

"... Welcome! This is a presentation designed to share with you some aspects of Cold-Formed Design which we hope will spark for you a new perspective about Metal Buildings and the many possibilities available, the inherent strengths and some room for innovation...."

Gene Farach, PE Principal Engineer Alliance Engineering, Inc. Baltimore's Office

# "...A Little Personal Background!"

- ✓ Graduate of The University of Florida
- ✓ Structural Engineer with thirty years of practice.
- ✓ Principal of The Farach Group...ten years
- ✓ Author, Researcher, Instructor...
- ✓ Participant on the "Twelfth International Specialty Conference of Cold-Formed Steel Structures"..."Light-Gauge Engineering in Today's Market – The Challenges!"
- ✓ Avid Light-Gauge engineering contributor...







# "...Just for fun and giggles!"

- ✓ Let us compare two framing elements...
  - A wooden 2x4 exterior wall framing stud
  - A 3-5/8" 20 gauge exterior wall framing stud
- ✓ We are going to use 90 MPH wind...
- ✓ We are going to assume that we do not have significant axial load...
- ✓ Compare the strength characteristics of the two framing elements...



### "...Strength Comparison!"

### Wind Loading...



### Stud Design Analysis...

#### Light-Gauge - using a 3-5/8CSJ20 by Dietrich...

#### **Properties:**

$$A = 0.215 \text{ in}^2$$

$$S_f = 0.309 \text{ in}^3 \text{ and } S_c = 0.304 \text{ in}^3$$

$$I_{f_{-x}} = 0.561 \text{ in}^4$$

$$I_{c-x} = 0.551 \text{ in}^4$$

$$r_{\star} = 1.601 \text{ ins}$$

$$r_v = 0.620 \text{ ins}$$

$$x_0 = -1.345 \text{ ins}$$

$$r_0 = 2.066 ins$$

$$J = 0.000115$$

$$C_{w} = 0.300$$

$$F_v = 40 \text{ ksi}$$

$$E = 29,500,000 \text{ psi}$$

$$L_b = \frac{8'-2''}{3}(12) = 32.67 \text{ ins}$$

#### Wood - using a 2X4 - Southern Pine...

#### **Properties:**

$$A^{2x4} = 5.25 \text{ in}^2$$

$$S_x^{2x4} = 3.063 \text{ in}^3$$

$$S_v^{2x4} = 1.313 \text{ in}^3$$

$$I_{x}^{2x4} = 5.359 \text{ in}^4$$

$$I_{y}^{2x4} = 0.984 \text{ in}^4$$

$$F_b = 625 \text{ psi}$$

$$F_t = 350 \text{ psi}$$

$$F_{c} = 1500 \text{ psi}$$

$$F_c^{Perpendicular} = 565 psi$$

$$F_{v}^{Parallel} = 90 \text{ psi}$$

$$E = 1,300,000 \text{ psi}$$

$$L_b = \frac{8'-2''}{3}(12) = 32.67 \text{ ins}$$

Studs are braced at third points...typical.



### **Stud Design Analysis...**

Light-Gauge - using a 3-5/8CSJ20 by Dietrich...

$$\begin{split} F_e &= \frac{C_b r_0 A}{S_t} \sqrt{\sigma_{ey} \sigma_t} \ \text{ where } C_b = 1.0 \\ \sigma_{ey} &= \frac{\pi^2 E}{\left(\frac{K_y L_y}{r_y}\right)^2} = \frac{\pi^2 \left(29.5 \times 10^3\right)}{\left(\frac{32.67}{0.620}\right)^2} = 104.86 \ \text{ksi; where } K_y = 1.0 \\ \sigma_t &= \frac{1}{A r_0^2} \left[ GJ + \frac{\pi^2 E C_w}{\left(K_t L_t\right)^2} \right] \\ \sigma_t &= \frac{1}{0.215 \left(2.066\right)^2} \left[ 11.3 \times 10^3 \left(0.000115\right) + \frac{\pi^2 \left(29.2 \times 10^3\right) \left(0.3\right)}{\left(32.67\right)^2} \right] \\ \sigma_t &= 90.59 \ \text{ksi} \\ F_e &= \frac{1.0 \left(2.066\right) \left(0.215\right)}{0.309} \sqrt{\left(104.86\right) \left(90.59\right)} \\ F_e &= 140.11 \ \text{ksi and...} \\ 0.56 F_y &= 22.4 \ \text{ksi} \\ 2.78 F_y = 111.20 \ \text{ksi} < F_e \ \therefore \ F_c = F_y = 40 \ \text{ksi} \\ M_n &= S_c F_c \ \Rightarrow M_n = 0.304 \left(40\right) = 12.16^{k-\text{in}} \\ W_{\text{max}} &= \frac{8 \left(12.16\right)}{\left(8^3 - 2^* \left(12\right)\right)^2} = 0.010 \frac{k}{\text{in}} = 10.129 \frac{\text{lbs}}{\text{in}} \end{split}$$



### **Stud Design Analysis...**

Light-Gauge - using a 3-5/8CSJ20 by Dietrich...cont.

$$\begin{split} &\Delta_{\frac{L}{360}} = \left(\frac{\left(8'-2"\right)12}{360}\right) = 0.272 \text{ ins} \\ &\Delta_{\frac{L}{240}} = \left(\frac{\left(8'-2"\right)12}{240}\right) = 0.408 \text{ ins} \\ &W_{\text{max}}^{\frac{L}{360}} = \frac{0.272 \left(384\right)29.5 \times 10^3 \left(0.551\right)}{5 \left(8'-2"\left(12\right)\right)^4} = 0.004 \frac{\text{kips}}{\text{in}} = 3.68 \frac{\text{lbs}}{\text{in}} \\ &W_{\text{max}}^{\frac{L}{240}} = \frac{0.408 \left(384\right)29.5 \times 10^3 \left(0.551\right)}{5 \left(8'-2"\left(12\right)\right)^4} = 0.006 \frac{\text{kips}}{\text{in}} = 5.52 \frac{\text{lbs}}{\text{in}} \end{split}$$



### **Stud Design Analysis...cont**

Wood - using a 2X4 - Southern Pine...

$$I_u = 32.67 \text{ ins}$$

$$\frac{I_u}{d} = \frac{32.67}{3\frac{1}{2}} = 9.33 \therefore 7 \le \frac{I_u}{d} \le 14.3 \implies I_e = 1.63(I_u) + 3d$$

$$I_e = 1.63(32.67) + 3(3.5) = 63.75$$
 ins

$$R_B = \sqrt{\frac{I_e(d)}{b^2}} = \sqrt{\frac{63.75(3.5)}{1.5^2}} = 9.958 < 50 \text{ OK}.$$

$$K_{bE} = 0.438$$
, since  $COV_E > 0.11$ 

$$\frac{K_{bE}}{R_B^2} (E_y) = \frac{0.438 (1.3 \times 10^6)}{(9.958)^2} = 57,255 \text{ psi}$$

$$\frac{\mathsf{F}_{\mathsf{bE}}}{\mathsf{F}_{\mathsf{b}}} = \frac{57,255}{625} = 91.61$$

$$C_{L} = \frac{1 + \frac{F_{bE}}{F_{b}}}{1.9} - \left[ \sqrt{\left[ \frac{1 + \frac{F_{bE}}{F_{b}}}{1.9} \right]^{2} - \frac{F_{bE}}{F_{b}}} \right]^{2} - \frac{F_{bE}}{0.95}}$$

$$C_{L} = \frac{1+91.61}{1.9} - \left[ \sqrt{\left[ \frac{1+91.61}{1.9} \right]^{2} - \frac{91.61}{0.95}} \right] \cong 1.00$$

$$C_{L} = 1.00$$

$$C_v = K_L \left(\frac{5.125}{b}\right)^{1/x} \left(\frac{12}{d}\right)^{1/x} \left(\frac{21}{L}\right)^{1/x} \le 1.0 \text{ where } x = 20 \text{ for Southern Pine}$$



### Stud Design Analysis...cont

Wood - using a 2X4 - Southern Pine...cont.

$$K_1 = 1.0$$
 (...for uniformly distributed load) ::

$$C_{V} = 1.0 \left( \frac{5.125}{1.5} \right)^{\frac{1}{20}} \left( \frac{12}{3.5} \right)^{\frac{1}{20}} \left( \frac{21}{8.17} \right)^{\frac{1}{20}} = 1.186$$

$$C_{V} = 1.186 > C_{L} USE!$$

$$F'_{b} = 1.186(625) = 741 \text{ psi}$$

$$M_{\text{max}} = F'_{b}(S_{x}) = 741(3.063) = 2,270^{\text{lbs-in}} = 189^{\text{lbs-ft}}$$

$$w_{\text{max}} = \frac{8(189)}{(8.17)^2} = 22.7 \frac{\text{lbs}}{\text{ft}} = 1.89 \frac{\text{lbs}}{\text{in}}$$

$$\Delta_{\frac{L}{360}} = \left(\frac{(8'-2")12}{360}\right) = 0.272 \text{ ins}$$

$$\Delta_{\frac{L}{240}} = \left(\frac{(8'-2")12}{240}\right) = 0.408 \text{ ins}$$

$$w_{\text{max}}^{\frac{1}{360}} = \frac{0.272(384)1.3x10^{6}(5.359)}{5(98)^{4}} = 1.58 \frac{\text{lbs/in}}{3}$$

$$w_{\text{max}}^{\frac{1}{240}} = \frac{0.408 (384) 1.3 \times 10^6 (5.359)}{5 (98)^4} = 2.367 \frac{\text{lbs/in}}{10}$$



### **Stud Design Analysis...Summary!**

#### Wood - using a 2X4 - Southern Pine...

#### **Limiting Load:**

$$w_{max} = 1.89 \frac{lbs}{in}$$

$$\Delta_{\underline{L}} = 0.272$$
 ins

$$\Delta_{\frac{L}{240}} = 0.408 \text{ ins}$$

$$W_{\text{max}}^{\frac{L}{360}} = 1.58 \frac{\text{lbs}}{\text{in}}$$

$$w_{\text{max}}^{\frac{L}{240}} = 2.367 \frac{\text{lbs}}{\text{in}}$$

$$Spa_{stress}^{max} = \frac{1.89}{14.01} (12) \cong 1'-7"$$

$$Spa_{\frac{1}{260}}^{max} = \frac{1.58}{14.01} (12) \cong 1'-4"$$

$$Spa_{L/240}^{max} = \frac{2.367}{14.01} (12) \cong 2' - 0"$$

#### Light-Gauge - using a 3-5/8CSJ20 by Dietrich...

#### **Limiting Load:**

$$W_{max} = 10.129 \frac{lbs}{in}$$

$$\Delta_{\underline{L}} = 0.272$$
 ins

$$\Delta_{\frac{L}{240}} = 0.408$$
 ins

$$w_{max}^{\frac{1}{360}} = 3.68 \frac{lbs}{in}$$

$$w_{max}^{\frac{1}{240}} = 5.52 \frac{lbs}{in}$$

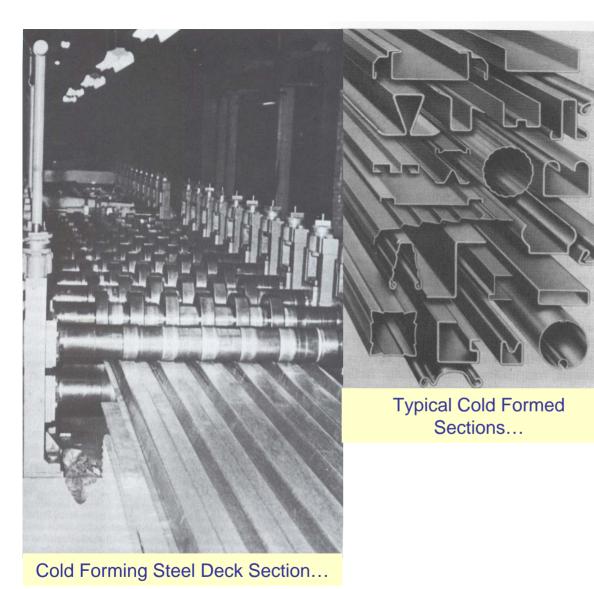
$$Spa_{stress}^{max} = \frac{10.129}{14.01} (12) \cong 8' - 8"$$

$$Spa_{\frac{1}{360}}^{max} = \frac{3.68}{14.01} (12) \cong 3' - 2"$$

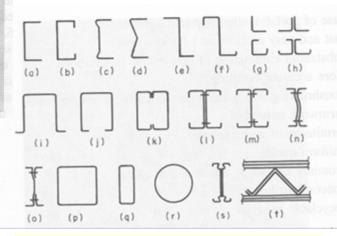
$$Spa_{L/240}^{max} = \frac{5.52}{14.01} (12) \cong 4' - 9"$$

"...Do these numbers in red look familiar?"





# "Brief History ..."



Typical Cold Formed Profiles...



### "Brief History ...cont"

- ✓ The use of Cold Formed steel began on or about the 1850s in the US and the UK…but, it was not until the 1942s when its use became widely for use in steel buildings
- Since 1946 the use and development of thin-walled Cold-Formed steel has accelerated mostly due to the development of design codes and the extensive research conducted at Cornell University since 1939 under the direction of George Winter and other research centers



### "Brief - Cold Formed Steel..."

- ✓ Steel Construction two families of structural members:
  - ✓ Hot-Rolled, and
  - ✓ Cold-Formed
- ✓ Hot-Rolled are the familiar structural shapes such as wide flanges, channels, angles and structural plates and
- ✓ Cold-Formed are metal studs, structural steel decks, tubes...
- Structural sections are Cold-Formed from steel sheets, strips, plates or flat bars in cold-forming machines or by press or bending press operations
- ✓ The thicknesses vary from 0.0149 ins to 0.25 ins and up to 1 in
  in the case of plates and flat bars
- ✓ Cold-Formed steel is used in car bodies, railway coaches, various types of equipment, storage racks, grain bins, transmission towers...We will limits our discussion to buildings.



### "Brief - Cold Formed Steel...cont"

- ✓ Advantages of the use of Cold-Formed members:

  - ✓ Unusual sectional configurations can be produced with excellent strength-to- weight ratios
  - ✓ Nestable sections allow for compact packing and shipping while providing greater strengths
  - And among many others the manufacturing process allows for a durable recyclable building material

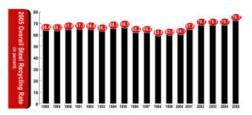


### "Brief - Cold Formed Steel...cont"

#### STEEL RECYCLING RATES AT A GLANCE

2005 STEEL RECYCLING RATES

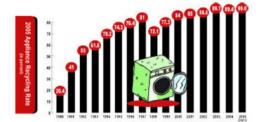
**Overall Rates** 



**Steel Can Recycling** 



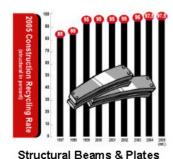
**Appliance Recycling** 



**Automobile Recycling** 



#### **Construction Recycling**



Reinforcement Bars & Other



# **Old Meets New In Orlando** "Cold Formed Steel...Manufacturers" Tyvek Tvvek Tyvek Griffic windows are old, comput-ers are new Combinatione to old, lead bearing lightweight steel framag is new Put and andrew together structure and you much come up with some structure for graphy intensions. Gene Farich could be described in a mode



### "Cold Formed Steel...Manufacturers, cont"

- ✓ Cemco
- ✓ Unimast
- ✓ AllSteel
- ✓ AMICO
- ✓ Dale
- ✓ Dietrich Industries
- ✓ AMICO/MAS
- ✓ Clark
- ✓ Bostwick
- ✓ Incor





### "Cold Formed Steel...Manufacturers, cont"

### Not all stud are created equal...

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### "Cold Formed Steel...Manufacturers, cont"

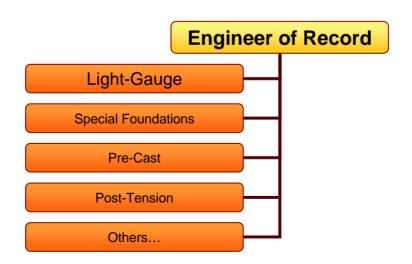
Manufacturer	Area	lxx	lyy	Sxx		
Cemco	0.480	2.491	0.165	0.830		
Unimast	0.397	2.351	0.144	0.779		
AllSteel	0.435	2.229	0.122	0.741		
AMICO	0.320	2.467	0.143	0.822		
Dale	0.441	2.268	0.139	0.733		
Dietrich	0.397	2.394	0.140	0.798		
AMICO/MAS	0.435	2.599	0.172	0.866		
Clark	0.320	2.467	0.143	0.822		
Bostwick	0.463	2.392	0.152	0.797		
Incor	0.358	2.406	0.137	0.802		

- ✓ Typical 6" 18 gauge stud
- ✓ 1-5/8" flange width



# "Role – Structural Engineer of Record"

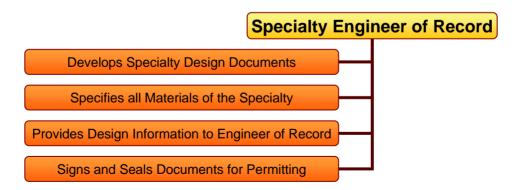
- ✓ Responsible for the *Entire* structural engineering aspects of the project
- Responsible for the Design and Code compliance
- ✓ Responsible for the Coordination between Structural Specialties and the structural design of the project
- Responsible for the submission of the permitting Structural part of the project





# "Role – Specialty Engineer of Record"

- Responsible for the *Portion* of the specialty services provided on the project *Only*!
- ✓ Responsible for the Design and Code compliance of the specialty
- Responsible for providing the engineer of record with pertinent information affecting the structural design of the project
- Responsible for the submission of the specialty's permitting part of the project

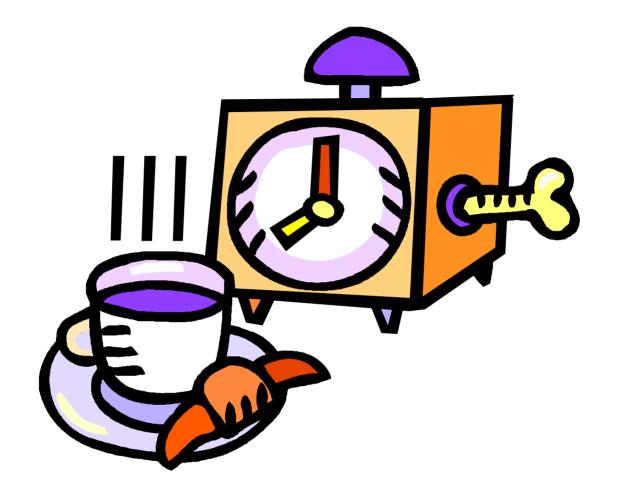




# "Specialty Engineer and Engineer of Record"

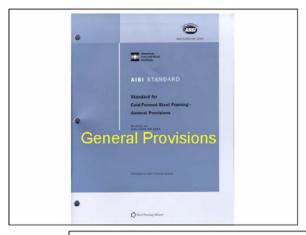
### **Present Practice – Pitfalls...**

- Specialty Engineer works for the manufacturing industry and the primary goal is to sell product
- ✓ Specialty Engineer is mostly concerned with the proprietary design issues and lacks in the integral resolution of design solutions of the whole...
- ✓ Specialty Engineer's "loyalty" rests with the manufacturer and not with the project's Owner...
- ✓ Specialty Engineer in some instances works for the Contractor and not the Engineer of Record
- ✓ Engineer of Record divorces his work from that of the Specialty Engineer providing for a division of responsibility not always in the interest of the project's Owner
- Engineer of Record relies on the signed and sealed documents of the Specialty Engineer a conflict of interest for the Owner



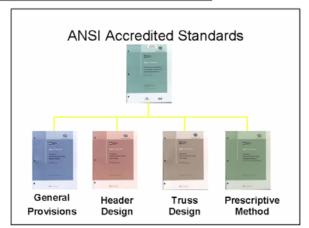
15 Minute Break...

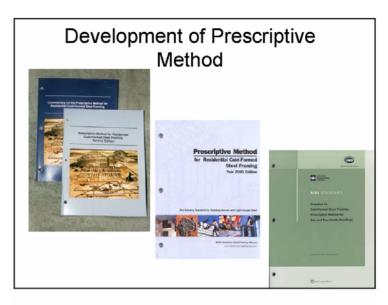


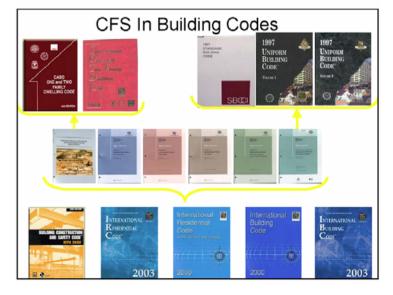








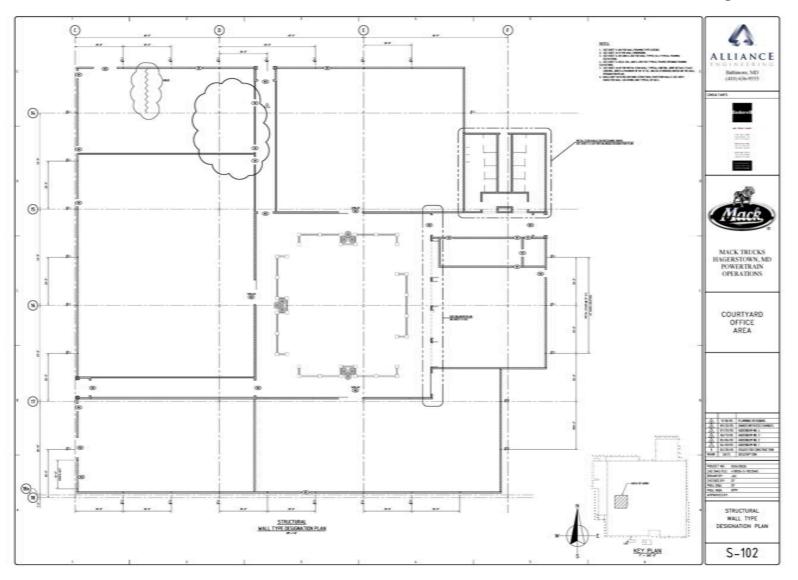




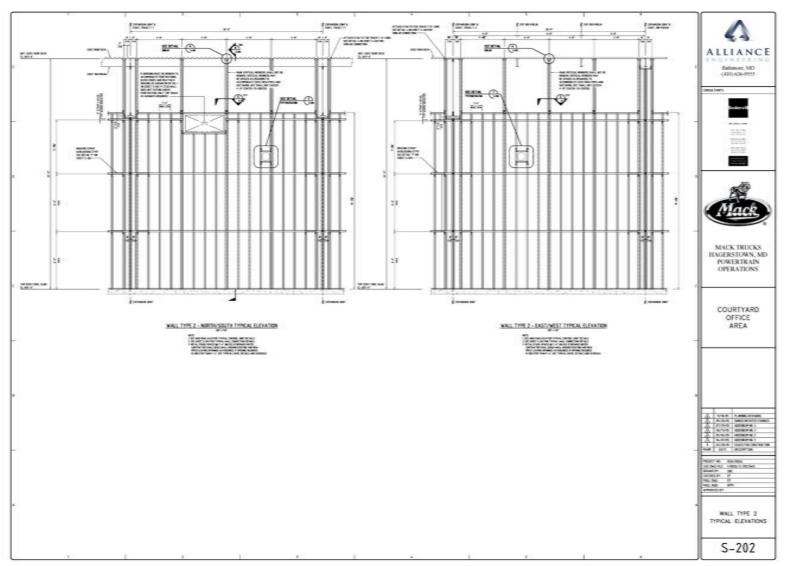




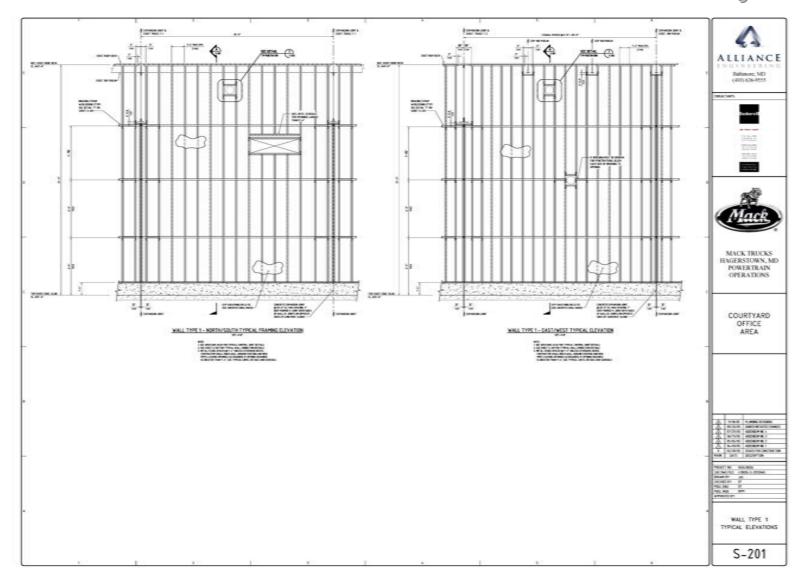




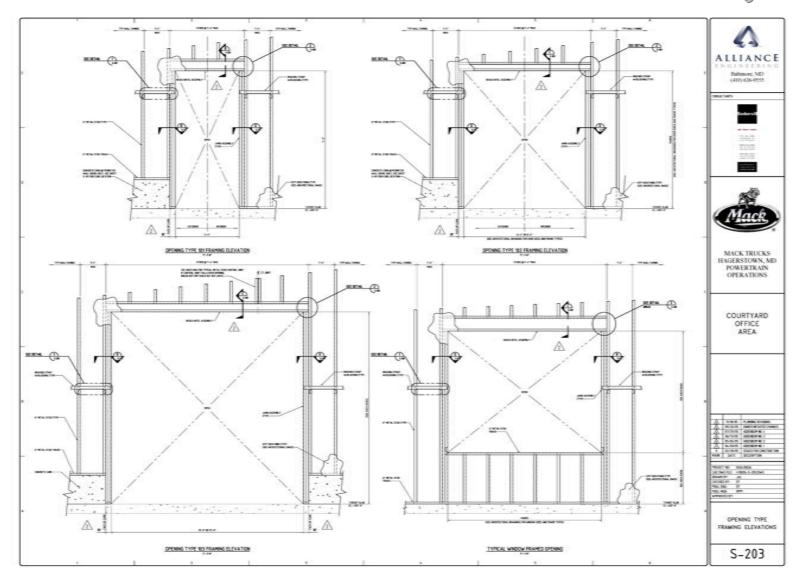






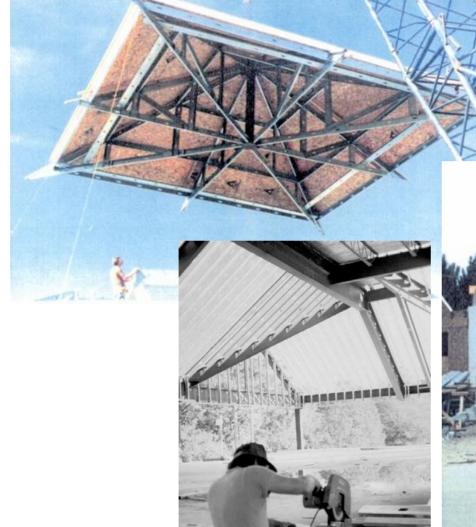








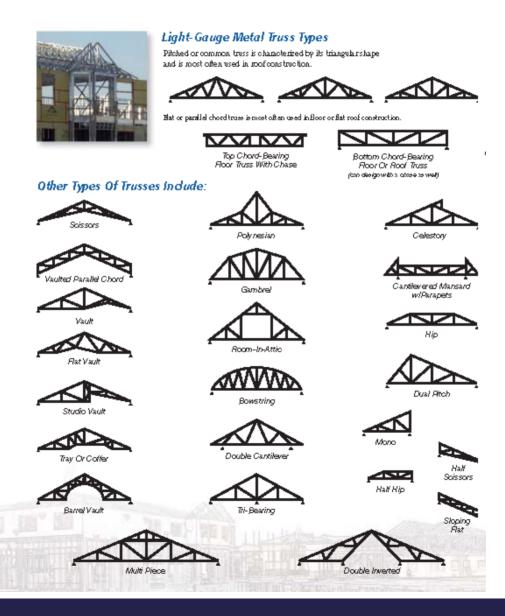
# "Truss Systems..."





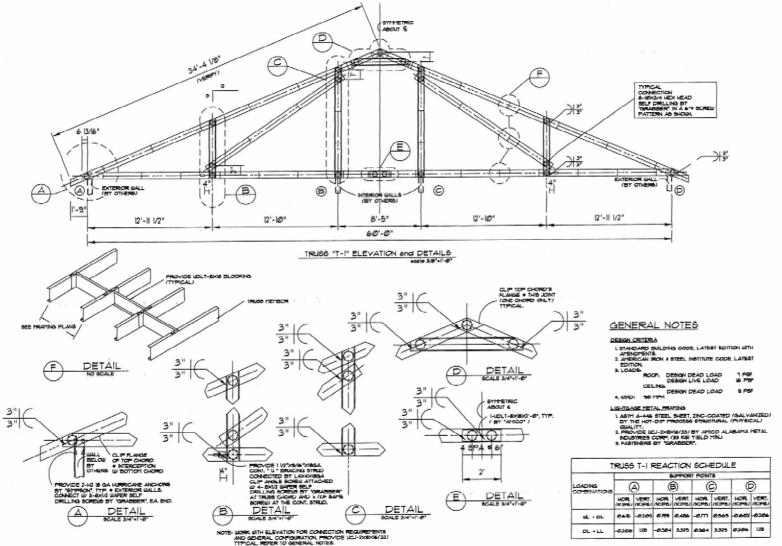


# "Truss Systems..."





"Truss Systems..."



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FILE N° - VET-TI

STATE DOMICILIARY HOME FOR THE VETERANS

designed EF drawn EF checked EF 3/10/00

drawing number LG-5



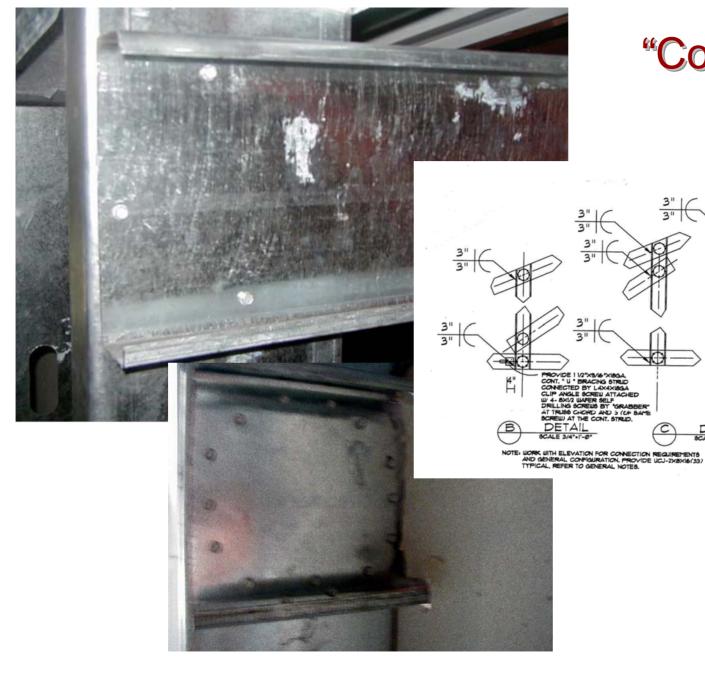
CLIP TOP CHORD'S FLANGE & THIS JOINT (ONE CHORD ONLY) TYPICAL.

DETAIL SCALE 3/4".1"-0"

SYMMETRIC ABOUT &

SCALE 3/4" - 1"-0"

DETAIL SCALE 3/4"-1"-0" I-UDLT-6XI6X2'-0", TYP.





### "Connections...cont"

### **Connection types...**

- ✓ Screwed
- ✓ Welded...or
- ✓ A combination thereof, and...
- ✓ Others...



### "Connections...cont"

### Screw types...







### Screw allowable loads for design...

#### TABLE 1-METAL-TO-METAL CONNECTIONS, ALLOWABLE SCREW LOADS FOR TENSION AND SINGLE SHEAR (pounds)

#### GAGE OF MATERIAL NOT IN CONTACT WITH SCREW HEAD

GAGE OF MATERIAL IN CONTACT WITH SCREW HEAD GAGE 25 25 20 18 12 12 16 16 14 0.0188 0.0188 0.0346 0.0451 0.0713 0.0713 0.1017 0.1017 Thickness (inch) 0346 0.0451 0.0565 0.0565 Thickness (mm) 18 18 33 33 43 54 54 68 68 97 97  $F_v = ksi$ 33 33 33 33 33 50 50 50 33 50 Allowable Shear Nominal Shear Tension Shear Tension Tension Shear Tension Shear Tension Shear Tension Loads Screw (pullout) (pullout) (pullout) (pullout) (pullout) (pullout) Dia. (inch) #7 Streaker 0.151 98 40 327 89 #8 Streaker 0.164 130 58 314 137 #6 Self-drill 0.138 223 95 319 115 317 #8 Self-drill 0.164 272 106 418 136 382 177 405 180 #10 Self-drill 0.19 271 147 429 166 533 217 558 263 664 433 \_ \_ #12 Self-drill 0.216 268 140 435 160 551 233 731 231 814 390 \_ \_ #14 Self-drill 0.250 299 96 451 184 224 798 241 386



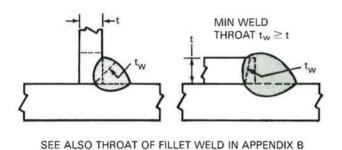


Figure 2.3 — Fillet Welds (See 2.2.4.1)

Figure 2.4A — Single Flare-Bevel Groove Weld (See 2.2.5(1))



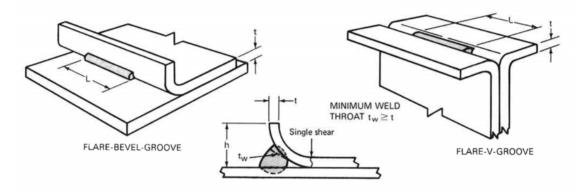


Figure 2.4B — Single Shear in Flare-Groove Welds (See 2.2.5(2))

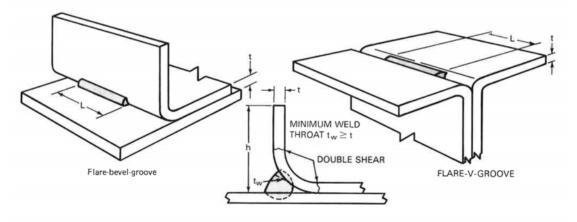
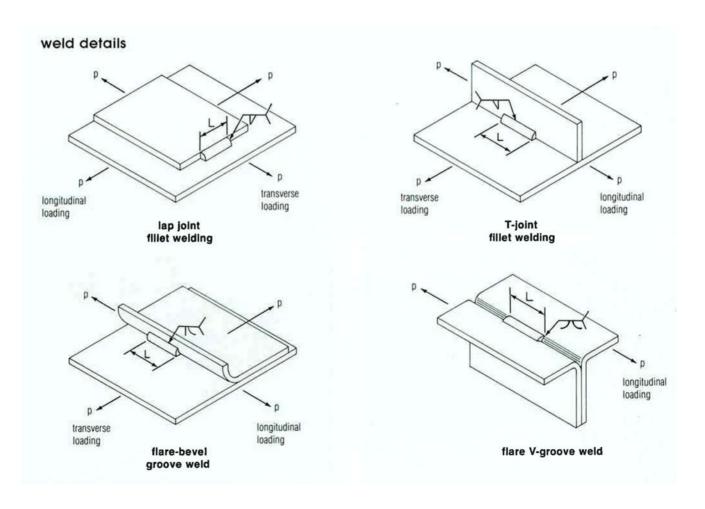


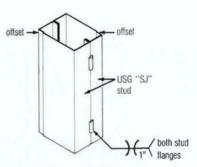
Figure 2.4C — Double Shear in Flare-Groove Welds (See 2.2.5(2))



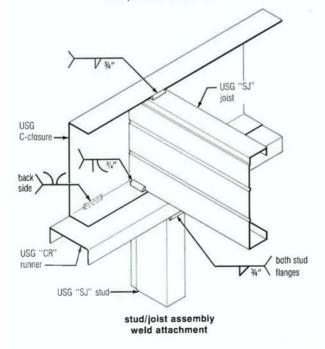


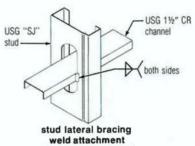


#### Construction Details - weld details (continued)

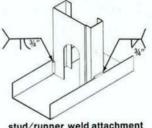


flare V-groove weld multiple stud attachment

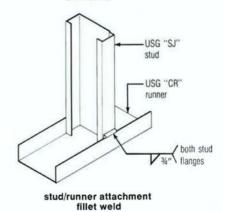




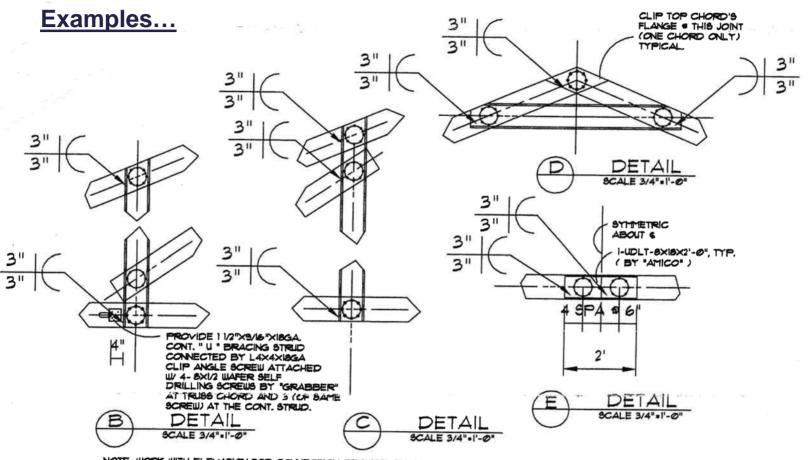
(31/2", 35/4", & 4" members)



stud/runner weld attachment alternate for fixtured fabrication (panelization)

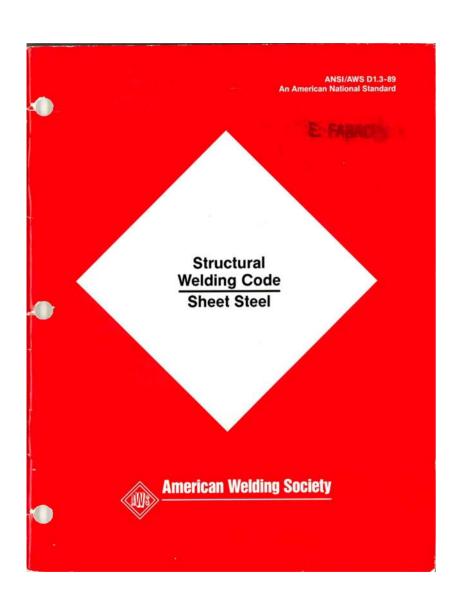


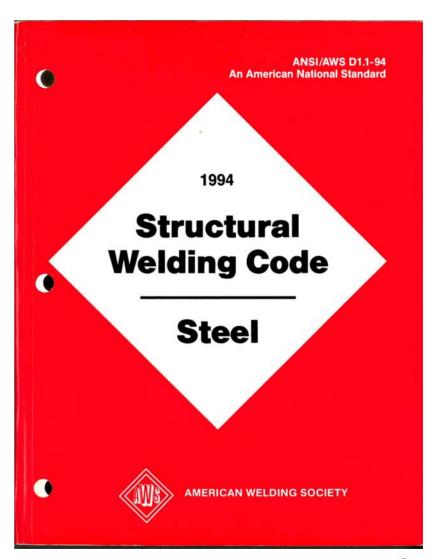




NOTE: WORK WITH ELEVATION FOR CONNECTION REQUIREMENTS
AND GENERAL CONFIGURATION. PROVIDE UCJ-2X8X16(33)
TYPICAL, REFER TO GENERAL NOTES.









#### "Connections...cont – Pre-Manufactured"







#### Cold-Formed Steel Connectors

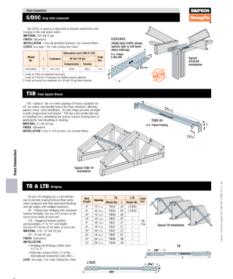
For Residential and Mid-Rise Construction

C-CFS06











Sample calculation...

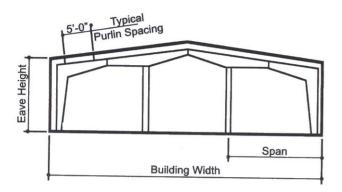








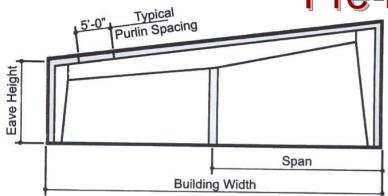
# "Pre-Engineered Buildings"

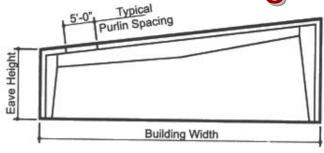


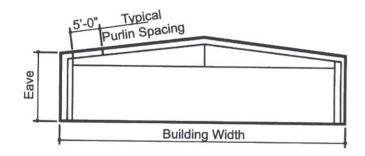


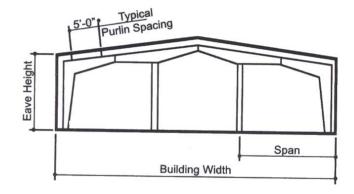


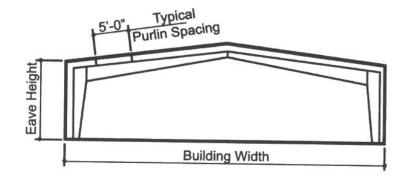


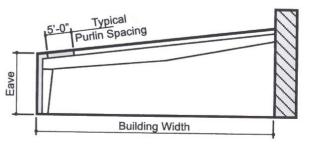




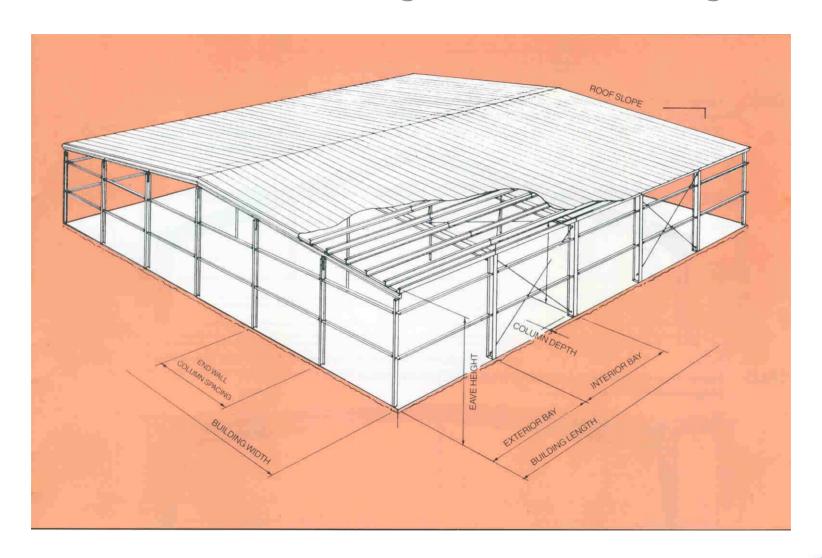




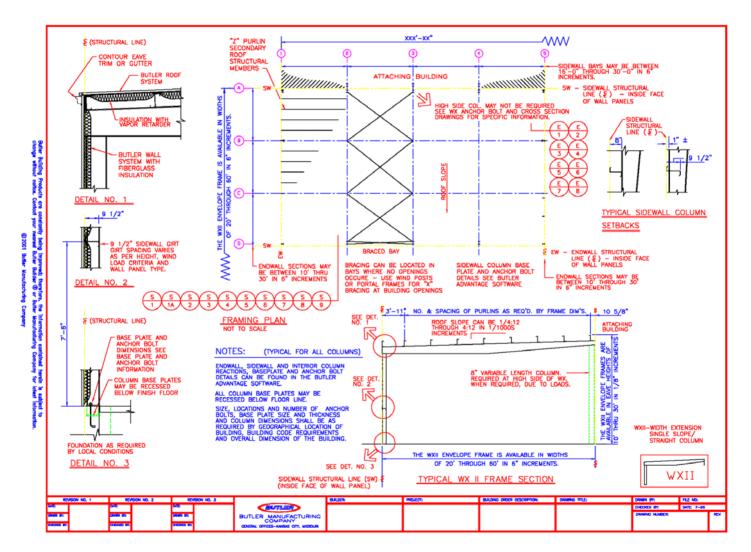




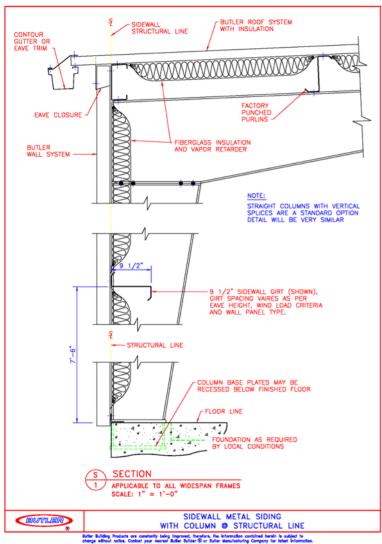




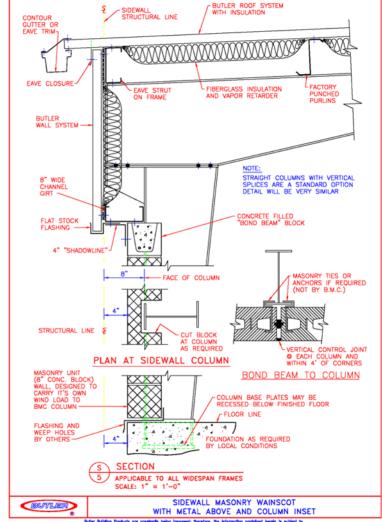








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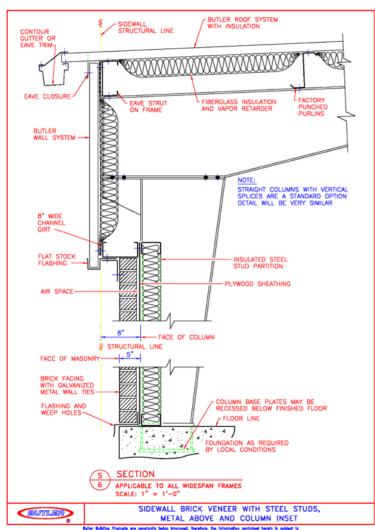


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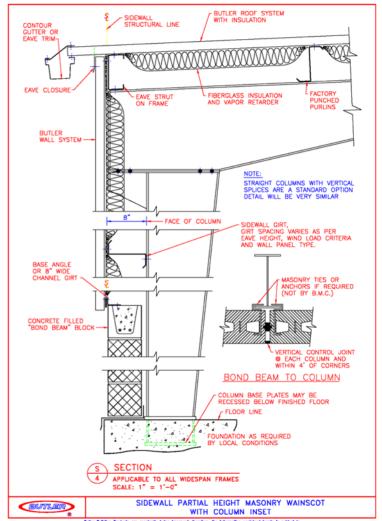
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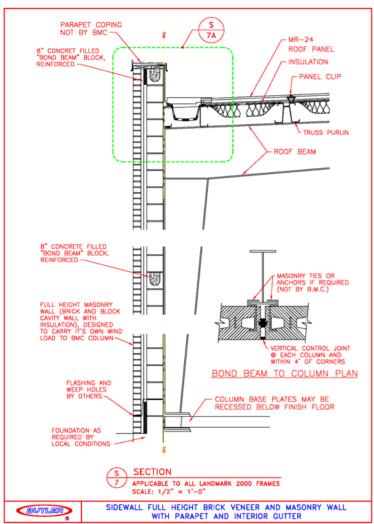
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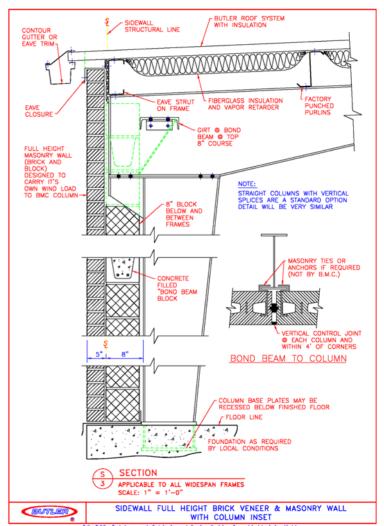


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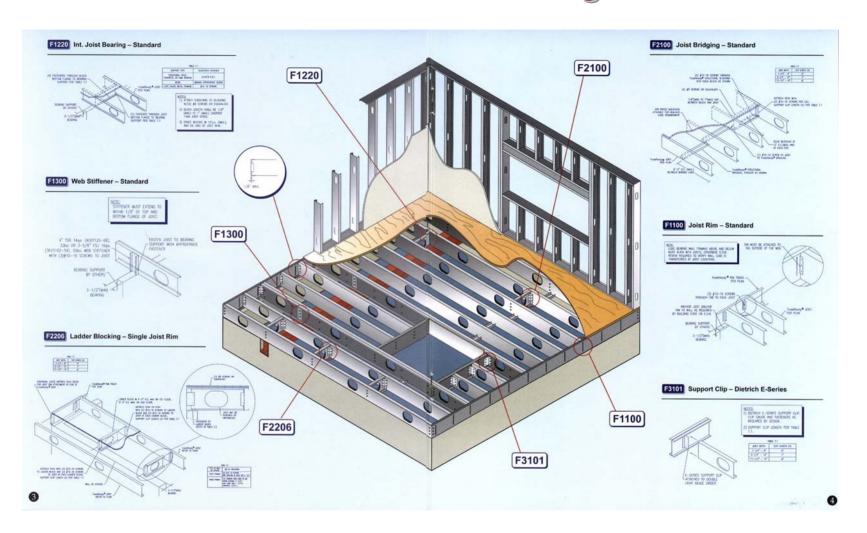


## "Steel Buildings - Homes..."

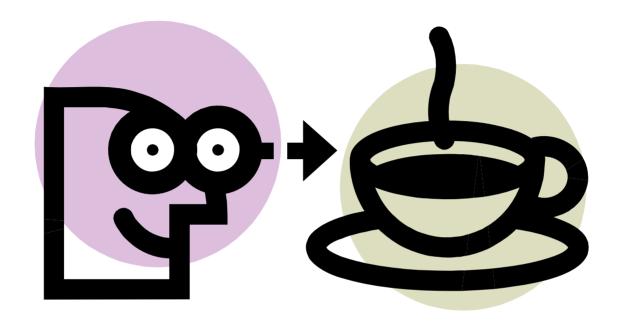
- Throughout the world more builders are switching to steel framing construction
- ✓ USA Structural Engineer with thirty years of practice.
- ✓ Principal of The Farach Group...ten years
- ✓ Author, Researcher, Instructor...
- ✓ Participant on the "Twelfth International Specialty Conference of Cold-Formed Steel Structures"..."Light-Gauge Engineering in Today's Market – The Challenges!"
- ✓ Avid Light-Gauge engineering contributor...



# "Steel Buildings - Homes..."







# 15 Minute Break...

