Designing Cold-Formed Steel Curtain Wall Connections

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Overview

• Code Requirements for Components & Cladding

• Loading on Connections for Typical Wall Configurations

• Engineered Connection Design

• Proprietary Connection Products
Code Requirements for Components & Cladding

- Structural Design
  - Wind Loads
  - Seismic Loads
  - Deflection Limitations

- Accommodate Building Movement
  - Vertical Movements
  - Lateral Drifts

Wind Design Loads

- 2010 California Building Code (2009 IBC) (ASCE-7 05 6.5.12.4) Wind Loads

\[ P = q_h(GC_p - GC_i) \]

- Loads decrease with increased Tributary Area
- Suction Loads typically govern and are typically constant over height of building

\[ GC_p = 1.1 \text{ (Elements not in areas of discontinuity)} \]

\[ GC_p = 1.4 \text{ (Elements in areas of discontinuity)} \]
Seismic Design Loads

  \[ F_p = \frac{0.4a_p S_{DSI_p}}{R_p} \left( 1 + 2 \frac{z}{h} \right) W_p \]
  \[ a_p = 1.0 \text{ and } R_p = 2.5 \text{ (Table 13.5-1)} \]
  For Fasteners of the Connecting system
  \[ a_p = 1.25 \text{ and } R_p = 1.0 \text{ (Exterior Only)} \]
- Loads Increase with Building Height
- \( F_p \) min = 0.3\( S_{DSI_p} \) \( W_p \)
- \( F_p \) max = 1.6\( S_{DSI_p} \) \( W_p \)

Deflection Limitations

- Out-of-plane deflection limitations are based upon limiting distress to finishes based on curvature of wall system.
  - Metal Panels: L/180 to L/240*
  - EIFS: L/240 to L/360
  - Cement Plaster: L/360*
  - Brick Veneer: L/360 to L/600 or more
  - Stone Veneer: L/360 to L/600 or more
- Out-of-plane deflections for cold formed wall systems are typically governed by wind loading.
- CBC Table 1604.3 – Serviceability limits for wall deflections based upon 70% of Component and Cladding Wind Loads
Accommodation of Building Movements

- Vertical Deflection of Perimeter Beams/Slabs
- Lateral Drift of Building Frame System

Allowable Vertical Deflection of Perimeter Beams/Slabs

- With typical 30 foot spans and design live load deflections of L/360, building live load deflections can reach 1 inch
- Value for perimeter beam live load deflection is typically limited to ¾ inch or less
- Actual design value must be verified with Engineer of Record for structure
Accommodation of Building Movements

Allowable Lateral Drift of Typical Systems

<table>
<thead>
<tr>
<th>Structure</th>
<th>Occupancy Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structures, other than masonry shear wall structures, 4 stories or less with interior walls, partitions, ceilings and exterior wall systems that have been designed to accommodate the story drifts.</td>
<td>LR I</td>
</tr>
<tr>
<td>Structures</td>
<td>0.025h_{la}</td>
</tr>
<tr>
<td>Masonry caseliever shear wall structures</td>
<td>0.010h_{la}</td>
</tr>
<tr>
<td>Other masonry shear wall structures</td>
<td>0.007h_{la}</td>
</tr>
<tr>
<td>All other structures</td>
<td>0.020h_{la}</td>
</tr>
</tbody>
</table>

- Actual drift should be obtained from Engineer of Record for structure
- For Category II structure $\Delta_a$ can be 2.5% of story height. (e.g. 15 ft floor @ 2.5% drift $\Delta_a = 4 \frac{1}{2}$”)

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)

Building Systems vs. Finish System

Building Systems
- Steel Moment Frames
- Concrete Moment Frames
- Eccentric Braced Frames
- Concentric Braced Frames
- Concrete Shear Walls

Flexible Systems
- EIFS Systems
- Cement Plaster Systems
- Adhered Veneer Systems
- Anchored Veneer and Stone Systems

Rigid Systems

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
11 Code Requirements for Drift Accommodation

- ASCE 7 – 13.5.2 & 13.5.3
  - Architectural components need to be designed for $F_p$ forces and for relative seismic displacement
  - Connecting members of exterior wall elements shall have sufficient ductility and adequate fastener strength to preclude a brittle failure at or near the fasteners.

12 Code Requirements for Drift Accommodation

- ASCE 7 – 13.5.2 & 13.5.3

  **13.5.2 Forces and Displacements.** All architectural components, and their supports and attachments, shall be designed for the seismic forces defined in Section 13.3.1.

  Architectural components that could pose a life-safety hazard shall be designed to accommodate the seismic relative displacement requirements of Section 13.3.2. Architectural components shall be designed considering vertical deflection due to joint rotation of cantilever structural members.

  **13.5.3 Exterior Nonstructural Wall Elements and Connections.** Exterior nonstructural wall panels or elements that are attached to or enclose the structure shall be designed to accommodate the seismic relative displacements defined in Section 13.3.2 and movements due to temperature changes. Such elements shall be supported by means of positive and direct structural supports or by mechanical connections and fasteners in accordance with the following requirements:
Code Requirements for Drift Accommodation

• ASCE 7 – 13.5.3
  a. Connections and panel joints shall allow for the story drift caused by relative seismic displacements \(D_r\) determined in Section 13.3.2, or 0.5 in. (13 mm), whichever is greatest.
  b. Connections to permit movement in the plane of the panel for story drift shall be sliding connections using slotted or oversized holes, connections that permit movement by bending of steel, or other connections that provide equivalent sliding or ductile capacity.
  c. The connecting member itself shall have sufficient ductility and rotation capacity to preclude fracture of the concrete or brittle failures at or near welds.
  d. All fasteners in the connecting system such as bolts, inserts, welds, and dowels and the body of the connectors shall be designed for the force \(P_r\) determined by Section 13.3.1 with values of \(R_r\) and \(a_{r,1}\) taken from Table 13.5-1 applied at the center of mass of the panel.

DSA & OSHPD Specific Code Requirements

• 2010 California Building Code Title 24 Requirement for DSA and OSHPD
  1615.10.11 ASCE 7, Section 13.3.2. Modify ASCE 7 Section 13.3.2 by adding the following:

  The seismic relative displacements to be used in design of displacement sensitive nonstructural components is \(D_r\) instead of \(D_p\), where \(D_r\) is given by Equations 13.3-5 to 13.3-8 and 1 is the building importance factor given in Section 11.5.

• Importance Factor
• DSA only permits 80% of allowable loads of code report listed products unless cyclically tested (IR A-5)
• Prohibits use of shotpins in concrete (PAF) in exterior wall framing
FEMA P-749 – Seismic Performance

• Limit the chance of total or partial collapse as a result of MCER ground motions to various percentages depending upon Occupancy Categories

• For all structures, minimize the risk that, in likely earthquakes, debris generated by damage to cladding, ceilings, or mechanical or electrical systems will fall on building occupants or pedestrians.

• To the extent practicable, avoid economic losses associated with damage to structural and nonstructural systems as a result of relatively frequent moderate earthquake events.

Questions?

• Please type your question into the chat box.
Typical Wall Configurations

- Balloon Framed Systems
- Spandrel Framed Systems
- Floor to Floor Framed Systems

Vertical Deflection Comparison – Un-Deflected Shape

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
19. Vertical Deflection Comparison – Deflected Shape

Balloon Framing  Spandrel Framing  Floor to Floor Framing

20. Lateral Deflection Comparison – Un-Deflected Shape

Balloon Framing  Spandrel Framing  Floor to Floor Framing

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Lateral Deflection Comparison – Deflected Shape – Drift Joints Do Not Allow for Drift

Balloon Framing  Spandrel Framing  Floor to Floor Framing

Lateral Deflection Comparison – Deflected Shape – Drift Joints Allow for Drift

Balloon Framing  Spandrel Framing  Floor to Floor Framing
Balloon Framed Systems

Vertical Slip Connection

Bearing Connection

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)

Balloon Framed Systems: Loading

Wind Loading  Gravity Loading  Analysis Model

\[ R_W = w_W \]

\[ R_G = w_G \times H \]

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Balloon Framed Systems: Seismic Loading

Seismic Loading In-Plane

Seismic Loading Out-of-Plane

Analysis Model

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)

Balloon Framed Systems: Clip Loading

Vertical Slip Connections – Loading Conditions to Consider

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Spandrel Framed Systems

Vertical Rigid Connection

Vertical Rigid Conn. @ Ea. Floor
Drift Joint Btwn Ea. Floor
- Allows for Vertical and In-Plane Differential Movement
Kicker Support
Bearing Connection

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)

Spandrel Framed Systems: Loading

Wind Loading Gravity Loading Analysis Model

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Spandrel Framed Systems: Loading

Seismic Loading
In-Plane

Seismic Loading
Out-of-Plane

Analysis Model

Isolation Joint
Allowing Vertical / Lateral Movement

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Rigid Connections – Loading Conditions to Consider

Spandrel Framed Systems: Clip Loading

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)

Spangrel Framed Systems

Kicker Connection

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Floor to Floor Framed Systems

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Floor to Floor Framed Systems: Loading

Gravity Loading

\[ R_G = w_G \times H \]

Wind Loading

\[ R_W = w_W \times H/2 \]

\[ R_W = w_W \times H/2 \]

Analysis Model

Seismic Loading

In-Plane

\[ R_{S1} = w_S \times H/2 \]

Out-of-Plane

\[ R_{S2} = w_S \times H/2 \]

Analysis Model

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Floor to Floor Framed Systems: Connection Detail

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)

Framing with Drift Clips

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Framing with Drift Clips

Gap Forms at One Building Corner

Wall Collides with Perpendicular Wall at Other Building Corner

Each exterior wall must be designed to transfer the induced seismic load from its self weight down to the slab on grade.

Seismic shear in wall piers may not exceed capacity of the sheathing.
Framing with Drift Clips
Loading on Connection

If building drift under MCE exceeds slot size then connection and anchorage must be checked for induced loading.

Only design for resultant wind loading.

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)

Engineered Connection Design

- Loads to consider
  - Gravity
  - Wind
  - Seismic
    - Fp Loading
      - Body of Connection Loads
      - Fastener Loads (3.125 x Body of Connection Loads)
    - Direction of Loading
      - Out-of-Plane
      - In-Plane
  - Ductility Requirements

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Code Ductility Requirements

ASCE 7-05 Section 13.5.3

a. Connections and panel joints shall allow for the story drift caused by relative seismic displacements ($D_s$) determined in Section 13.3.2, or 0.5 in. (13 mm), whichever is greater.

b. Connections to permit movement in the plane of the panel for story drift shall be sliding connections using slotted or matching holes, connections that permit movement by bending of steel, or other connections that provide equivalent sliding or ductile capacity.

c. The connecting member itself shall have sufficient ductility and rotation capacity to preclude fracture of the concrete or brittle failures at or near welds.

d. All fasteners in the connecting system such as bolts, inserts, welds, and dowels and the body of the connectors shall be designed for the force ($P_t$) determined by Section 13.3.1 with values of $R_p$ and $u_a$ taken from Table 13.5-1 applied at the center of mass of the panel.

Interpretation of Code Ductility Requirements

Option #1:
- Detail corners and intersection with curtain walls to not collide.

Option #2:
- Provide clips from wall stud to base building that can sustain ductile bending.
- Design connection of clip to base building such that it can resist the Mp capacity of the clip.
Example Slip Clip Design

• Design Loading

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)

Wind Load Design – Usually Controls for Out-of-Plane Loading

Design Process
• Check shear capacity of screws
• Check tension capacity of clip leg
• Check weld from clip to deck edge

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Seismic Load Design – Controls for In-Plane Loading

Design Options
• Option A:
  – Cantilevered Clip w/ No Rotational Restraint
• Option B:
  – Cantilevered Clip w/ Some Rotational Restraint

Seismic Load Design – Option A

Option A: Cantilevered Clip w/ No Rotational Restraint

Design Process
• Check tension capacity of screws.
  - \( T_{\text{allow}} > P_{\text{fasteners}} \)
  - \( P_{\text{fasteners}} = \text{Load from } F_p \text{ for Fasteners} \)
• Check bending capacity of clip leg.
  - \( M_{\text{allow}} > M \)
  - \( M = P_{\text{Body of Conn}} \times e \)
  - \( P_{\text{Body of Conn}} = \text{Load from } F_p \text{ for Body of Connection} \)
• Check weld from clip to deck edge.
  - Use \( P_{\text{fasteners}} \) level loads
Seismic Load Design – Option B

Option B: Cantilevered Clip w/ Rotational Restraint

Design Process

• Check tension capacity of screws.
  - $T_{allow} > P_{fasteners}$ (Include Additional Tension from Force Couple)
  - $P_{fasteners} = \text{Load from } F_p \text{ for Fasteners}$

• Check bending capacity of clip leg.
  - $M_{allow} > M_{max}$
  - $M_{max}$ from Bending Moment Diagram using $P_{body \ of \ Conn}$
  - Load from $F_p$ for Body of Connection

• Check weld from clip to deck edge.
  - To Resist $M_{max}$
  - Use $P_{fasteners}$ level loads

Seismic Load Design – Ductility Check

Design to have Ductile Bending and Avoid Fastener Failure

• Determine Plastic Moment Capacity of the Clip
  - $M_p = Z \times F_y$

• Check Welds to Resist $M_p$
Designing for Ductility

- Design to have ductile bending and avoid fastener failure
- Welds
  - Work well to resist plastic moment capacity of clips
- Shotpins and sometimes expansion anchors
  - Frequently do not have enough capacity to resist plastic moment capacity of clips

\[ M_p = 964\text{#} \times \text{in} \]

- For 5” x 10Ga. Clip: \( M_p = 964\text{#} \times \text{in} \) therefore, \( T = C = 964\text{#} \)

Questions?

- Please type your question into the chat box.
Proprietary Clip Design

- Proprietary clips offer tested solutions that may be more cost effective and easier to install than engineered designs
- Lighter gage steel with features such as embossments, stiffeners, optimized hole layout
- May feature proprietary fasteners that are load-rated higher than standard fasteners

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)

Proprietary Clip Design

- Alternative Materials: Conformance to Building Codes
- Acceptance Criteria and Testing Methodology
- Allowable load determination
  - Average ultimate value of 3 tests / factor of safety per AISI
  - Deflection limit
  - Fastener calculation
  - Testing of clips

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
104.11 Alternative materials, design and methods of construction and equipment

- The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved.

- An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)

104.11.1 Research reports.

- Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this code, shall consist of valid research reports from approved sources.

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Accredited Product Certification Bodies

Directory Details

<table>
<thead>
<tr>
<th>ACCREDITATION ID</th>
<th>1098</th>
</tr>
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<tbody>
<tr>
<td>ORGANIZATION</td>
<td>ICC Evaluation Service, LLC</td>
</tr>
<tr>
<td>LETTER CODE</td>
<td>ICCEBLCC</td>
</tr>
<tr>
<td>WEBSITE</td>
<td></td>
</tr>
</tbody>
</table>

LIST OF SITES

- **High-Efficiency Flushing Urinals**
  - SCOPE: 2011-12-04
- **High-Efficiency Lavatory Faucets**
  - SCOPE: 2011-12-04
- **ICCE evaluation reports address compliance with code, under the conditions specified in each report, of building products, materials, systems, designs, and methods. The third-party certification program of ICC-ES encompasses the International family of codes, the BOCA National Codes, the Standard Codes, and the Uniform Codes. To indicate compliance with these codes, ICC-ES evaluation reports include consideration of product performance, installation requirements, and quality control.**
  - SCOPE: 2011-03-08
- **Plumbing, Mechanical and Gas Product Listings**
  - SCOPE: 2010-12-01
- **Tank-Type High-Efficiency Toilets**
  - SCOPE: 2011-12-04

Acceptance Criteria AC261

- **Testing to include CFS structural member, connector, supporting member representative of field conditions**
- **Minimum of 3 tests, less than 15% variance**
- **1/8" deflection serviceability limit**
- **Factor of safety determination per AISI S100-2007 Section F1**

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
F.1.2 Allowable Strength Design

Where the composition or configuration of elements, assemblies, connections, or details of cold-formed steel structural members are such that calculation of their strength cannot be made in accordance with the provisions of this Specification, their structural performance shall be established from tests and evaluated in accordance with Section F1.1, except as modified in this section for allowable strength design.

The allowable strength shall be calculated as follows:

\[ R = \frac{R_m}{\Omega} \quad \text{(Eq. F1.2-1)} \]

where

\[ R_m = \text{Average value of all test results} \]
\[ \Omega = \text{Safety factor} \]
\[ = \frac{1.6}{\phi} \quad \text{(Eq. F1.2-2)} \]

where

\[ \phi = \text{A value evaluated in accordance with Section F1.1} \]

The required strength shall be determined from nominal loads and load combinations as described in Section A4.

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Sample Curtain Wall Clips Code Report

4.1.1 General: The tabulated loads shown in this report are for use with Allowable Stress Design (ASD) and are applicable to both basic load combinations contained in IBC Section 1605.3.1 and the alternative load combinations in IBC Section 1605.3.2. Allowable load increases for wind or seismic loads are not permitted.

Allowable loads are presented in Tables 1 - 4 and are based on the least of the following values:

1. The average test load at which 1/8 inch relative movement occurs between the supported cold-formed steel member and the supporting structural member.
2. The average ultimate test load divided by a safety factor, determined in accordance with AISI S100 Chapter F.
3. Allowable load for screws used to attach the connectors to the supported cold-formed steel member:
   a. For the SCB, SSB, and SCW slip-clip connectors, the allowable shear for the #14 shouldered screws based on IAPMO ES ER-242.
   b. For the FCB fixed-clip connectors, the allowable load for #12 self-drilling screws calculated in accordance with Section E4 of AISI S100.
4. Allowable load for welds and screws used to anchor the connectors to the supporting structure, calculated in accordance with Section E2 and E4, respectively, of AISI S100.

Allowable loads tabulated for connectors attached to 54 mil (16 ga.) members are also applicable to thinner members, up to a maximum thickness of 118 mil (10 ga.), provided the steel has a yield strength and tensile strength meeting the requirements for 54 mil (16 ga.) material outlined in Section 3.2.4.
**Sample Curtain Wall Clips Code Report: Connector Load Table**

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Connector Material Thickness (mil.)</th>
<th>L (in.)</th>
<th>No. of #14 Shouldered Screws</th>
<th>Allowable Load (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35 mil (20 ga.)</td>
</tr>
<tr>
<td>SCB43.5</td>
<td>54 (16)</td>
<td>3%</td>
<td>2</td>
<td>520 250 610 600 760 975</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>675 675 855 1000 990 1200</td>
</tr>
<tr>
<td>SCB45.5</td>
<td>54 (16)</td>
<td>5%</td>
<td>2</td>
<td>490 520 610 600 760 975</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>675 675 855 1000 990 1200</td>
</tr>
<tr>
<td>SCB47.5</td>
<td>54 (16)</td>
<td>7%</td>
<td>2</td>
<td>490 520 610 600 760 945</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>675 675 855 1000 990 1200</td>
</tr>
<tr>
<td>SCB49.5</td>
<td>54 (16)</td>
<td>9%</td>
<td>2</td>
<td>490 520 600 600 760 945</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>675 675 855 1000 990 1200</td>
</tr>
<tr>
<td>SCB411.5</td>
<td>54 (16)</td>
<td>11%</td>
<td>2</td>
<td>490 520 600 600 990 500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>675 675 800 1000 990 1200</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 lb = 4.45 N

1. Refer to Figure 1 for anchorage options. All anchorage options will achieve tabulated allowable loads, except for values shown shaded, where the allowable load will be the least of the tabulated values and the capacity of the selected anchorage as follows:
   - 2 #12: 795 lbs
   - 4 #12: No reduction
   - 3 #12: 1120 lbs
   - Welded: No reduction

2. When the SCB connector is used with 2 shouldered screws, the screws may be installed in any 2 slots.

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**ASCE7-05 Table 13.5-1**

<table>
<thead>
<tr>
<th>Architectural Component or Element</th>
<th>a_0</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior Nonstructural Walls and Partitions</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>All other walls and partitions</td>
<td>1.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Cantilever Elements (Unbraced or braced to structural frame below its center of mass)</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Parapets and cantilever interior nonstructural walls</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Chimneys and stacks where laterally braced or supported by the structural frame</td>
<td>1.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Cantilever Elements (Braced to structural frame above its center of mass)</td>
<td>1.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Parapets</td>
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<td>Chimneys and Stacks</td>
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<tr>
<td>Body of wall panel connections</td>
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</tr>
<tr>
<td>Fuselines of the connecting system</td>
<td>2.5</td>
<td></td>
</tr>
</tbody>
</table>

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Typical bearing failure in stud

Typical screw tilting
### In-Plane Loads: Design Assumptions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Curtain Wall System</th>
<th>Design Assumptions</th>
</tr>
</thead>
</table>
| Case 1:   | Heavy cladding with no rotational restraint | • Connector acts as cantilever  
• Load applied at exterior face of stud  
• F1 = M/e |
| Case 2:   | Lightweight cladding with no rotational restraint | • Connector acts as cantilever  
• Load applied at centroid of fasteners  
• F1 = M/e |
| Case 3:   | Complete rotational restraint of studs | • Connector acts as beam fixed at both ends (double curvature)  
• Load applied at fastener nearest support  
• F1 = 2M/e |

### In-Plane Loads

- \( V_1 = \frac{M_1}{L_1} \)
- \( V_2 = \frac{M_2}{L_2} \)
- \( V_3 = 3V_1 \)
- \( V_3 = 2M_3/L_3 \)
### Table 2: SCB and FCB Allowable In-Plane (F1) Loads (lbs.)

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Fasteners to Stud</th>
<th>Stud Depth (in.)</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3%</td>
<td>6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>SCB43.5</td>
<td>2#14</td>
<td>28</td>
<td>25</td>
<td>20</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>12#14</td>
<td>28</td>
<td>25</td>
<td>20</td>
<td>85</td>
</tr>
<tr>
<td>SCB45.5</td>
<td>3#14</td>
<td>35</td>
<td>24</td>
<td>19</td>
<td>55</td>
</tr>
</tbody>
</table>

PRELIMINARY – NOT FOR DESIGN

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**Sample Curtain Wall Clips Code Report: Anchorage**

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Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)
Acceptance Criteria

Design of CFS Curtain Wall Connections (K. Zeydel/A. Kao, 4/11/12)

Anchorage – Factor of Safety

- Calculated per AISI for steel, screw, or weld failure
- 4.0 for concrete failure
- 5.0 for shot pin failure
Failure Modes: Anchorage

Proprietary Clip Design

- Use design values and data from code report published from an accredited agency
- Read the footnotes! (stud thickness, anchorage capacity)
- Contact manufacturer for information on conditions that fall outside scope of code report (anchorage, in-plane loads)
Engineered vs. Proprietary

- Engineered clips are more time consuming to design but allow for unlimited options and configurations to meet a project’s needs.
- Proprietary clips are easier to design but it is imperative that the engineer understand the parameters by which the in-plane load capacity of the clip was determined.
- The ductility (or lack thereof) of the clips needs to be considered for systems using both engineered and proprietary clips.

Connection Challenges

- Deck edge clips that have the capacity to resist the $F_p$ seismic forces while having the ductility to meet the intent of the code.
- Do not connect to protected zones of the base building’s lateral system (RBS zones, gusset plates, etc.)
- Stickers to beam bottoms and kickers to slabs can have adverse affects on the base building structure if not accounted for in the base building design.
Summary

• Exterior Wall Framing Systems can be quite challenging to design
  • System must accommodate base building movement as provided by the SEOR
  • Coordinate joint locations and system performances with the architect
  • Account for all loading (gravity, wind, and seismic) in the connection designs
  • Make sure to design fasteners for the higher $F_p$ value
  • Ensure the system meets the ductility requirements of the code

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