Design Engineering and Exterior Light-Gauge Steel Framing Basics

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Course Description

This course provides a basic overview of exterior cold-formed steel framing, as well as the characteristics and usage of different types of exterior deflection systems. Review how to avoid common mistakes when framing, and the ASTM standards for cold-formed steel framing products.
Upon completion of this course the Design Professional will be able to:

- List the features and characteristics of cold-formed steel c-stud and track products
- Explain the SFIA nomenclature and ASTM standards for cold-formed steel framing products
- List the characteristics and usage of different types of exterior deflection systems
- Describe bridging systems, including spacer bars, u-channels, and block and strap bridging
- Explain the types of headers, including box headers, I-beam headers, and U-shaped headers
- Describe how to avoid common mistakes when framing with cold-formed steel products
EXTERIOR FRAMING PRODUCTS
Exterior Framing Products

Introduction

- Exterior cold-formed steel framing products can be used for various applications, including curtain walls, load-bearing walls, and connections.

- The basic components of cold-formed steel framing systems are c-studs with knockouts and u-shaped tracks.

- The high strength-to-weight ratio of cold-formed steel maximizes building design flexibility, while providing structural integrity.
Exterior Framing Products

C-Studs

- Cold-formed steel c-studs are typically used in exterior wall construction to provide an envelope to the outside skin of the building.

- Cold-formed steel c-studs are ideal as back-up support assemblies for brick veneer, stucco, and EIFS systems.

- C-studs are also used for in-fill, bypass (balloon), and spandrel framing and are available in a wide range of sizes, flanges, gauges, and yield strengths.
Web and Return Sizes

- Structural steel c-studs are available with web sizes ranging from 2-1/2" to 14". Web depths greater than 14" are typically not available.

- Structural steel c-studs are also available with returns in a variety of depths. Standard return depths include 3/8", 1/2", 5/8", 1".
Exterior Framing Products

Flange Sizes

- The flange of the c-stud provides a bearing surface for cladding materials and is a key contributor to the load-bearing capacity of the member.

- Flanges are available in sizes from 1-3/8" to 3". Custom sizes are also available.
Exterior Framing Products

Flange Sizes Cont'd...

C-studs are available with a variety of flange sizes for use in various applications.

- **1-3/8" Flange:** Used to support exterior skin or cladding against wind loads.
- **1-5/8" Flange:** Provides vertical strength for load-bearing structural applications. This is the most typical flange size.
- **2" Flange:** Larger bearing surface for attaching sub-flooring and sheathing.
- **2-1/2" Flange:** Used in floor joist assemblies and heavy loading conditions.
- **3" Flange:** Used in very heavy loading and long-span conditions.
Exterior Framing Products

Knockouts

- C-studs are pre-punched with knockouts at regular intervals to allow rapid installation of electrical conduit, mechanical, and piping.

- Bridging products are also installed through these knockouts typically in stud depths 6" or less.

- Standard knockouts are 1-1/2" x 4" and are punched 12" (East and Central) and 24" (West) from the leading edge and every 24" after that.
Tracks

- Tracks are u-shaped steel framing components typically used as top and bottom runners to secure wall studs or as head and sill plates at openings.

- Tracks can also be used to provide end support closures for joists at exterior/foundation walls or for solid blocking.

- Standard leg length is 1-1/4”, however other leg lengths (e.g. 2”, 3”) are available. Tracks with deeper legs are typically used for slip track conditions.
Tracks Cont'd...

- For instance, longer leg tracks can be used for deflection conditions or to accommodate inconsistent or uneven floor or ceiling conditions.

- Structural steel tracks are typically available in standard 10' lengths. Longer tracks may be available.

- Track web sizes vary from a minimum of 2-1/2" to a maximum of 14" and are normally ordered in a size and gauge corresponding to c-studs.
Yield Strength

- Yield strength is a measure of the maximum pressure that a material is designed to resist. Yield strength can be expressed in different units, however kips (1000 pounds) per square inch (ksi) is the most common unit used. For instance, many generic specifications require that material of gauges 16 and heavier to be 50 ksi.

- It should be noted however, that 50 ksi is typically unnecessary for most curtain wall framing. Increased yield strength adds axial and bending capacity, however axial loads and bending stresses are usually low in curtain wall conditions.

- In most cases, the design of curtain wall studs is controlled by deflection (i.e. the stiffness of the stud), which is unrelated to yield strength. In other words, 33 ksi materials will be sufficient for most curtain wall applications, unless otherwise specified. If necessary, 50 ksi materials are available in 16, 14, and 12 gauge.
Exterior Framing Products

Thickness

- Structural products are available in a variety of "minimum deliverable" steel thicknesses (see table). This minimum represents 95% of the design thickness.

- This difference gives manufacturers some tolerance on the delivered product versus the thickness used specified for the design.

- This 5% difference is in accordance with the American Iron and Steel Institute (AISI) Code.

<table>
<thead>
<tr>
<th>Thickness (&quot;&quot;&quot;)</th>
<th>Mils</th>
<th>Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0329&quot;</td>
<td>33 mil</td>
<td>20 ga.</td>
</tr>
<tr>
<td>0.0428&quot;</td>
<td>43 mil</td>
<td>18 ga.</td>
</tr>
<tr>
<td>0.0538&quot;</td>
<td>54 mil</td>
<td>16 ga.</td>
</tr>
<tr>
<td>0.0677&quot;</td>
<td>68 mil</td>
<td>14 ga.</td>
</tr>
<tr>
<td>0.0966&quot;</td>
<td>97 mil</td>
<td>12 ga.</td>
</tr>
</tbody>
</table>
Exterior Framing Products

Galvanized Coatings

- Structural (exterior) cold-formed steel framing products typically are manufactured from steel with a galvanized coating in order to provide corrosion resistance.

- Products are designated as G60 or G90, based on the thickness of the galvanized coating.

- The standard galvanized coating is G60 as per ASTM C 955. G90 may be used in coastal regions, however it involves increased cost, lead times and is often specified unnecessarily when a G60 coating will suffice.
Exterior Framing Products

SFIA Nomenclature

• The SFIA (Steel Framing Industry Association) has created a standard nomenclature system that is used to name various steel stud products.

• SFIA nomenclature is used for steel c-stud (S), steel track (T), u-channel (U), and furring (F) channel sections.

• The first three digits represent web size, the next three digits represent flange size, and the last two digits represent thickness or gauge.
Exterior Framing Products

Standards

There are several ASTM standards that apply cold-formed steel framing, including:

- **ASTM C 955**: This standard deals with quality issues related to steel studs, tracks, and bracing or bridging for screw application of gypsum panel products and metal plaster bases in load-bearing (transverse and axial) construction assemblies and it includes the specific coating requirements for the finished products.

- **ASTM A 1003**: This standard covers chemical, structural, and general coating standards for metallic coated steel sheet intended for cold-formed steel products. The coating requirements for the specific individual products are found in the manufacturing specification C955.

- **ASTM C 1007**: This standard covers minimum requirements for the installation of structural steel framing manufactured in accordance with ASTM C955.
EXTERIOR DEFLECTION SYSTEMS
Exterior Deflection Systems

Introduction

- Curtain wall framing can be attached to the primary structure of a building using a variety of deflection clips, connectors, and assemblies.

- In most cases, curtain wall framing is attached to a structure using Powder Actuated Fasteners (PAFs).

- However, at highly stressed areas, such as at jamb studs and areas near deflection connections, welding or drilled-in anchors may be required.
Exterior Deflection Systems

Deflection Limits

• As previously discussed, deflection, not yield strength, is the primary factor that affects the selection of framing members. When specifying deflection, "L" refers to the length of the member, or span, in inches. Therefore, a 10' or 120" span at L/360 would deflect by 120/360 or 0.333".

• In other words, the member must only deflect 0.333" when the maximum design loads are applied. If the same member was designed to L/480, then it would only deflect 120/480 or 0.25" when maximum design loads are applied.

• Some exterior finishes allow more deflection than others. For example, EIFS and metal panels require L/240, while stucco requires L/360, and brick and stone panels require L/600 or L/720. These deflection limits are typical, but may vary depending on the project as outlined in the contract documents.
Exterior Deflection Systems

System Types

Various types of deflection connectors and assemblies are available, including:

1. Slide Clip Connectors
2. Strut Connectors
3. Top Clip Connectors
4. Vertical Clip Connectors
5. Spacing Bar Assemblies
6. Double Track Assemblies
7. Slotted Slip Tracks

Each type of connector or assembly is suited to specific construction conditions.
Slide Clip Connectors

- The biggest advantage of this type of slide clip, or slip connector, is its ability to accommodate imperfect perimeter structural steel angles.

- However, traditional types of slip connector require the use of scab studs to allow sufficient standoff or to make up for in-and-out tolerances in the slab edge location.

- As a result, this becomes a two-piece attachment, which means more labor and a more expensive connection even though the part itself is inexpensive.
Exterior Deflection Systems

Slide Clip Connectors Cont'd...

- In order to make the use of slide clips more efficient, some manufacturers have started to offer slip connectors that do not require scab studs.

- 3-1/2" clips can accommodate up to a 1" standoff, while 5-1/2" clips can accommodate up to a 2" standoff.

- These clips are typically made of 14 gauge 50 ksi steel and are designed to accommodate 1-1/2" of vertical deflection in the primary structure.
Exterior Deflection Systems

Slide Clip Connectors Cont'd…

- Some manufacturers offer clips with lines inscribed into the leg that show exactly where the fasteners need to be installed to achieve design loads.

- Slide clips are also typically supplied with proprietary deflection screws designed to allow for movement.

- Slide clips with ribs in the heel have a greater capacity to resist (negative) suction loads on the wall than other products without such reinforcing ribs.
Exterior Deflection Systems

Strut Connectors

- Strut connectors are typically most useful in situations where a perimeter structural angle is not provided at the top of the edge of the slab.

- One concern in this situation is the introduction of a lateral load to the unbraced bottom flange of the beam.

- When this type of strut connection is required, the Engineer of Record may need to check the design of the perimeter beam for these torsional forces.
Exterior Deflection Systems

Strut Connectors

• This type of connector is typically manufactured from 14 gauge steel with a yield strength of 50 ksi and can accommodate 1-1/4" deflection.

• Strut connectors are manufactured with no loose bushings and are available in lengths from 12" to 24".

• Like slide clips, strut connectors are typically provided with proprietary self-drilling deflection screws that are designed to allow for movement.
Exterior Deflection Systems

Top Clip Connectors

• This type of clip is used when the curtain wall assembly is installed between floors as opposed to the more common bypass assembly.

• It can also be used as an alternative to the more common heavy-gauge single slip track connection.

• The clip allows for the use of a 20 gauge top track (for alignment) and creates a positive attachment with each stud and the primary structure.
Top Clip Connectors Cont'd...

- Another condition where this type of connection is useful is at the top of window jambs where there is a high concentrated load on the slip track.

- In most cases, the gauge of the slip track must be increased because of the high concentrated load only at the jambs.

- This type of clip would only be used at window jambs as a way to account for high concentrated loads without increasing the gauge of the slip track throughout the project.
Exterior Deflection Systems

Vertical Clip Connectors

- This type of connector is typically manufactured from 10 gauge 50 ksi steel and is attached to the concrete slab when loading of the bottom flange of the beam is a concern or is prohibited.
Spacing Bar Assemblies

- Spacing bar assemblies utilize bridging bars in the top knockout and can be used for curtain wall assemblies installed between floor decks.

- Some advantages of this method are that it uses standard products and it installs relatively easily.

- It is important to note that in a slip track condition, the top track of the assembly will normally consist of heavier gauge steel than that of the typical studs.
One disadvantage of this type of assembly is that it relies upon the use of mechanical bridging within 12" of the top of the stud.

Bridging is needed to brace the stud against rotation since the stud and track are not mechanically fastened.

Because there is no mechanical attachment between stud and track, this assembly may not be allowed in areas of high seismic concern.
A similar deflection system can be used for curtain wall assemblies installed between floor decks, but without a requirement for bridging.

This double track system allows 1/2" to 3/4" of deflection by using a deep leg over-track over another-track.

One advantage of this method is that it does provide a mechanical attachment between the vertical studs and the inner track.
Double Track Assemblies Cont'd…

• A disadvantage of this method is that the inner track must have a longer leg than the outer track to prevent interference with the screw heads.

• Another disadvantage of this method is that it requires the use of twice as much track material. Both of these tracks are special sizes and not off the shelf products.

• In addition, double track assemblies cannot be used in axial load-bearing stud conditions or above continuous window spandrels.
Exterior Deflection Systems

Slotted Slip Tracks

- Slotted slip tracks offer the easiest slip track installation and, since both legs are designed to resist loads, they also offer higher design loads.

- Unlike spacing bar assemblies, slotted slip tracks do not require the use of bridging or double top tracks.

- In addition, slotted slip tracks are designed to provide a mechanical attachment between the stud and track for added stability.
Exterior Deflection Systems

Slotted Slip Tracks Cont'd...

- Because of this attachment between the studs and top track, slotted slip tracks are the preferred deflection method in high seismic regions.

- Some manufacturers also offer slotted slip track assemblies with a full line of fire test (head of wall) approvals.

- One disadvantage of this method is that it does not work in sloped gabled end wall conditions because the slots would not be vertical.
EXTERIOR BRIDGING SYSTEMS
Exterior Bridging Systems

Introduction

- Bridging maintains stud alignment, resists axial loads caused by weak axis rotation of the studs, and prevents torsional and lateral buckling of studs.

- The three general types of bridging include spacer bars, u-channels and block and strap bridging.

- Spacer bar and u-channel bridging is typically used for studs less than or equal to 6", while blocks and straps are typically used for studs deeper than 6".
Exterior Bridging Systems

Bridging Options

There are three general types of bridging options for curtain walls, including:

- Spacer Bar Bridging
- U-Channel Bridging
- Block and Strap Bridging

Most bridging requirements call for a vertical spacing between 4’ and 8’ on center vertically.
Exterior Bridging Systems

Spacer Bar Bridging

- Spacer bar bridging is ideal for long straight runs of curtain wall (with members less than 6” in depth) and is the lowest installed cost bridging option.

- Spacer bars are available pre-notched for 16" and 24" on-center stud spacing, which dramatically reduces layout time.

- Spacer bars are friction fit in most applications, however load bearing installations require the use of spacer bar guards that are screwed in place.
Exterior Bridging Systems

U-Channel Bridging

• U-channel bridging is the most conventional bridging method for curtain walls and is typically used where studs are 6" deep or less.

• Unlike spacer bars, u-channels are not pre-notched and need to be attached using clips or welds.

• In cases where u-channel bridging is used for back-to-back applications, a smaller clip is required in order to connect the u-channel to the stud.
Exterior Bridging Systems

Block and Strap Bridging

- Block and strap bridging is typically used when studs are 8" or deeper, or in instances where the knockouts in the studs do not line up.

- Block and strap bridging is the only one of three methods that is suitable for curved or radius walls.

- Solid blocks are used at 8' on center along the length of the strapping to prevent rotation and are fastened to studs with clips and the straps are then attached to them to complete the assembly.
EXTERIOR WALL HEADERS
Exterior Wall Headers

Introduction

There are three general types of light-gauge steel load-bearing wall headers that are commonly used, including:

- Box Beam Headers
- Back-to-Back Headers
- U-Shaped Headers

The first two types of headers are made using c-studs, while the last type is made from preformed u-shaped members.
Exterior Wall Headers

Box Beam Headers

- Box beam headers are field or shop assembled by positioning two c-stud sections with the open side of the webs or “c” section facing each other.

- The “c” sections are capped with a top and bottom track with jack studs for additional header support.

- In most cases, the connection to the jamb is made by nesting the boxed header into a vertical track attached to the jamb. Box beam headers must be pre-insulated during fabrication.
Back-to-Back Headers

- Back-to-back, or I-beam headers, consist of two c-sections with the webs screwed back to back to form the shape of an I-beam.

- Headers are attached to the jamb stud with support clips and jack studs are used to provide additional support.

- This type of header must be field-fabricated, however many contractors prefer back-to-back headers because they can be insulated after assembly.
Exterior Wall Headers

U-Shaped Headers

• Some manufacturers offer preformed u-shaped headers designed to slide easily over the wall assembly and provide maximum carrying capacity.

• In many cases, these types of headers are pre-engineered to fit standard door and window openings.

• In addition, U-shaped load-bearing headers drastically reduce labor costs as compared to box beam headers made from c-shaped members.
HEAVY-DUTY FRAMING
Heavy-Duty Framing

Introduction

• Heavy-duty framing is a roll-formed shape with outstanding bending strength in two directions, and superior axial strength.

• The shape makes it possible for additional members to be attached to both sides.

• As a result of these features, heavy-duty framing has many applications and can be more beneficial (cost effective) when compared to typical framing methods.
Heavy-Duty Framing

Applications

• A heavy-duty framing system is a high-performance, cost-effective, multipurpose stud that can be used in many applications. It can have an additional return lip to strengthen the section.

• These may include the following:
  – Curtain-wall headers, jambs and sills
  – Drywall headers and jambs
  – Load-bearing jambs
  – Trusses
  – Any other application involving nested stud and track
Heavy-Duty Framing

Benefits

• Since heavy-duty framing has superior strength and carrying capacity, this allows for higher performance with fewer members.

• As a result, it can eliminate the need for box beam headers and nesting track and stud for posts and jambs.

• In addition, it can also improve the finish quality around doors and windows by eliminating excessive material and screw head buildup.
Heavy-Duty Framing

Benefits cont'd...

• Other benefits of heavy-duty framing include, bending strength in two directions, reduction of installation time by approximately 50%, reduction of material and labor costs (up to 50%), the ability to be screw-attached from either side, can be used in openings up to 15' wide and it has superior axial strength.

• As mentioned above, heavy-duty framing systems can also allow for cost savings. Below is a chart of potential cost savings for window headers and jambs.

<table>
<thead>
<tr>
<th>Window Width (ft)</th>
<th>Conventional Framing</th>
<th>HDS Framing</th>
<th>Savings</th>
<th>Conventional Framing</th>
<th>HDS Framing</th>
<th>Savings</th>
<th>Total Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>$67</td>
<td>$66</td>
<td>$1 (2%)</td>
<td>$38</td>
<td>$19</td>
<td>$19 (50%)</td>
<td>$20 (19%)</td>
</tr>
<tr>
<td>8</td>
<td>$107</td>
<td>$104</td>
<td>$3 (5%)</td>
<td>$71</td>
<td>$21</td>
<td>$50 (70%)</td>
<td>$53 (30%)</td>
</tr>
<tr>
<td>10</td>
<td>$138</td>
<td>$122</td>
<td>$16 (12%)</td>
<td>$92</td>
<td>$23</td>
<td>$69 (75%)</td>
<td>$85 (37%)</td>
</tr>
</tbody>
</table>

**Table Notes**

1) Based on a wall height of 12' with 1' parapet, with 30 psf wind load and L/600 deflection.
2) Assumed screw cost is $0.02 per screw.
3) Framing labor assumed to be $1.00 per foot of header.
4) Labor savings associated with header installation neglected.
Heavy-Duty Framing

Heavy-Duty Header Bracket

• The heavy-duty header bracket is an innovative complement to the heavy-duty framing system.

• The heavy-duty header bracket makes it possible for one person to perform curtain-wall header installation.

• The heavy-duty header bracket is a pre-punched clip that eliminates surface head fastener buildup that can potentially create finishing challenges.
COMMON EXTERIOR FRAMING MISTAKES
Introduction

Some common mistakes made with exterior light-gauge steel framing are:

- Improper Spandrel Framing
- Inadequate Knee Walls
- Insufficient Edge Distance
- Underbidding Tall Walls

These conditions are commonly overlooked by architects and engineers.
Common Exterior Framing Mistakes

Improper Spandrel Framing

- In many cases, spandrel framing above continuous windows (i.e. windows that are wider than 15'-0") are improperly specified.

- Cold-formed built-up headers are not capable of spanning across a continuous opening wider than 15'.

- In this case, framing must be hung from the connection to the roof and the connection must be rigid and capable of resisting vertical loads.
Common Exterior Framing Mistakes

Improper Spandrel Framing Cont'd...

- Sometimes this rigid connection is mistakenly shown on drawings as a slip connection, which of course cannot support vertical loads.

- In situations where slip connections are required, they must be provided by the window manufacturer at the head of the window.
Common Exterior Framing Mistakes

Inadequate Knee Walls

- One condition that is commonly overlooked is excess loading of the knee wall below a wide window. With windows wider than about 15'-0", the cripple studs located below the window rely entirely upon the base connection in order to prevent the "hinge" type failure shown on the following slide.

- In this case, the connection at the base of the wall must be specially designed and constructed or vertical structural steel must be added to the wall in order to provide a second connection point for the cripple studs.

- Both options are much more costly that standard stud and track shot down to the concrete with PAFs. As a result, when bidding a job with wide windows, the contractor should add extra money to the bid for the costly connections involved with this condition (if structural steel is not already shown in the wall).
Common Exterior Framing Mistakes

Inadequate Knee Walls Cont'd...

Provide structural steel @ 4' to 6 o/c

Rigid connection difficult without structural steel

Provide structural steel @ 4' to 6 o/c

Hinge Failure

Rigid connection difficult without structural steel
Insufficient Edge Distance

- In order to obtain the allowable capacities listed in manufacturers’ literature, certain spacing and edge distances are required for PAFs.

- In most cases, manufacturers of PAFs require a minimum edge distance of 2" to 3" and a minimum 3" spacing.

- As a result, it is particularly important to consider placement of the studs in relation to the slab edge and edge distance for PAFs for 3-5/8" walls.
Insufficient Edge Distance

- When wall studs are placed off the edge of the slab, it is often impossible to use PAFs because the edge distance requirements cannot be met.

- PAFs are the most commonly used fastener to attach track to concrete, however other options are available.

- Concrete screws have smaller edge distances, but have reduced allowable capacity and require pre-drilling of the concrete, which is slow and costly.
Common Exterior Framing Mistakes

Underbidding Tall Walls

• In many projects, wall framing of the stairwells is not quoted correctly because the requirement for taller studs is not picked up by estimators.

• While spans from landing to landing are typical, the first and top levels generally require taller studs.

• In most cases, this requirement for taller studs results in the use of heavier gauge members, spacing reductions, or use of double studs.
Common Exterior Framing Mistakes

Underbidding Tall Walls Cont’d…

- With brittle finishes, such as brick or stone veneer, the deflection of the wall studs is the determining factor for member sizing.

- In these cases, it is often difficult to get studs for the first and top levels to meet the deflection criteria called out by the architect.

- For these areas, it may be best to add structural steel girts to add a third connection point and make it easier to meet the stud deflection criteria.
The Design Professional will now be able to:

- List the features and characteristics of cold-formed steel C-stud and track products
- Explain the SFIA nomenclature and ASTM standards for cold-formed steel framing products
- List the characteristics and usage of different types of exterior deflection systems
- Describe bridging systems, including spacer bars, u-channels, and block and strap bridging
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- Describe how to avoid common mistakes when framing with cold-formed steel products
An AIA Continuing Education Program
Credit for this course is 1 AIA HSW CE Hour.

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