Consideration for Snow Loads
- Responsibility of the Designer to Check These Loads

Snow

Fix Point



Environmental Factor: Fire

Fire

Fire Testing

Fire

Fire Testing

1505.2 Class A Roof Assemblies:

Exceptions:

2. Class A Roof Assemblies also Include **Ferrous** or Copper Shingles or **Sheets, Metal Sheets**, and Shingles, Clay or Concrete, Roof Tile or Slate **Installed on Noncombustible Decks or Ferrous, Copper or Metal Sheets Installed With Out a Roof Deck on Noncombustible Framing**.

Fire

Fire Testing

1505.1 General:

Class A, B, C Roof Assemblies and Roof Coverings Required to be Listed by This Section Shall be Tested in Accordance With

ASTM E 108 or UL 790.

Fire

Fire Testing

Class A Components:

(When Used Over a Combustible Deck)

Fire Rated Underlayment – Nailed Base Sheet

or

Use of a Barrier Board Such as Gypsum Board Product

Aesthetics

Aethetics

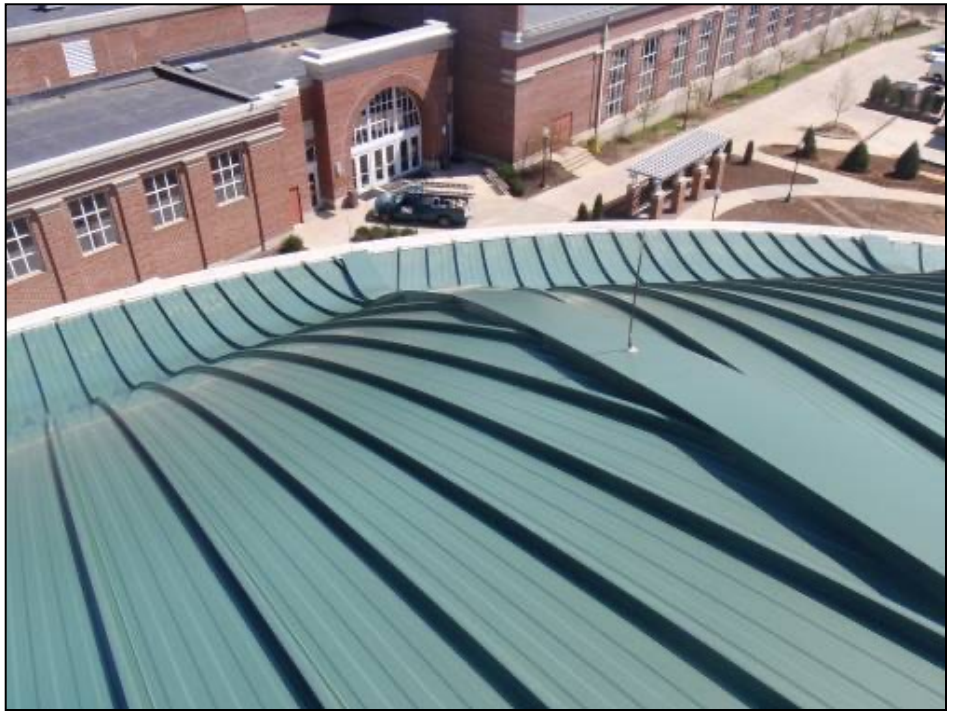
Curving

- Mechanical Curving
- Minimum Radius
  - Aluminum vs. Steel
  - Thicker is Better

Aesthetics

Reverse or "S" Curving

- Minimum Radius
  - Aluminum vs. Steel
  - Seam Profile
  - Thicker is Better



Aesthetics

Severe Oil Canning can be a Result of Poor Quality Roll Forming Equipment

Aesthetics

Tapering

Metal Applications

Long Panels

Long Panels

Spreader Bar Used to Lift Large Panels

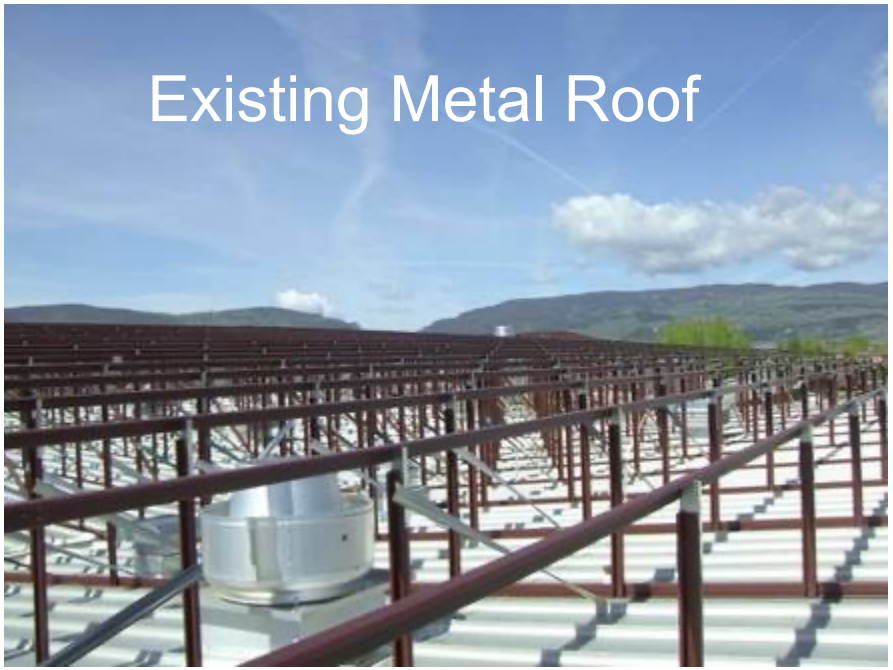

CHARLOTTE CRANE

Long Panels

Long Panels

- Field Roll Forming Equipment Must Equal the Quality of Factory Equipment

Retrofit Metal Roofing




ACE
Ice & Water Shield

Summary

Design Considerations to Include:

- Wind – Wind Uplift Calculations for Every Project
- Temperature – Unlimited Thermal Movement
- Rain – Details with “Multiple Layers of Protection” and Specify Performance Testing
- Snow – Panels Must be Engineered for Snow Load
- Fire – Assembly Testing for Fire Rating
- Aesthetics – Mechanical Curving and Quality Manufacturing Equipment
- Warranty

Thank You!