3

CASE STUDY: R-ANELL HOUSING GROUP, LLC

R-Anell Housing Group is a producer of both modular and HUD-code homes. The company is headquartered in Denver, North Carolina. It has two manufacturing facilities: one in Denver, NC and the other in Cherryville, NC. The Denver plant uses wood framing systems to produce both modular homes that conform to the International Residential Code and HUD-code homes built to the preemptive HUD manufactured home standards. R-Anell distributes its homes through builders (modular) and retailers (manufactured) with most homes sold throughout the southeastern and Middle Atlantic states.

The Cherryville operation, formerly one of the largest home manufacturing facilities in the nation, was recently refitted to produce steel-frame commercial structures. These structures are of single-story modular construction using light-gauge components. Entering the market for steel construction required retooling the plant, developing steel fabrication skills, and training plant crews in the handling of steel products. With the combination of steel manufacturing expertise and the existing network of sales centers, R-Anell is well positioned to launch a line of light-gauge steel homes.

3.1 OBJECTIVES OF THE WORK WITH R-ANELL

In contrast to QHP, R-Anell is in the formative stages of evaluating the costs and potential benefits of utilizing light-gauge steel for their residential construction. For R-Anell, steel is a technology that may complement or compete with its wood-framed homes. Steel may have advantages in certain markets, such as inner city construction, where steel framing is widely accepted and may be preferred for certain dwelling types. While the company is well positioned to move into steel-framed, single-family or multifamily manufacturing, it views the technology as an alternative where the hurdles are economic, technical, and market acceptance. In these regards, R-Anell is representative of many manufacturers in the nation that depend on wood framing but are wary of the volatility of wood prices and availability and recognize that steel offers compelling advantages for factory builders.

R-Anell is an ideal partner for pioneering steel technology for other reasons, including the fact that it builds both modular and HUD-code homes. By breaking ground with steel on the modular side, R-Anell is following in the footsteps of a few companies in the Northeast that build steel-framed modulars mainly for multistory housing in inner city areas. However, it is ideally positioned to refine the technology in modular construction and then transfer that knowledge to its HUD-code production.

The initial stages of this assessment required R-Anell to develop a steel design equivalent to one of its popular wood-framed homes to serve as a baseline for cost and manufacturing comparisons. By selecting a best selling model for comparison, R-Anell challenged steel technology to replicate many of the more complex details common to high-end homes.

The goals in conducting such a comparison include the following:

- Determine the relative costs of wood and steel-framed designs on a raw material basis. Like QHP, the company recognizes that this is a first generation and the direct comparison is only a rough approximation of the relative costs for the two framing systems.

- Identify major manufacturing costs associated with a switch to steel. This involves an initial assessment of aspects of the design that will slow production and potentially hinder construction quality. As prototypes will be built in later stages, production line issues were identified by R-Anell based on review of the construction drawings.

- Investigate alternative connection systems. Like QHP, R-Anell has focused on connectors as the key to cost-effectiveness and reducing manufacturing time.

The company also recognizes that other issues that affect the viability of steel are not considered in this early stage of product development, thermal performance being among the most challenging. However, solutions exist for meeting the thermal requirements of the International Residential Code and HUD standard, such as exterior rigid board sheathing often used by steel frame builders in the north. While cost prohibitive for the more modestly priced HUD-code homes, rigid sheathing board is widely accepted in the modular and site building markets in the north.

3.2 GENERAL DESIGN CRITERIA

The design criteria for the R-Anell design were taken from the International Residential Code (2000) for the region containing the majority of R-Anell's new home sales. Some of the design parameters included the following:

Design Loads

- Wind: velocity of 120 miles per hour, exposure C

- Roof live load: 30 pounds per square foot (psf)

- Floor live load: 40 psf

Floor Plan

- Box dimensions: 28 x 60 feet, two sections

- Floor joists: 24 inches on center

- Roof pitch: nominal 9 in 12

- Roof trusses: hinged 24 inches on center

- Eaves: 6-inch sidewall overhang

- Marriage line walls: load bearing in each half with 2 x 4-inch nominal studs at 24 inches on center

- Exterior walls 2 x 6-inch nominal studs 24 inches on center

- Habitable attic with two optional dormers and one overframed gable

3.3 DESIGN DEVELOPMENT

The discussions that follow suggest how steel would be used to form the structural system of the R-Anell model. These details have evolved through an iterative design process involving steel engineering specialists and R-Anell engineering and production offices. Each component of the building is discussed separately. A full set of the steel framing details is provided in Appendix A.

3.3.1 Roof

The roof slope for R-Anell's model is 9 in 12 with the truss system designed to provide an additional 780 square feet of habitable space (Figure 3-1) including space provided by two windowed dormers, accessed by stairs from the first floor. R-Anell currently uses a hinged roof truss to build this high sloped roof in the plant and meet height and width restrictions for road transportation. The steel design attempts to provide this same hinged roof system (Figure 3-2).

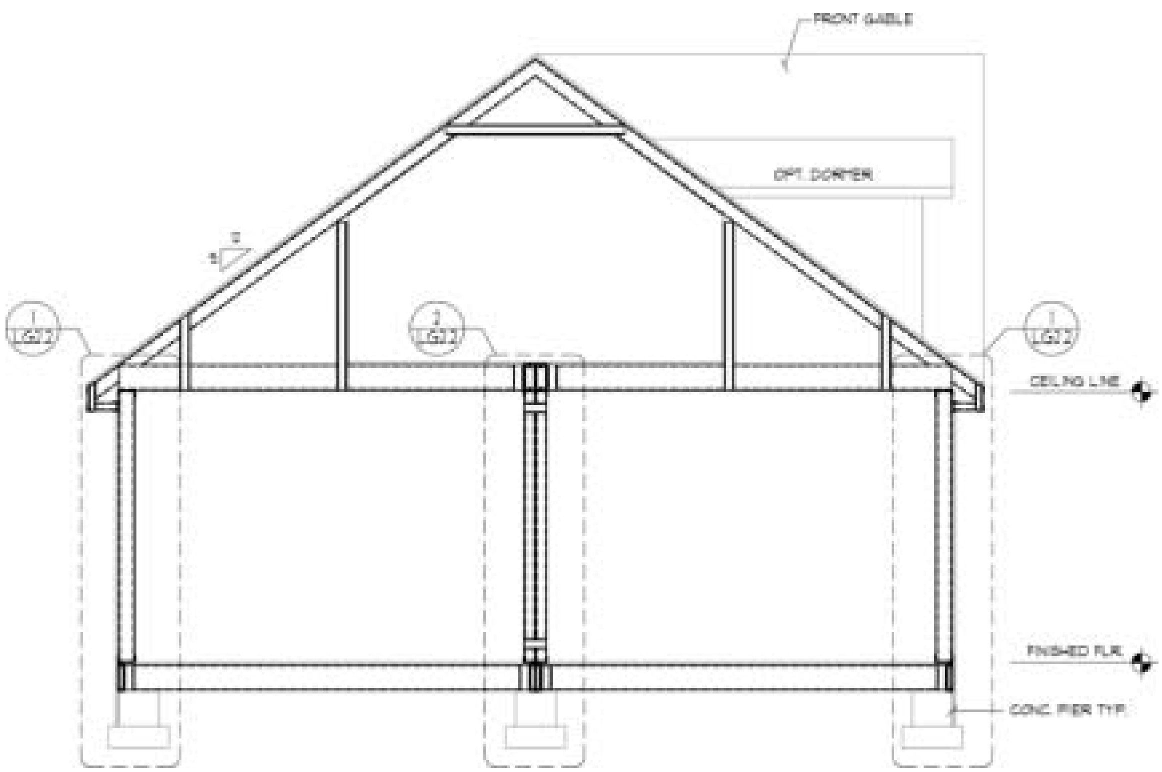


Figure 3-1 Building section

Each roof truss consists of a 9¼-inch deep, 14-gauge bottom chord, a 5½-inch deep, 16-gauge top chord, a 3½-inch deep, 20-gauge collar tie, and two pairs of knee walls utilizing 3½-inch, 18-gauge studs. The bottom chords from each home section end at a continuous boxed beam built up from light-gauge steel members. The chords are connected to the beam with a short section of wall stud in the same fashion as the floor joists are connected to the rim beam.

The top chord is hinged at two locations; one just above the shorter knee wall and the other at the point where the collar tie intersects the chord. The lower hinge allows the roof to fold down to meet the height restriction and the upper hinge allows the top section of the roof to fold back over itself to meet the width restriction. The short outer knee wall supports the top chord so that the lower hinge pivot point is at the proper height above the bottom chord. The inner knee wall pivots on a hinge to fold down into the vertical position when the roof is lifted, thereby serving as a support for the lifted roof. This allows the crane to be released prior to installation of the many fasteners required to complete the roof assembly. Because crane rental time costs several hundred dollars per hour, it is important to minimize the time it is required at the home site.

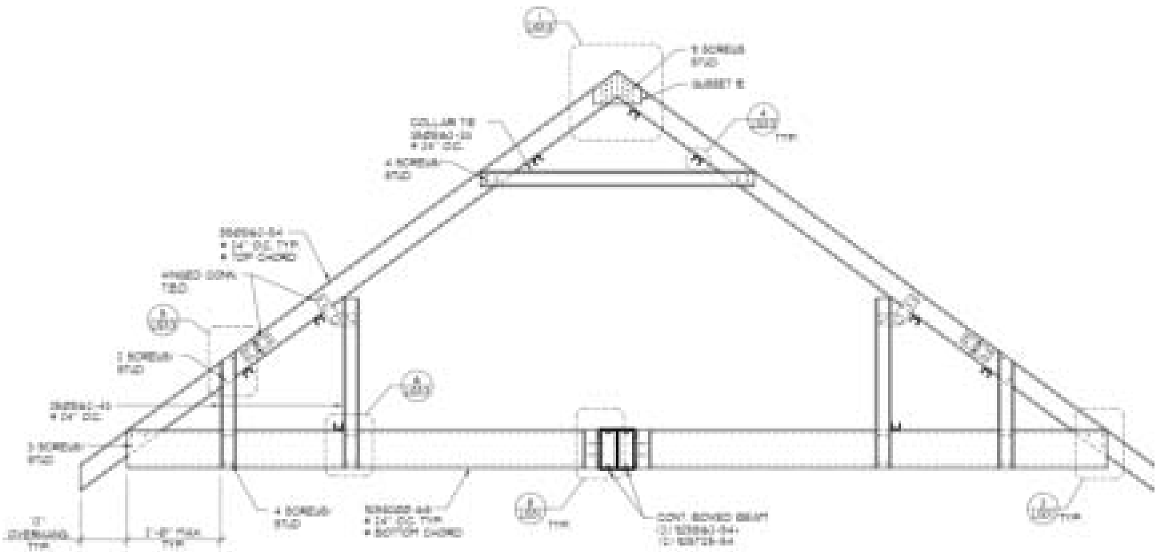


Figure 3-2 Roof truss section

The light-gauge steel hinged roof truss system is one of the components that will require prototyping and testing. Generic details for hinged steel truss sections and the specialized hinge connectors are not readily available, although they may be adaptable from existing wood truss hinge designs. The eccentricity of the steel members (as opposed to symmetrical wood cross-sections) may pose a problem for a steel hinged roof.

The roof design includes a turn-gable constructed of trusses built over the main roof truss system and installed in the field (Figure 3-3).

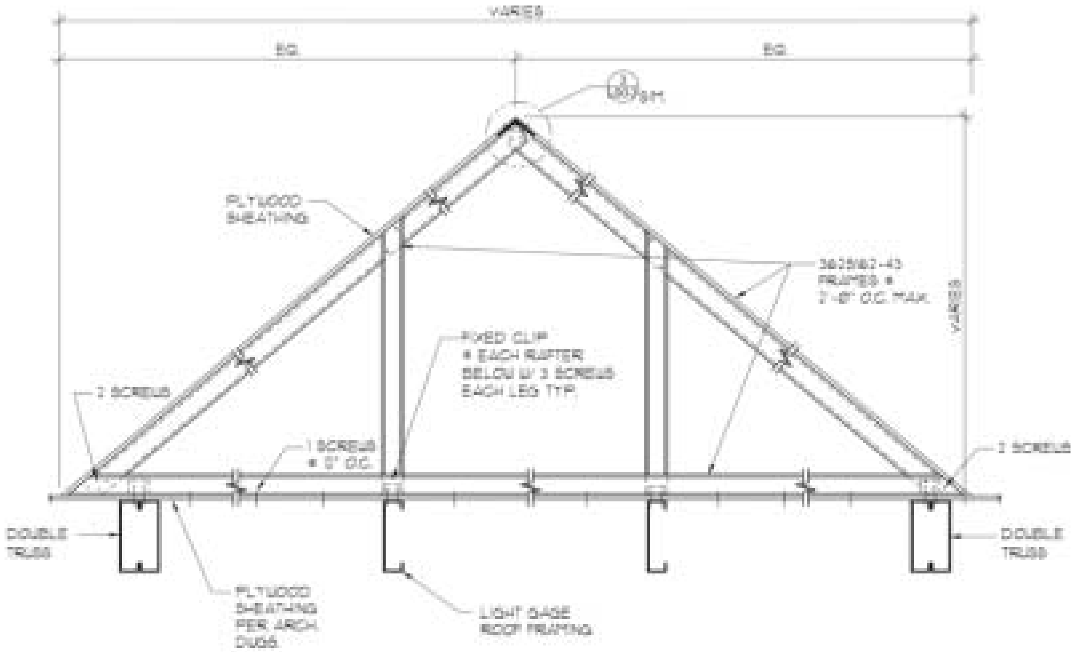


Figure 3-3 Typical overbuild frame detail

Because steel increases in structural efficiency (compared to wood) as spans increase, the short span roof truss may be more economical to build in wood than in steel. The open attic space precludes the typical truss web members and results in the steel members being of a heavier material (14-gauge bottom chords and 16-gauge top chords) than would normally be required for a roof truss of this size. Because of these complications, the design provides the option for using a wood truss as an alternative to steel. It is likely that a hybrid wood/steel design would retain wood framing for the roof system, much as the site builders who pioneered light-gauge steel framing continue to used wood roof framing even after they switched to steel floors and walls.

3.3.2 Walls

Exterior walls are framed with 18-gauge steel studs 5½ inches wide by 1ę inches deep spaced 24 inches on center (Figure 3-4). The marriage walls are made of 20-gauge steel studs 3½ inches wide by 1ę inches deep on each side of the marriage line. All wall studs are spaced 24 inches on center. No blocking or cross-bracing is required on exterior wall studs.

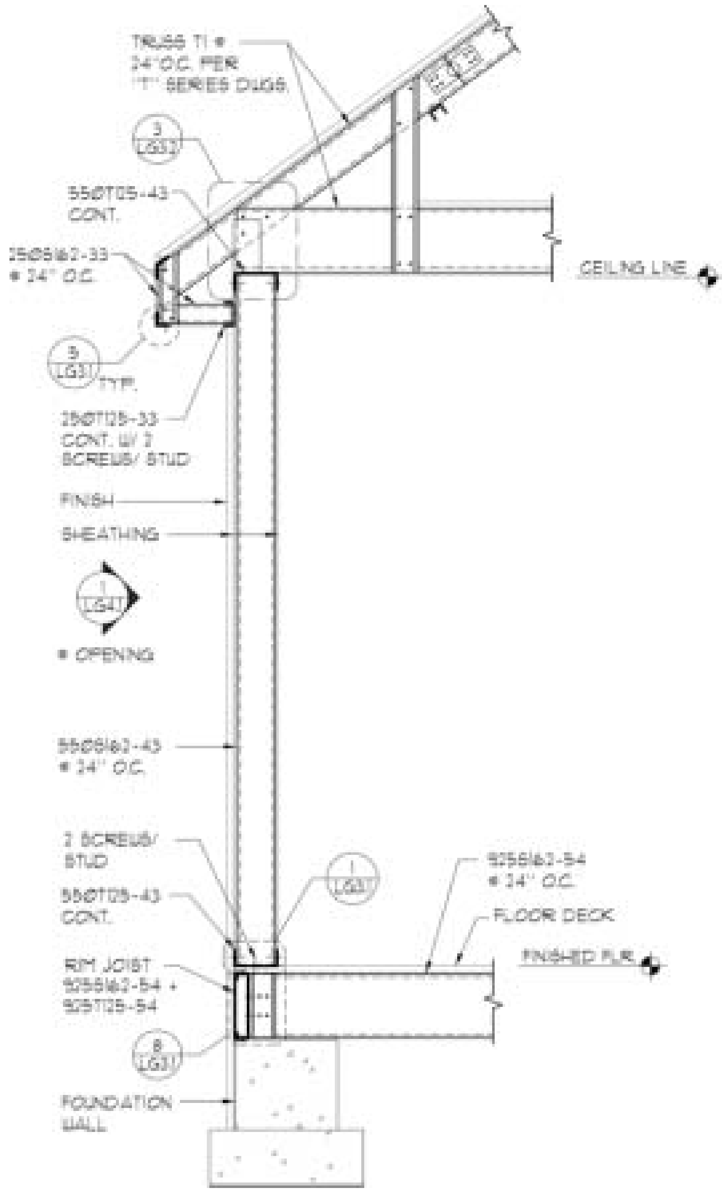


Figure 3-4 Typical section at side wall

Ties between marriage line walls consisting of short sections of wall stud were initially specified at three locations on each stud (Figure 3-5). However, this would preclude installing wallboard on the marriage line walls in the plant. Wall ties were, therefore, limited to locations at marriage line wall openings and ties were added within the floor to connect the rim joists from each half of the home. Lateral stiffness is provided by the wall sheathing consisting of 7/16-inch thick oriented strand board sheathing and gypsum wallboard. Wall studs, roof trusses, and floor joists are aligned vertically, eliminating the need for a structural wall top plate. Only 1¼-inch deep, 18-gauge top and bottom tracks (20 gauge on marriage line walls) are used. Box beams built up from studs and track are used to span marriage wall openings.

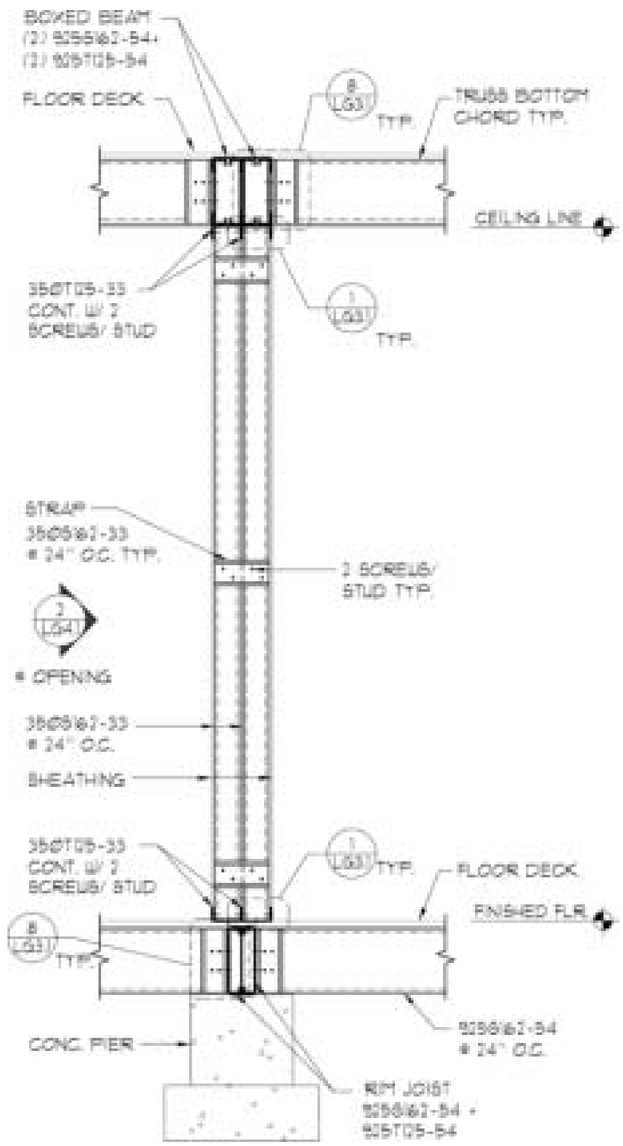


Figure 3-5 Section at marriage wall

R-Anell preferred to use 3½- and 5½-inch wall stud widths for the marriage line walls and exterior walls respectively to maintain the same architectural dimensions of its wood design. Light-gauge steel studs of this width are less common and therefore more costly per foot than the standard 3ę - and 6-inch wide studs. Were R-Anell to go into full-scale production with steel homes, its production volume may be sufficient to eliminate this cost premium.

3.3.3 Floor system

The floor system consists of 16-gauge steel joists, 9¼ inches deep by 1ę inches wide spaced 24 inches on center spanning 13½ feet between rim beams (Figure 3-6) and braced at mid-span (Figure 3-7). The rim beam is made up of a 9¼-inch deep by 1ę -inch wide 16-gauge stud nested within a joist to form a rectangular box beam. Joists butt into the rim beam and are fastened by a 9¼-inch long 3½-inch wide wall stud screwed to one side of the joist and to the rim beam (Figure 3-8). At end walls and under the stair wall, joists are doubled up with the open sides of the C facing toward each other.

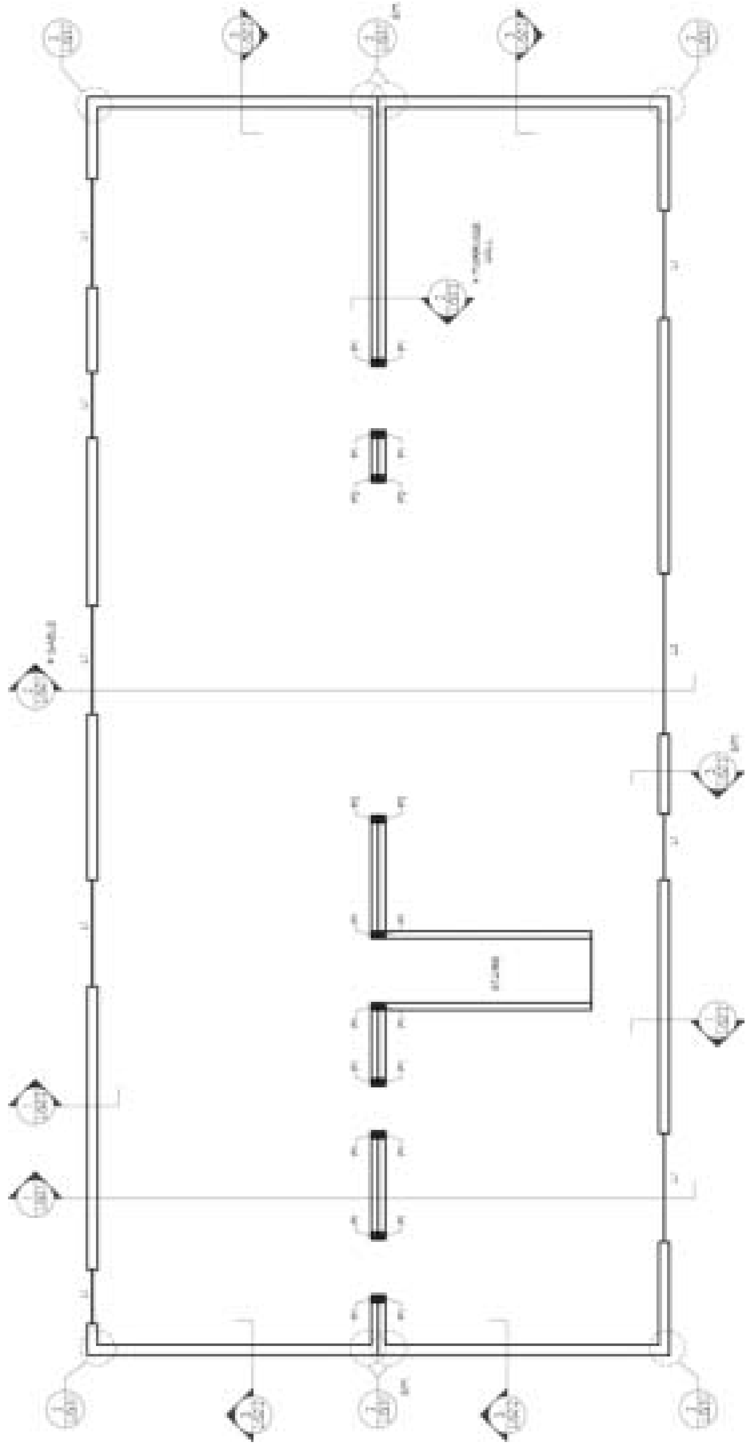


Figure 3-6 First floor wall framing plan

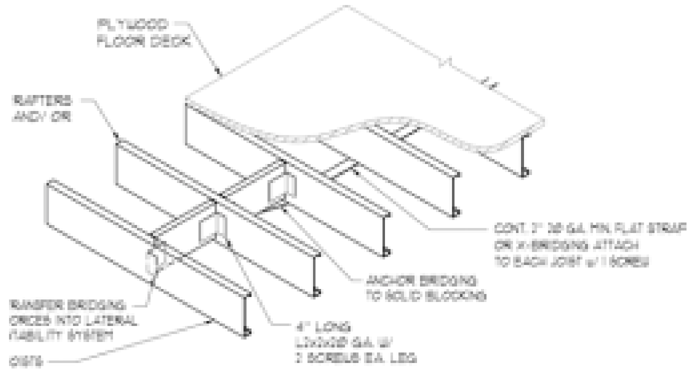


Figure 3-7 Typical floor bracing detail

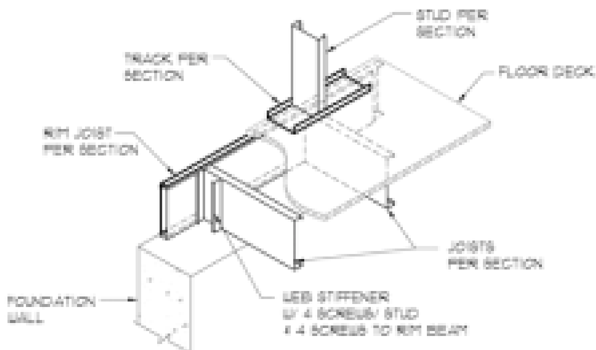


Figure 3-8 Typical rim joist connection detail

3.3.4 Foundation connection

Three strategies for connecting the home to the foundation were discussed as options. The first strategy explored was to screw the rim beam to a 6-inch by 6-inch by 6-inch clip angle fastened to a threaded bolt cast into the concrete pier or foundation (Figure 3-9). To provide the necessary flexibility of placement, the angle would have to be connected through an adjustable slot after the home was set. This would require the bolted and screwed connections to be made from under the home in the crawlspace that may have as little as 20 inches of headroom.

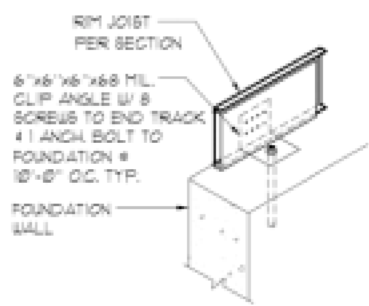


Figure 3-9 Typical detail at foundation edge

A second alternative is to cast a J-bolt with welding plate into concrete and then weld the rim joist to the plate after the home was set. This would have the advantage that no work would be done under the home (except at the marriage line connections for the second home to be set). However, welding is a far more expensive fastening method, particularly when done at the home site. It is also more prone to error and requires unique skills and equipment.

The third and preferred option is to bolt or cast into the foundation a steel strap that would be bent down and away from the bearing surface while the home is being installed and then bent up and screwed into the rim beam from the outside. This version has the advantage of ample installation tolerance, no welding, and no work performed under the home (except for the marriage line of the second half of the home).

The steel design was intended for lifting during installation. It may be lifted by a crane with strapping around the quarter points of the box

3.3.5 Fasteners

A variety of methods are available to fasten light-gauge steel framing members together, including screws, welds, crimping, and even adhesives. The most reliable and cost-effective means for most connections in factory built housing still seems to be the self-tapping screw. They provide a strong, reliable, inexpensive connection and do not require a large investment in equipment. They are, however, labor intensive when numerous screws are required. Including the screws used during field installation and in the plant during fabrication, the R-Anell steel design utilizes an estimated 12,000 screws for light-gauge connections (not including fasteners for applying sheathing). Clearly this is an area that requires attention—both to reduce the number of fasteners and to simplify the fastening system.

3.4 SUGGESTED NEXT STEPS

The technical assistance provided to R-Anell initiated its investigation of steel framing for residential modular construction. This research began the process of describing how this technology may be implemented and identified areas where further research is necessary.

It is anticipated that R-Anell will move forward with product development if the design resulting from the re-engineering effort is cost competitive with traditional wood frame construction. Future efforts may address the following technical issues:

- Development of a hinged roof system using steel members, particularly the hinge detail.
- Fastening options such as welding as an alternative to screws.
- Testing of certain components, such as a steel hinged roof, to demonstrate compliance with applicable standards.
- Development of a two-story design, including framing for stairs and increased structural loads
- Changes to the design requirements that may make the steel design more efficient, such as utilizing more commonly produced 3-ę - and 6-inch wide studs.

- Determination of what steel components (such as roof trusses and the floor system) are most efficient to produce in the R-Anell plant versus out-sourced to fabricators.
- Development of a thermal solution for the northern regions of R-Anell's market, especially for the floor system when the floor is placed over an unconditioned basement or crawlspace.
- Potential integration of structural steel into the floor system to eliminate light-gauge members and fasteners in the rim joists and make the modules easier to transport.

Important cost, manufacturing, systems integration, and marketing issues must also be addressed:

- In-depth cost analysis for both materials and labor.
- Construction of a full-scale home with steel framing or a wood and steel hybrid design.
- Transportation testing of the full-scale home.
- Process engineering analysis and the design of a prototype manufacturing facility based on the use of steel as the primary structural material. This may include a design for the plant layout tailored to an all-steel design or a steel and wood hybrid.
- Effective methods for training plant staff in the use of steel.
- Research into markets, such as inner cities, that are more likely to be receptive to steel-based manufactured homes.
- Consideration of how the use of steel for much of a home's structural framework will engender changes in the use of sheathing and other materials that attach to the home's frame.

APPENDIX A

R-ANELL DRAWINGS

GENERAL NOTES:

1. THESE DRAWINGS ARE FOR THE FABRICATION AND ERECTION OF THE LIGHT GAGE FRAMING SYSTEM ONLY.

2. THE LIGHT GAGE FRAMING MATERIALS ARE MANUFACTURED BY ANY SSMA MEMBER MANUFACTURER. IN ACCORDANCE WITH ASTM C955. MATERIAL SIZES AND GAUGES ARE INDICATED ON THE DRAWINGS. ALL LIGHT GAGE MEMBERS SHALL BE MANUFACTURED FROM SHEET STEEL AND GALVANIZED IN ACCORDANCE WITH ASTM A1003, FORMERLY A653, A924, A525 AND A446, WITH A MINIMUM G 60 COATING.

3. THE MINIMUM YIELD STRENGTH OF THE LIGHT GAGE FRAMING COMPONENTS SHALL BE AS FOLLOWS:

   a) 16 GAGE (54 MILS) OR HEAVIER - MINIMUM 50,000 PSI
   b) 18 GAGE (43 MILS) OR LIGHTER - MINIMUM 33,000 PSI UNLESS NOTED OTHERWISE
   c) ALL TRACKS & ACCESSORIES - MINIMUM 33,000 PSI UNLESS NOTED OTHERWISE
   d) ALL TRUSS AND RAFTER MEMBERS 16 GAGE (54 MILS) OR HEAVIER TO BE MINIMUM 50,000 PSI
   e) ALL TRUSS AND RAFTER MEMBERS 18 GAGE (43 MILS) OR LIGHTER TO BE MINIMUM 50,000 PSI

4. THE LIGHT GAGE WALL STUDS AND FLOOR JOISTS SHALL BE PUNCHED. ALL TRUSS AND RAFTER MEMBERS SHALL BE UNPUNCHED.

5. THE LIGHT GAGE FRAMING HAS BEEN DESIGNED IN ACCORDANCE WITH THE FOLLOWING CODES, LOADS AND SPECIFICATIONS:

   a) IRC 2000
   b) ANSI/ASCE 7-98
   c) WIND LOAD: V=100 MPH, I=1.0, EXPOSURE C
   d) SNOW LOAD: Pg=20 PSF, Ce=0.7, I=1.0
   e) LIVE LOAD: ROOF=30 PSF, FLOOR=40 PSF
   f) AISI 'SPECIFICATIONS FOR DESIGN OF COLD-FORMED STEEL STRUCTURAL MEMBERS'-1996

6. THIS SUBMITTAL IS SUBJECT TO THE REVIEW OF THE PROJECT ARCHITECT AND ENGINEER OF RECORD. LIGHT GAGE MEMBER SIZES AND CONNECTION DETAILS MAY DIFFER FROM THE PROJECT CONSTRUCTION DOCUMENTS.

7. UNLESS NOTED OTHERWISE, THE FOLLOWING ITEMS SHOWN ON THE LIGHT GAGE PLANS, DETAILS AND SECTIONS ARE SHOWN FOR REFERENCE ONLY AND ARE DESIGNED BY OTHERS:

   - FOUNDATIONS AND GRADE SLABS
   - STRUCTURAL CONCRETE SLABS
   - VENEERS, TIES AND CONTROL JOINTS
   - FLOOR AND ROOF DECKING
   - TIMBER FRAMING

   REFER TO THE ARCHITECTURAL AND STRUCTURAL CONSTRUCTION DOCUMENTS FOR DETAILS OF THE ITEMS LISTED ABOVE THAT ARE NOT FULLY DETAILED ON THESE DRAWINGS.

8. DESIGN VERIFICATION OF THE PRIMARY STRUCTURAL SYSTEM TO SUPPORT THE LOADS IMPOSED BY THE LIGHT GAGE FRAMING IS BY OTHERS UNLESS NOTED OTHERWISE ON THE LIGHT GAGE DRAWINGS.

9. REFER TO THE LIGHT GAGE ENGINEERING CALCULATIONS FOR ADDITIONAL DESIGN INFORMATION.

10. REFER TO THE APPROVED CONSTRUCTION DOCUMENTS FOR DIMENSIONS AND ELEVATIONS NOT INDICATED ON THESE DRAWINGS.

11. ALL CONNECTIONS SHALL BE WELDED, SCREWED OR POWDER FASTENED AS INDICATED ON THESE DRAWINGS.

    WELDS - ALL WELDED CONNECTIONS SHALL BE PERFORMED IN ACCORDANCE WITH THE LATEST EDITION OF THE AWS D1.3 SPECIFICATION FOR WELDING SHEET STEEL IN STRUCTURES. ALL WELDING SHALL BE PERFORMED BY AWS CERTIFIED WELDERS. ALL WELDS SHALL BE CLEANED AND COATED WITH RUST INHIBITIVE ZINC PAINT.

SCREWS - #10 SELF DRILLING SCREWS MANUFACTURED BY GRABBER OR HILTI AND INSTALLED PER THE FASTENER MANUFACTURER'S SPECIFICATIONS. MINIMUM 1/2" LENGTH FOR LIGHT GAGE TO LIGHT GAGE CONNECTIONS. (MINIMUM 1-1/2" LENGTH FOR LIGHT GAGE TO TIMBER CONNECTIONS.) SCREWS SHALL BE SPACED A MINIMUM OF 1/2" BETWEEN ADJACENT SCREWS AND FROM METAL EDGES.

POWDER ACTUATED FASTENERS (P.A.F.) - Ø.138" MINIMUM SHANK DIAMETER P.A.F. MANUFACTURED BY RAMSET OR HILTI AND INSTALLED PER THE FASTENER MANUFACTURER'S SPECIFICATIONS.

PROVIDE MINIMUM 1-1/4" LONG P.A.F. FOR LIGHT GAGE CONNECTIONS TO CONCRETE. P.A.F. IN CONCRETE SHALL BE SPACED A MINIMUM OF 4" BETWEEN ADJACENT P.A.F. AND A MINIMUM OF 3" FROM CONCRETE EDGES. MINIMUM P.A.F. EMBEDMENT IN CONCRETE SHALL BE 1-1/8".

PROVIDE MINIMUM 1/2" LONG P.A.F. WITH KNURLED SHANKS FOR LIGHT GAGE CONNECTIONS TO STRUCTURAL STEEL. P.A.F. SHALL BE SPACED A MINIMUM 1-1/2" BETWEEEN ADJACENT P.A.F. IN STRUCTURAL STEEL AND A MINIMUM 1/2" FROM STEEL EDGES. THE P.A.F. POINT SHALL BE DRIVEN COMPLETELY THROUGH THE BACK SIDE OF THE STRUCTURAL STEEL MEMBER.

MASONRY ANCHORS - 1/4" DIAMETER x 2" LONG SELF DRILLING SCREW ANCHORS MANUFACTURED BY RAMSET (TAPCON) OR HILTI (KWIK CON II) AND INSTALLED PER THE FASTENER MANUFACTURER'S SPECIFICATIONS FOR LIGHT GAGE CONNECTIONS TO CONCRETE MASONRY.

DRIVE-IN EXPANSION ANCHORS (MUSHROOM HEAD) - 1/4" DIAMETER x 1-1/4" LONG ZAMAC NAILIN BY RAWL, METAL HIT BY HILTI OR HAMMER SET BY RAMSET AND INSTALLED PER THE MANUFACTURER'S SPECIFICATIONS. ANCHORS IN CONCRETE SHALL BE SPACED A MINIMUM OF 4" BETWEEN ADJACENT ANCHORS AND A MINIMUM OF 3" FROM CONCRETE EDGES. MINIMUM ANCHOR EMBEDMENT IN CONCRETE SHALL BE 1-1/8".

EXPANSION ANCHORS - PROVIDE MINIMUM 3/8" DIAMETER KWIK BOLT II EXPANSION ANCHORS BY HILTI OR EQUAL, WITH A MINIMUM 2-1/2" EMBEDMENT INTO CONCRETE. MINIMUM SPACING BETWEEN ADJACENT EXPANSION ANCHORS TO BE 5". EXPANSION ANCHORS SHALL BE LOCATED A MINIMUM OF 3" FROM CONCRETE EDGES. USE OVERSIZE WASHERS FOR ATTACHING LIGHT GAGE WITH EXPANSION ANCHORS. INSTALL PER THE MANUFACTURER'S SPECIFICATIONS FOR LIGHT GAGE CONNECTIONS TO CONCRETE.

12. ALL MEMBERS SHALL BE CUT SQUARELY FOR ATTACHMENT TO PERPENDICULAR MEMBERS OR SLOPE CUT AS REQUIRED FOR AN ANGULAR FIT AGAINST ABUTTING MEMBERS.

13. FIELD CUTTING OF LIGHT GAGE MEMBERS SHALL BE DONE BY SAWING OR SHEARING. TORCH CUTTING OF LIGHT GAGE MEMBERS IS NOT PERMITTED.

14. DO NOT CUT OR SPLICE LIGHT GAGE FRAMING MEMBERS UNLESS INDICATED BY THESE DRAWINGS.

15. DO NOT BEAR OR CONNECT LIGHT GAGE MEMBERS WITHIN TWELVE INCHES OF THE PUNCHED OPENINGS IN THE MEMBER WEBS UNLESS THE MEMBERS ARE REINFORCED WITH A MINIMUM 18" LONG UNPUNCHED TRACK OR STUD AT THE PUNCH OPENING. THE TRACK OR STUD REINFORCING PIECE SHALL BE THE SAME SIZE AND GAGE AS THE PUNCHED MEMBER. FASTEN THE REINFORCING PIECE TO THE MEMBER WITH A MINIMUM OF FOUR SCREWS.

16. THE LIGHT GAGE FRAMING HAS BEEN DESIGNED TO SUPPORT THE LOADS INDICATED IN THE CALCULATIONS. ADDITIONAL TEMPORARY BRACING AND SHORING SHALL BE PROVIDED AS REQUIRED TO STABILIZE THE FRAMING AND TO SUPPORT CONSTRUCTION LOADS. TEMPORARY BRACING SHALL REMAIN IN PLACE UNTIL PERMANENT BRACING IS INSTALLED AND/OR ADDITIONAL CONSTRUCTION LOADS ARE REMOVED.

17. THE CONTRACTOR SHALL PROVIDE LIGHT GAGE MEMBERS AT THE SIZE AND SPACING INDICATED ON THESE DRAWINGS. LARGER SIZES AND/OR CLOSER SPACING MAY BE SUBSTITUTED PROVIDED THE SUBSTITUTIONS ARE COORDINATED WITH THE PROJECT ARCHITECTURAL AND STRUCTURAL DRAWINGS.

18. THESE DRAWINGS ARE INTENDED TO INDICATE THE MEMBER SIZES AND CONNECTIONS RELEVANT TO THE LIGHT GAGE FRAMING. THESE SHOP DRAWINGS ARE NOT INTENDED TO BE "DIMENSIONED" DRAWINGS AND SHOULD NOT BE USED FOR MATERIAL TAKE-OFFS. REFER TO THE ARCHITECTURAL DRAWINGS FOR REQUIRED MEMBER LENGTHS.

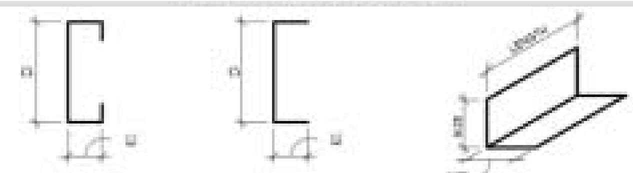
19. SHEATHING ON THE LIGHT GAGE FRAMING SHALL BE INSTALLED AS INDICATED IN THE PROJECT CONSTRUCTION DOCUMENTS AND SPECIFICATIONS AND PER ASTM C955.

20. UNLESS OTHERWISE NOTED, THIS SUBMITTAL DOES NOT INCLUDE THE DESIGN AND DETAILING FOR THE INTERIOR LIGHT GAGE FRAMING.

21. ALL CONSTRUCTION SHALL BE IN ACCORDANCE WITH O.S.H.A. STANDARDS.

22. LIGHT GAGE JOISTS, RAFTERS AND TRUSSES SHALL ALIGN OVER BEARING WALL STUDS UNLESS DETAILED OTHERWISE IN THE SHOP DRAWINGS.

TYPICAL LIGHT GAGE MEMBER DESIGNATION LEGEND (EXAMPLE ONLY)



TYPICAL STUD AND RAFTER — TYPICAL TRACK — TYPICAL ANGLE

MEMBERS ARE DESIGNATED ON THIS SHOP DRAWING AS FOLLOWS:

STUDS AND RAFTERS - 600S162 - 68 (D = 600; S = STUD; W = 162; THICKNESS IN MILS = 68)

TRACKS - 600T125 - 68 (D = 600; T = TRACK; W = 125; THICKNESS IN MILS = 68)

ANGLES - ∠3 x 3 x 68 x 4½ (SIZE = 3 x 3; MILS = 68; LENGTH (INCHES) = 4½)

33 MILS	= 20 GA.
43 MILS	= 18 GA.
54 MILS	= 16 GA.
68 MILS	= 14 GA.
97 MILS	= 12 GA.

125 = 1.25" = 1¼"	250 = 2.5" = 2½"	550 = 5.5" = 5½"
137 = 1.37" = 1⅜"	300 = 3.0" = 3"	600 = 6.0" = 6"
162 = 1.62" = 1⅝"	362 = 3.62" = 3⅝"	725 = 7.25" = 7¼"
200 = 2.00" = 2"	400 = 4.0" = 4"	800 = 8.0" = 8"

THE LEGEND NOTED ABOVE IS AN EXAMPLE OF HOW TO READ THE STEEL STUD MANUFACTURERS ASSOCIATION (SSMA) LIGHT GAGE MEMBER DESIGNATIONS. ACTUAL STUD SIZES, TRACK SIZES AND MIL THICKNESSES REQUIRED FOR THIS PROJECT ARE NOTED ON THE ENCLOSED PLANS, SECTIONS AND DETAILS.

TYPICAL LIGHT GAGE ABBREVIATIONS

&	= AND	MAX.	= MAXIMUM
@	= AT	MFR.	= MANUFACTURER
℄	= CENTER LINE	MTL.	= METAL
ARCH.	= ARCHITECTURAL	MIN.	= MINIMUM
C.R.C.	= COLD ROLLED CHANNEL	O.C.	= ON CENTER
CONC.	= CONCRETE	P.A.F.	= POWDER ACTUATED FASTENERS
C.M.U.	= CONCRETE MASONRY UNIT	PL	= PLATE
CONT.	= CONTINUOUS	±	= PLUS OR MINUS
DEFL.	= DEFLECTION	REQ'D	= REQUIRED
⌀	= DIAMETER	SIM.	= SIMILAR
DWG.	= DRAWINGS	T.O.S.	= TOP OF STEEL
ELEV.	= ELEVATION	TYP.	= TYPICAL
EQ.	= EQUAL	U.N.O.	= UNLESS NOTED OTHERWISE
EXIST.	= EXISTING	V.S.C.	= VERTICAL SLIP CLIP
FLR.	= FLOOR	W/	= WITH

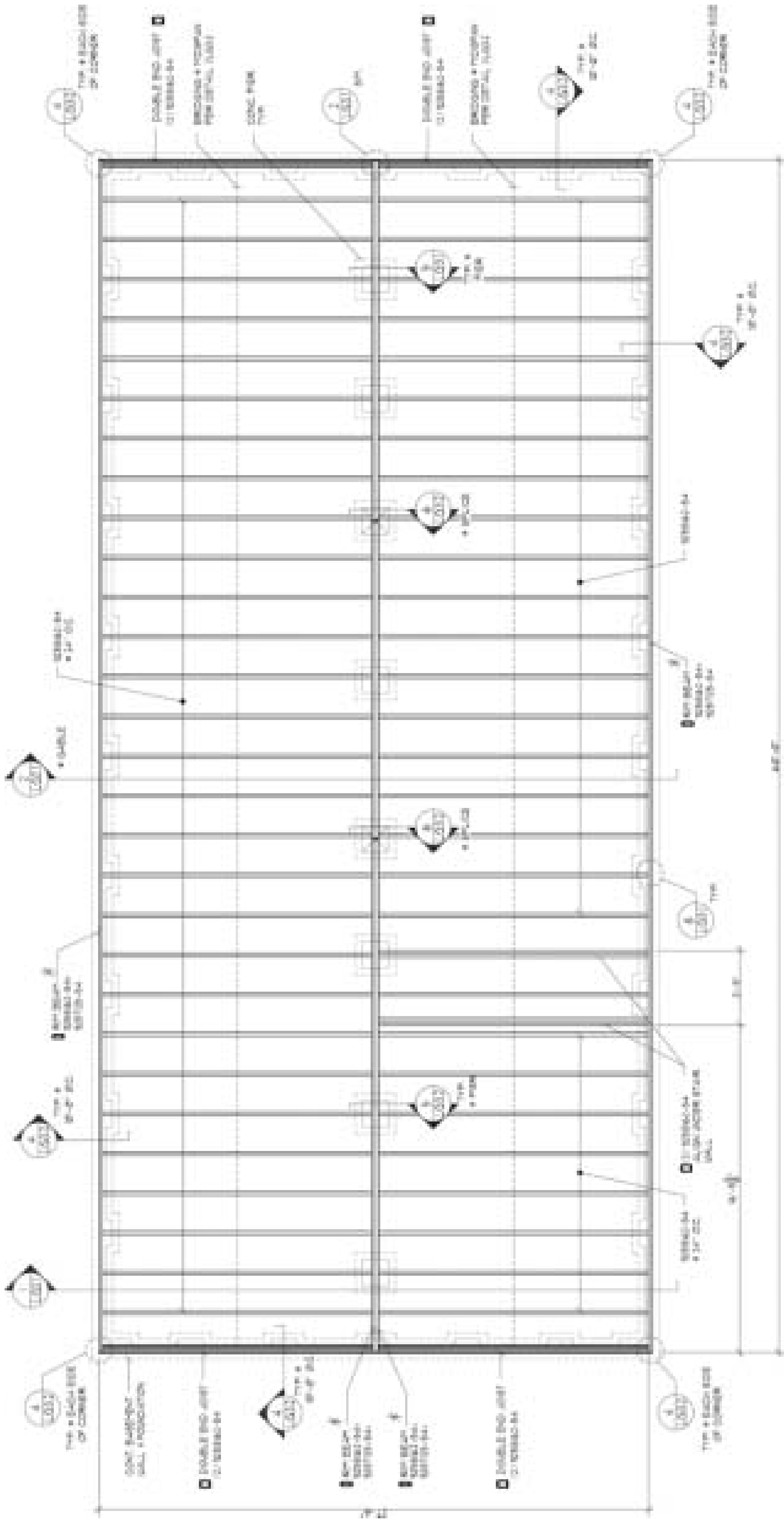


Figure A-1 First floor framing plan

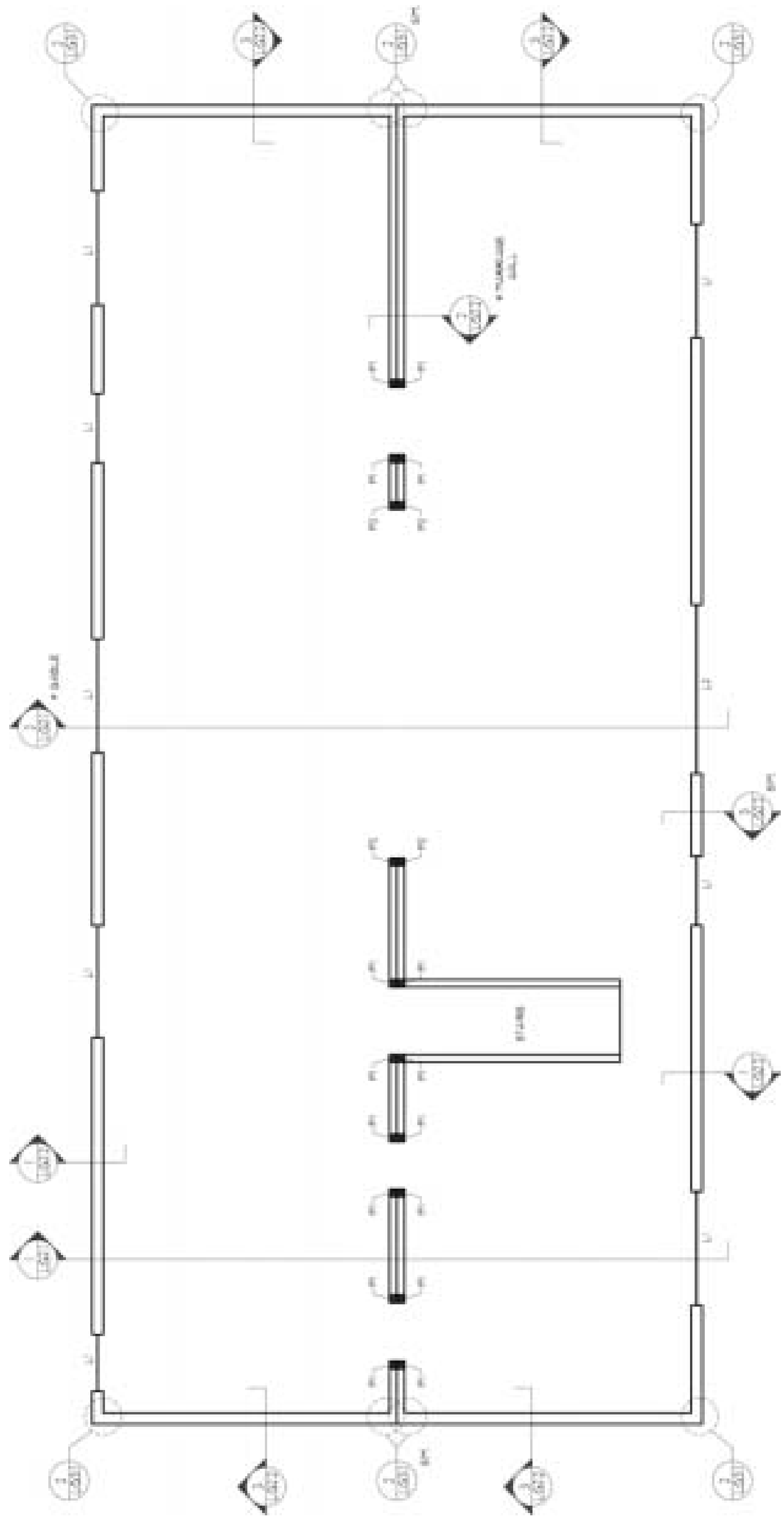


Figure A-2 First floor wall framing plan

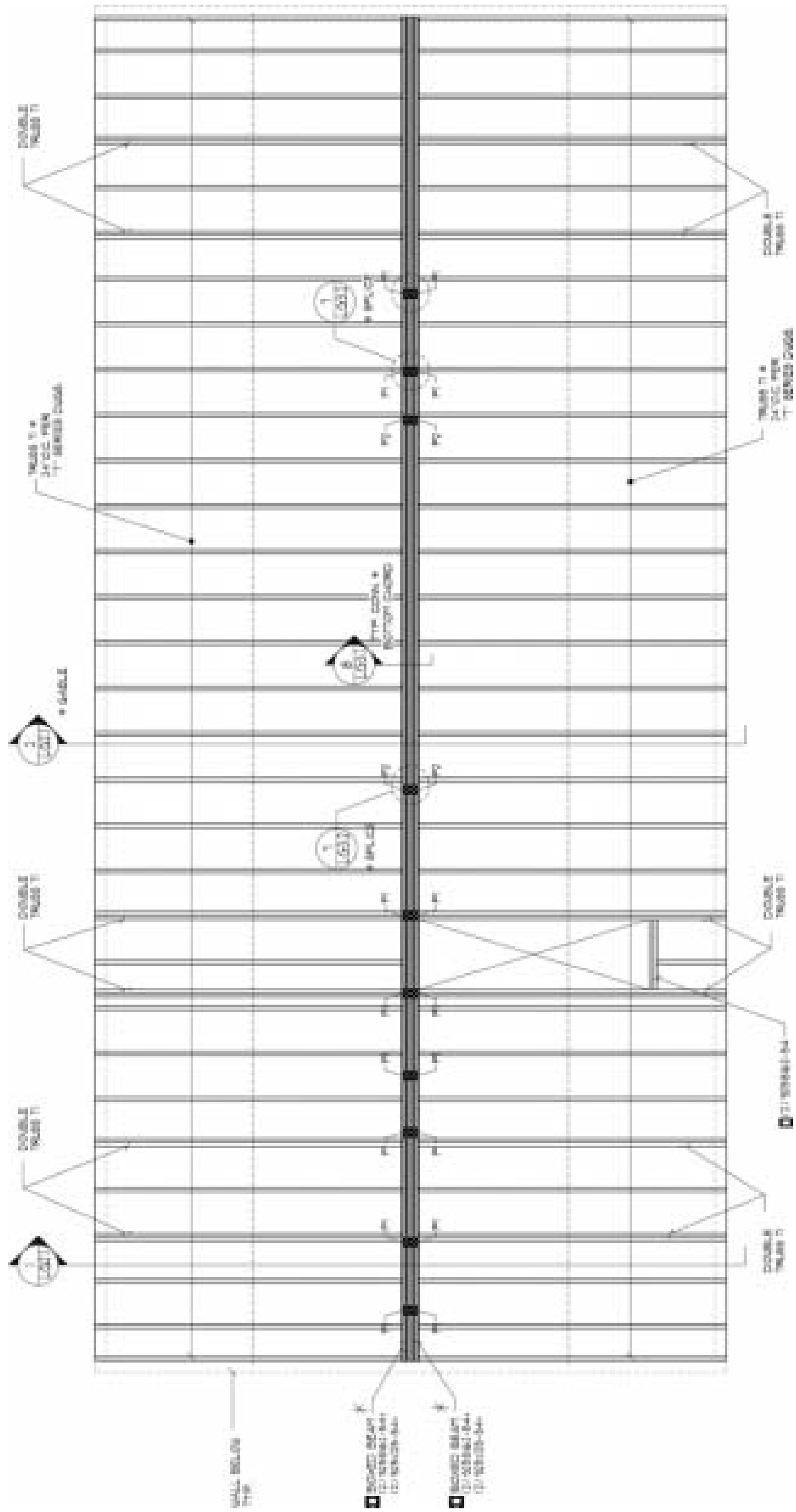


Figure A-3 Second floor framing at truss bottom chord

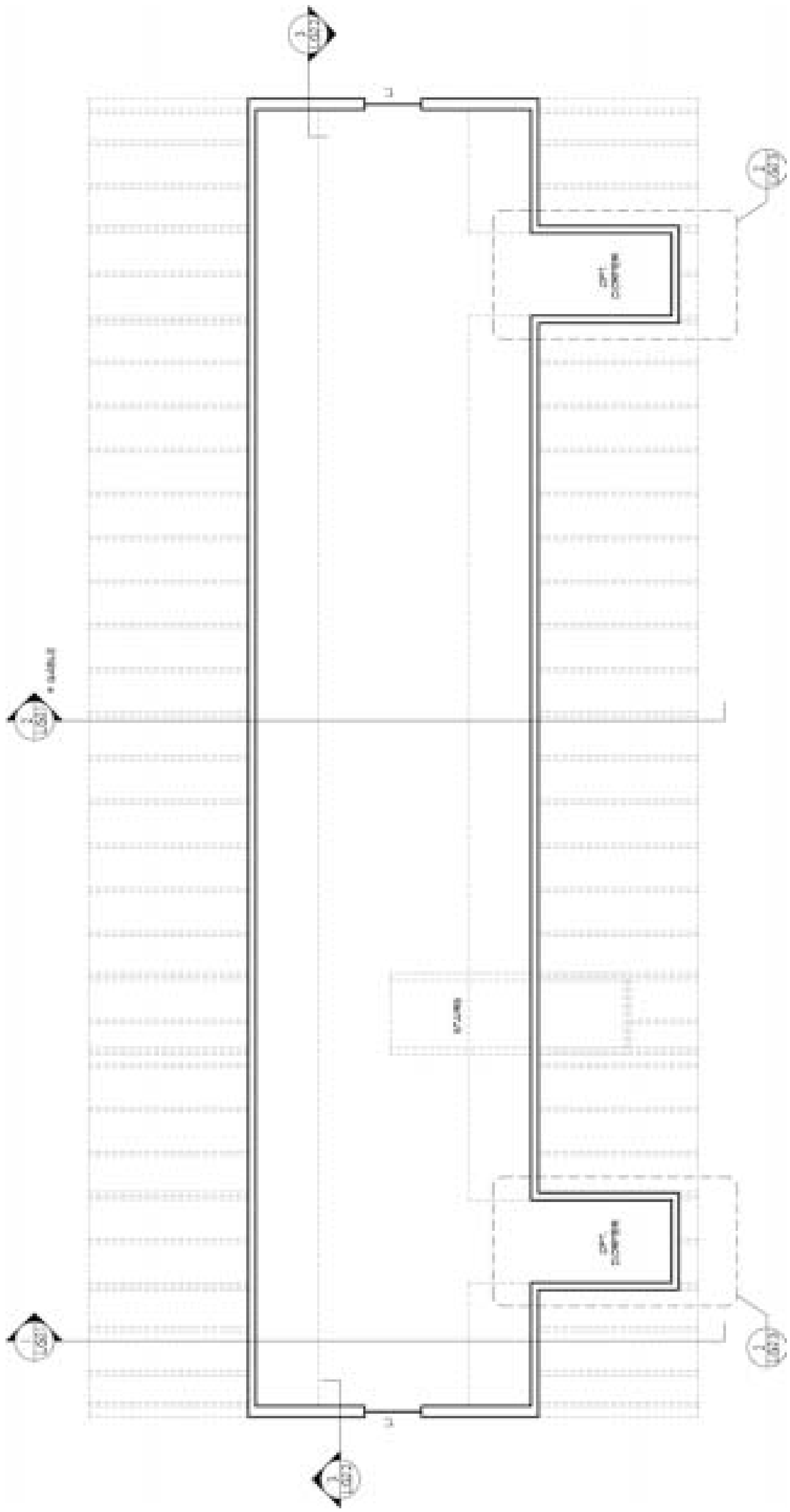


Figure A-4 Second floor wall framing plan

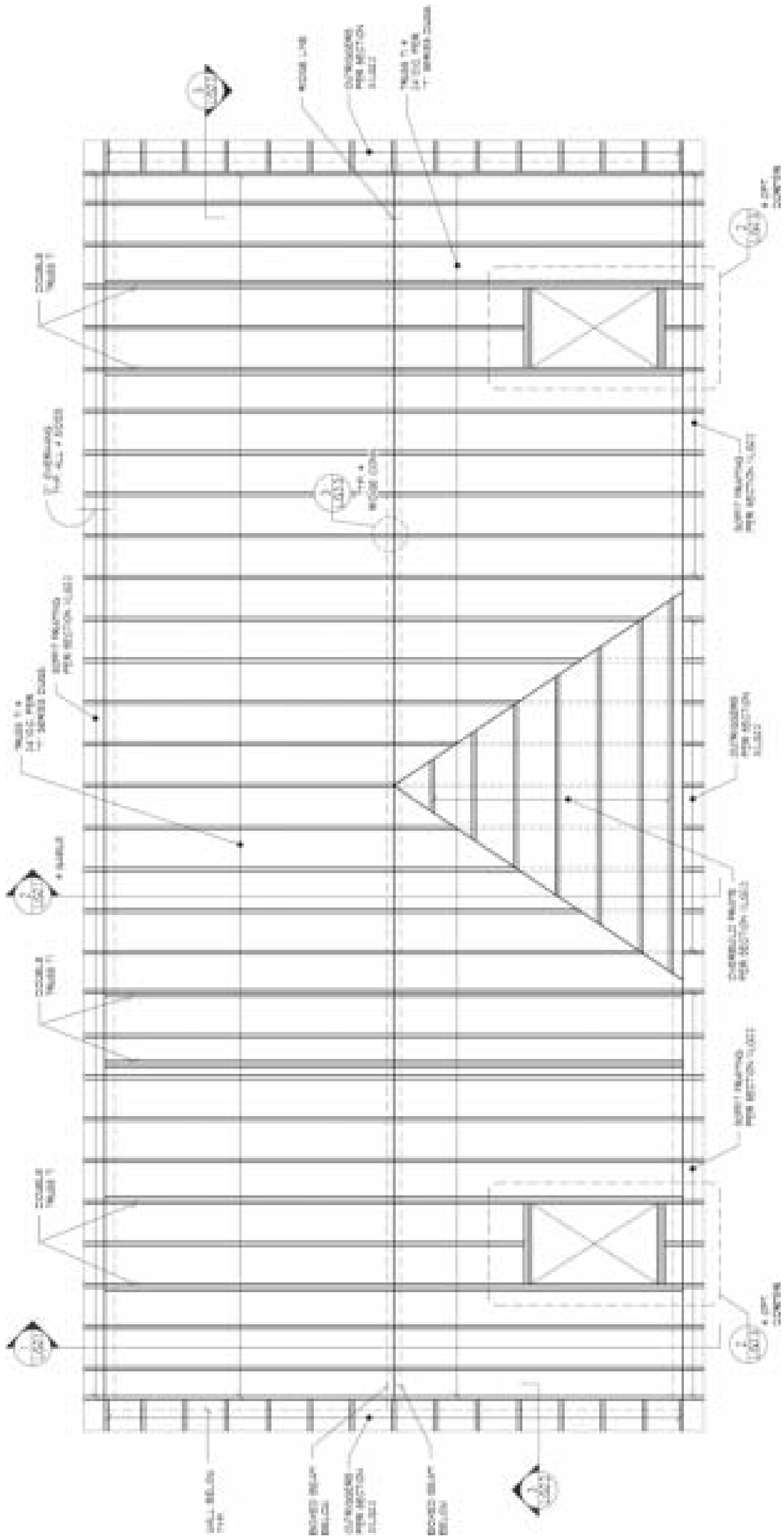


Figure A-5 Roof framing plan at truss top chord

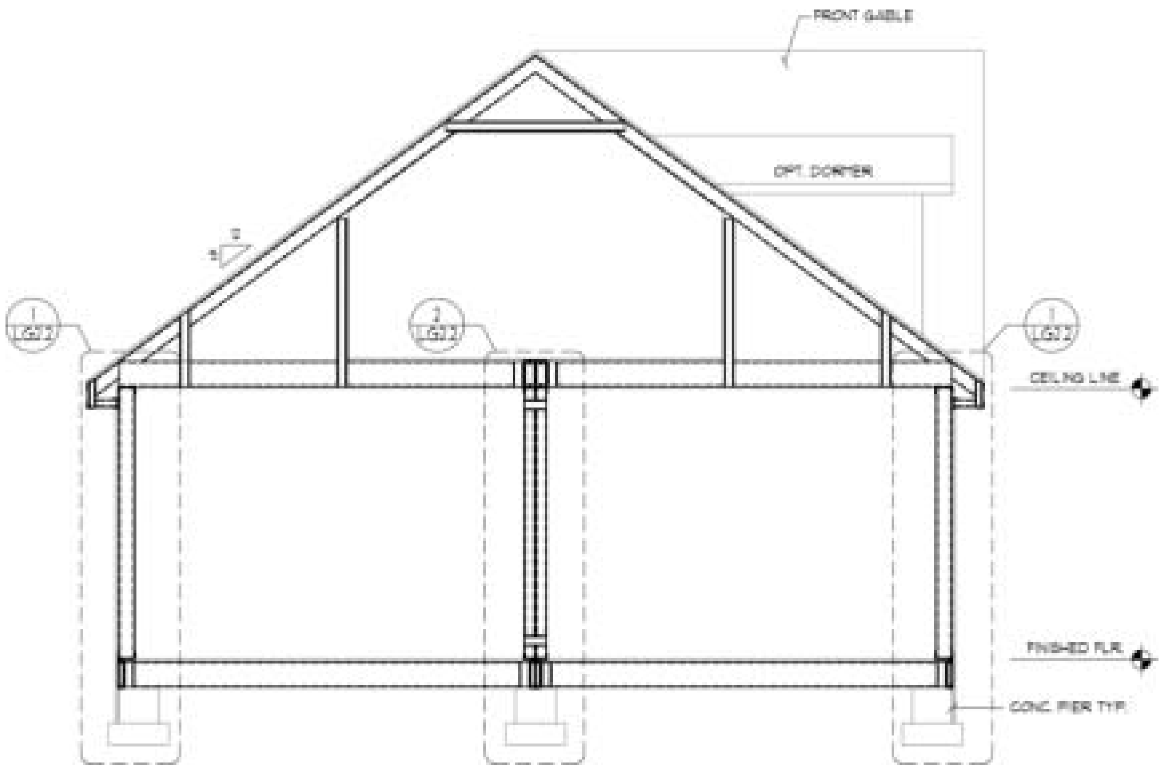


Figure A-6 Building section

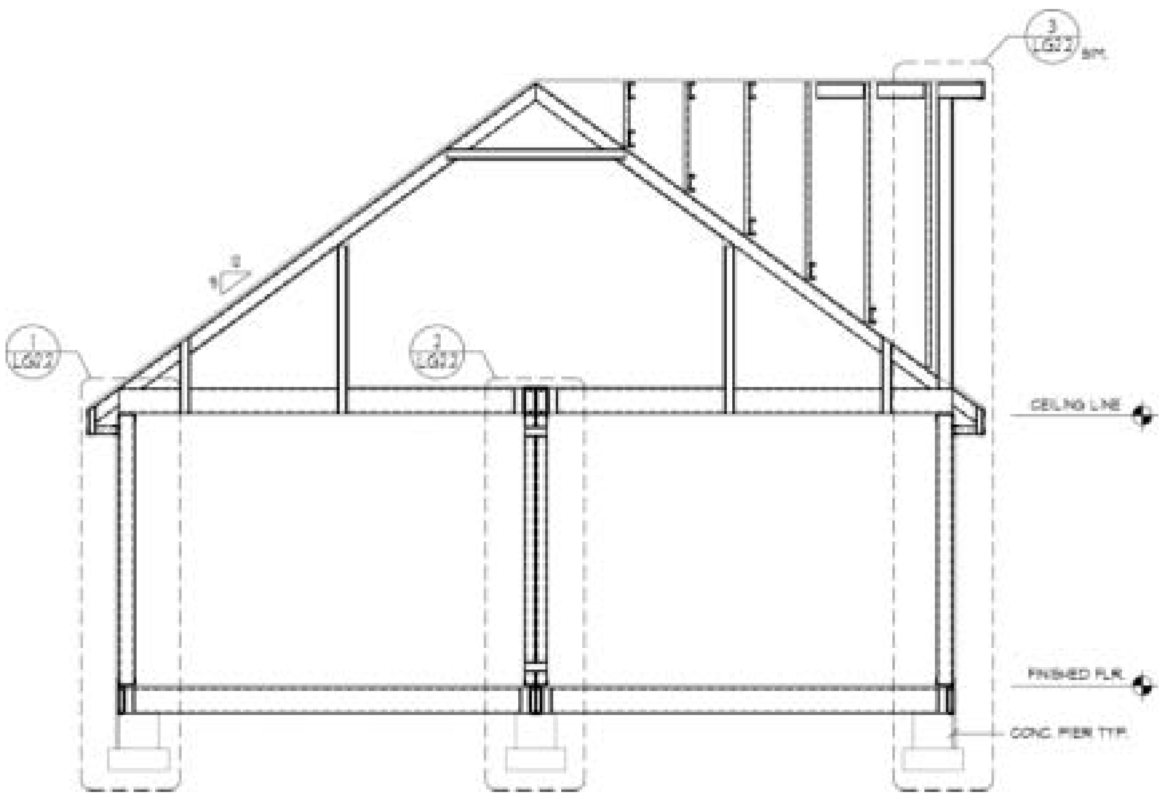


Figure A-7 Building section at front gable

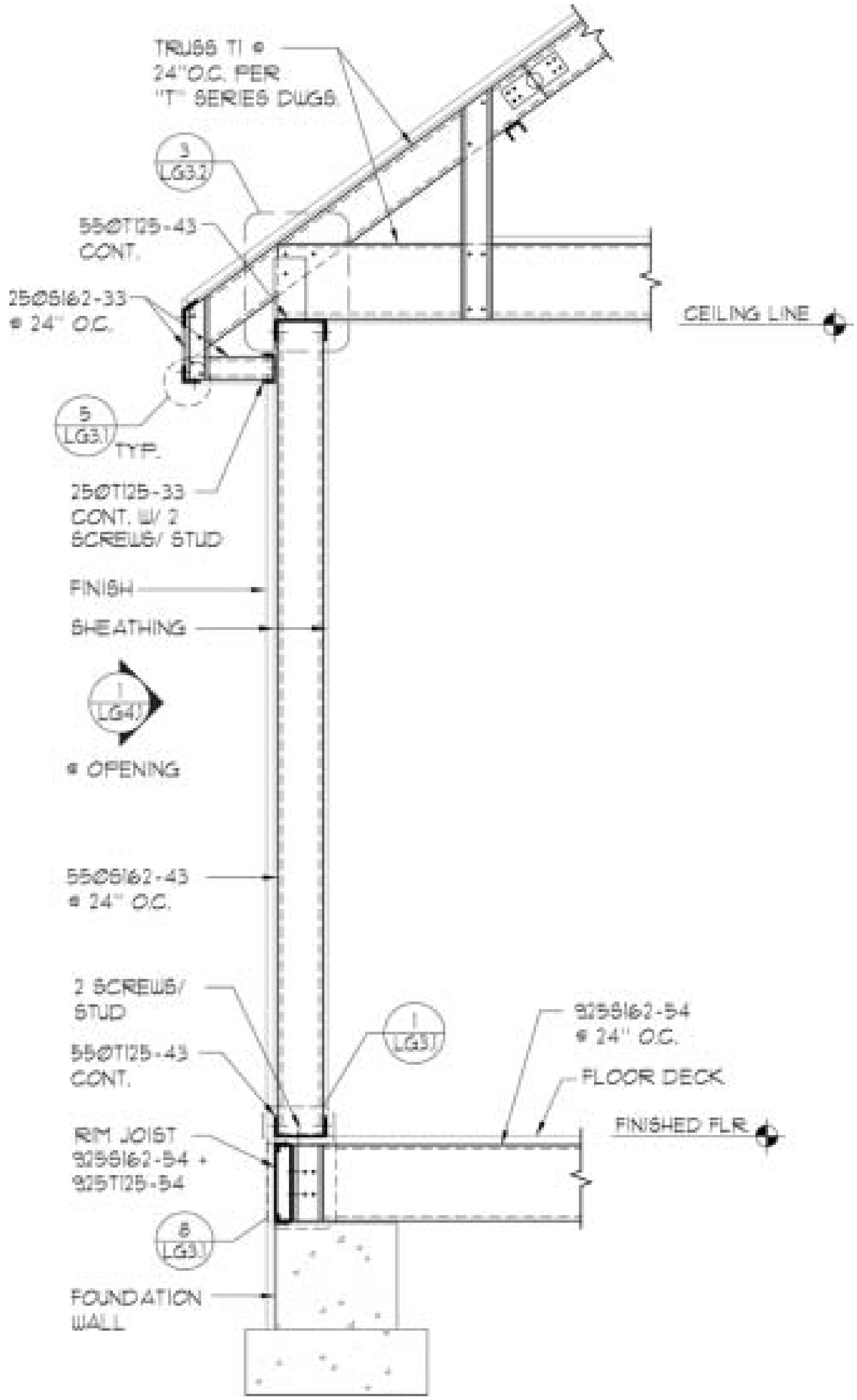


Figure A-8 Typical section at side wall

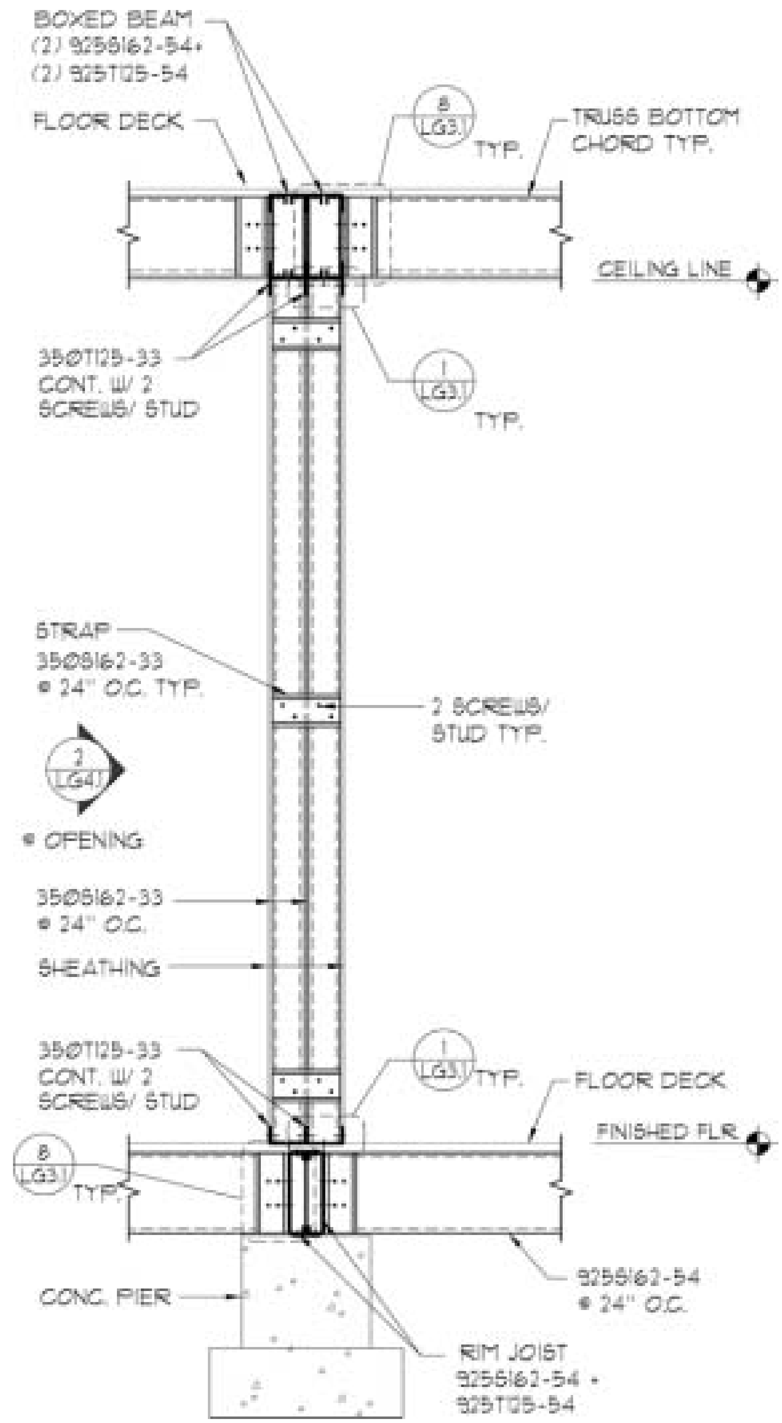


Figure A-9 Section at marriage wall

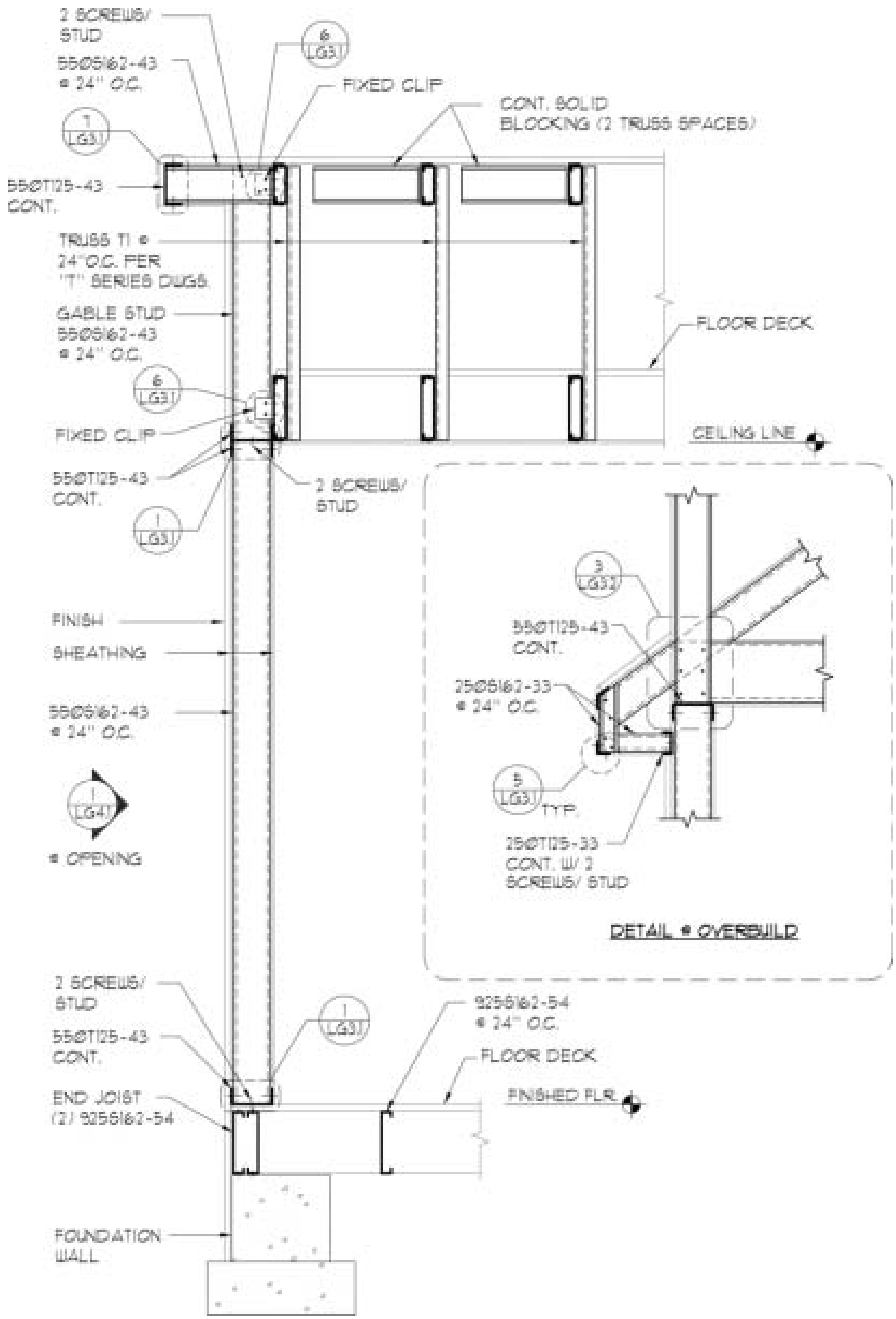


Figure A-10 Typical section at gable end

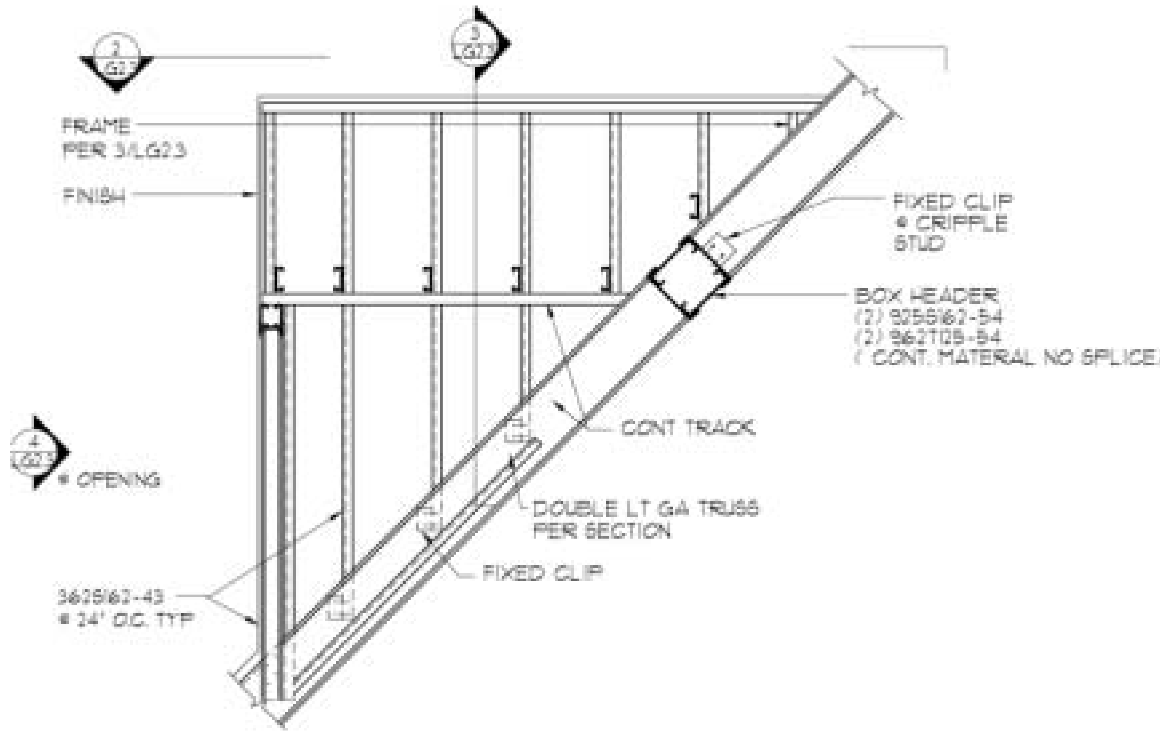


Figure A-11 Dormer section

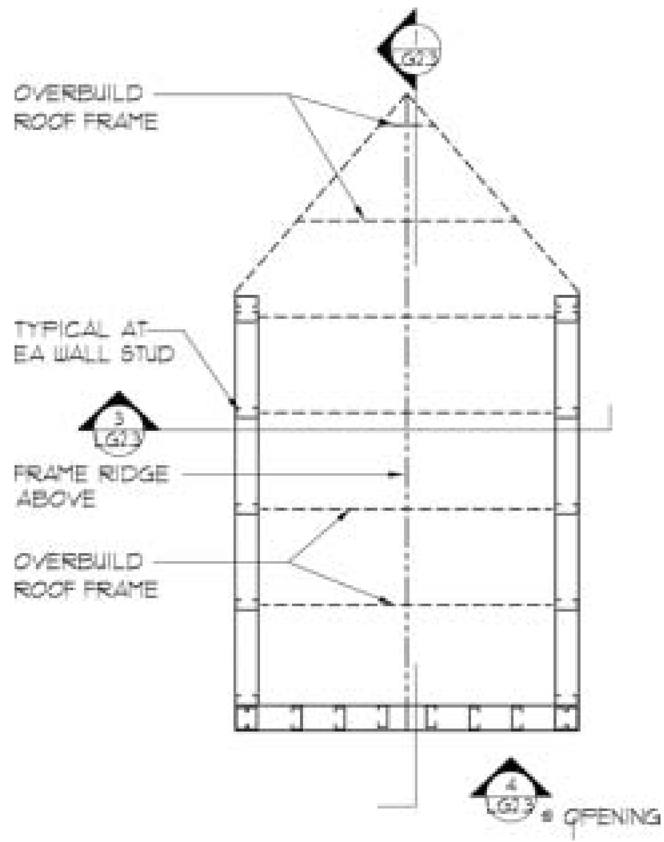


Figure A-12 Dormer plan

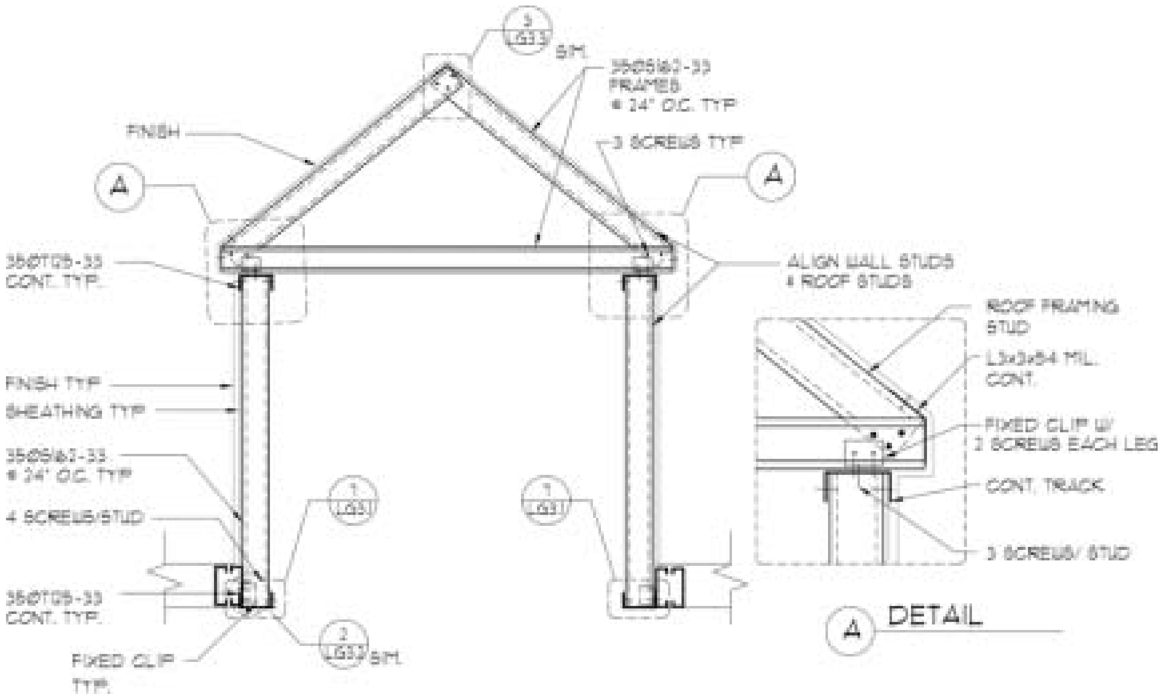


Figure A-13 Dormer section (detail)

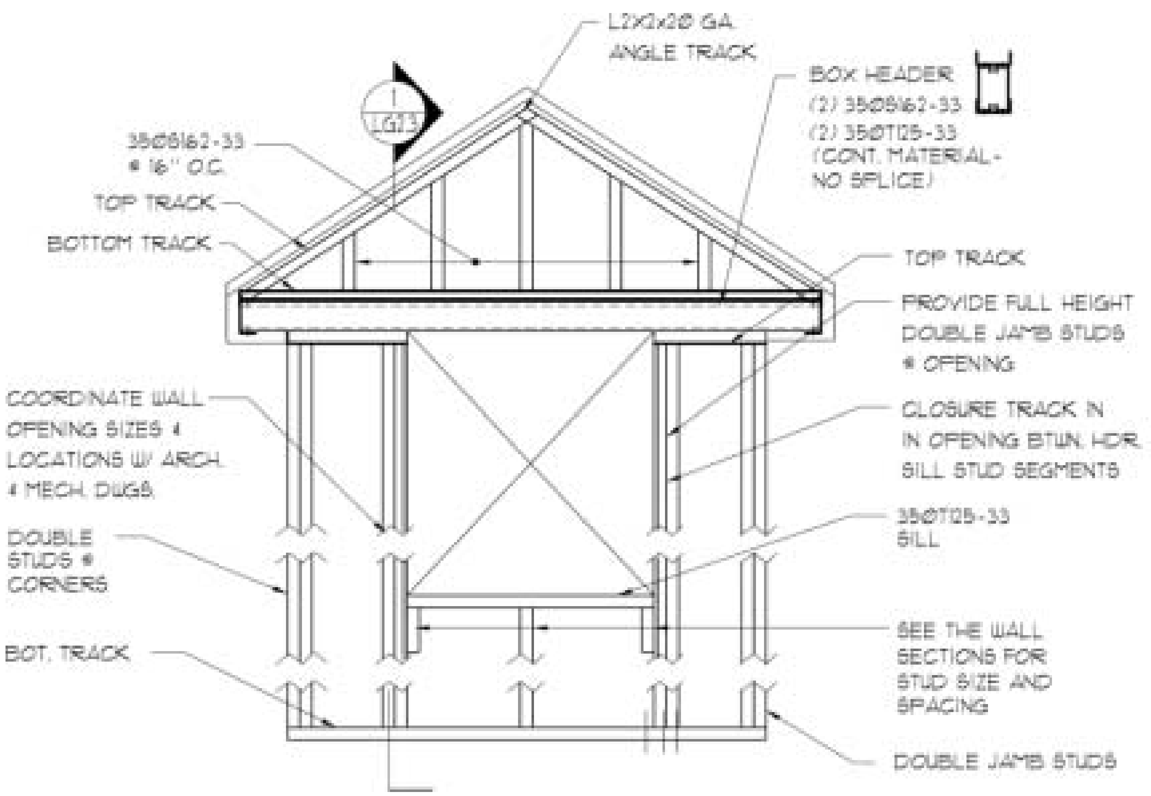


Figure A-14 Opening elevation at dormer

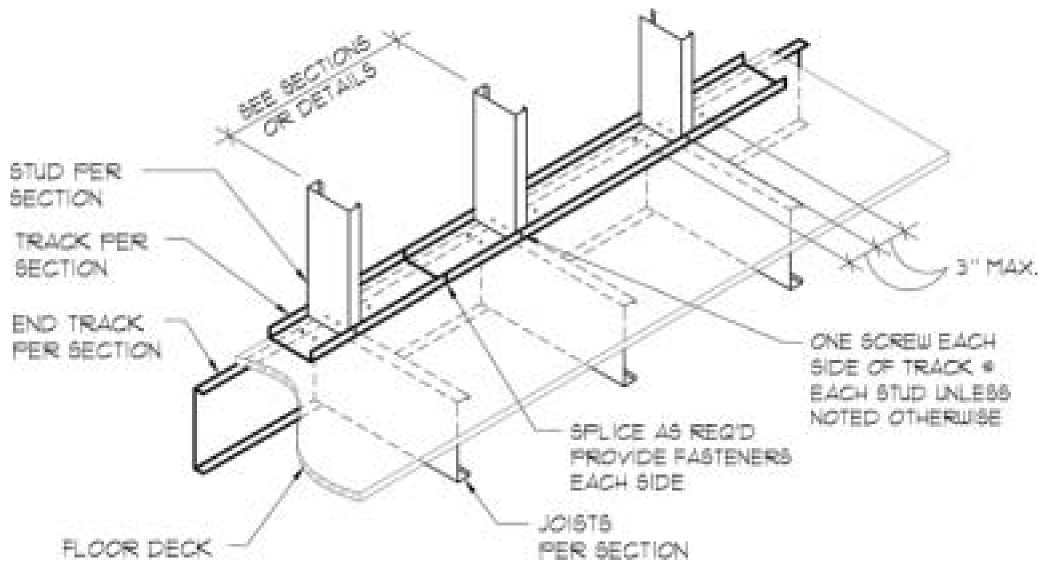


Figure A-15 Typical track-to-stud connection detail

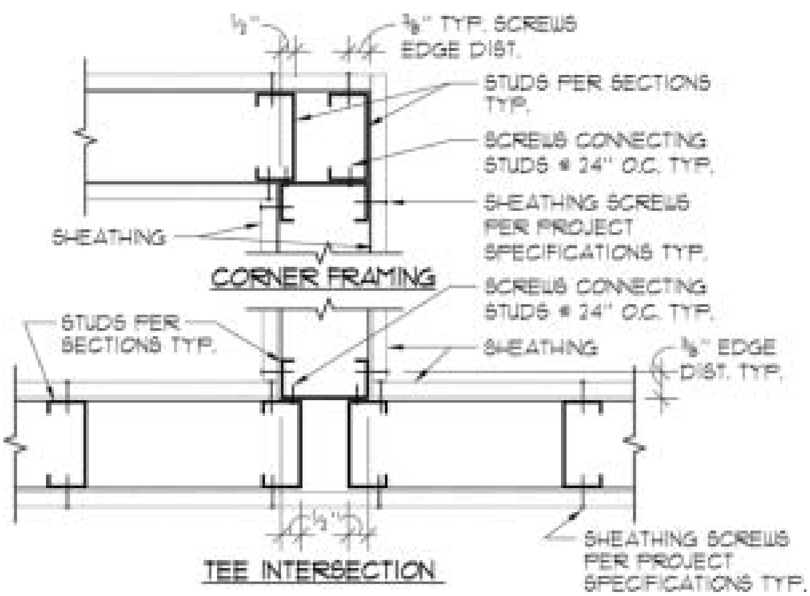


Figure A-16 Typical corner wall details

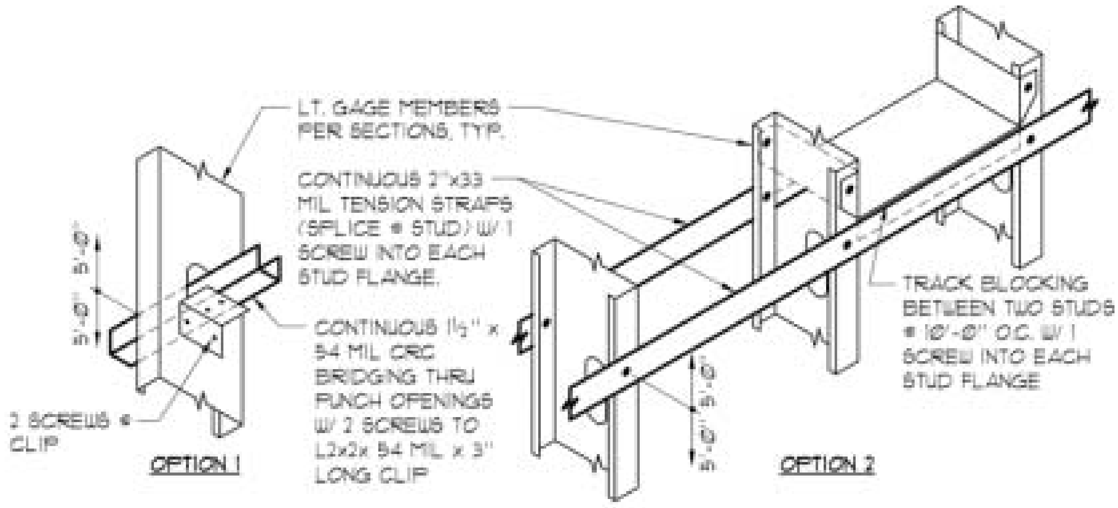


Figure A-17 Typical stud and rafter bridging details

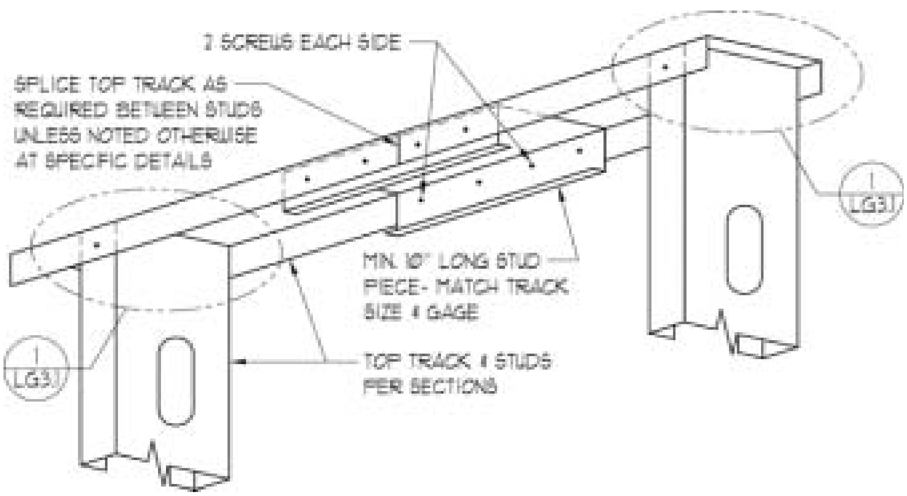


Figure A-18 Typical unsupported track splice detail

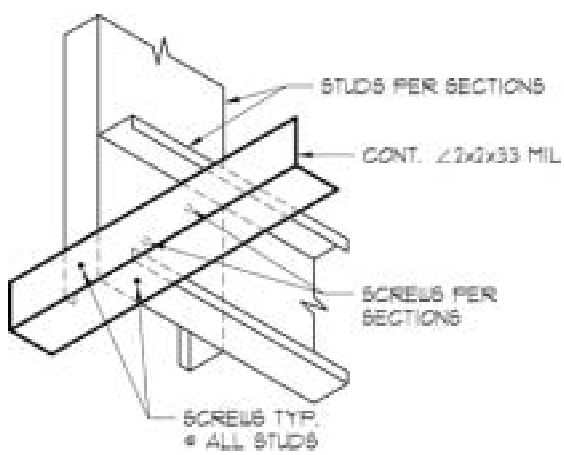


Figure A-19 Typical bulkhead connection detail

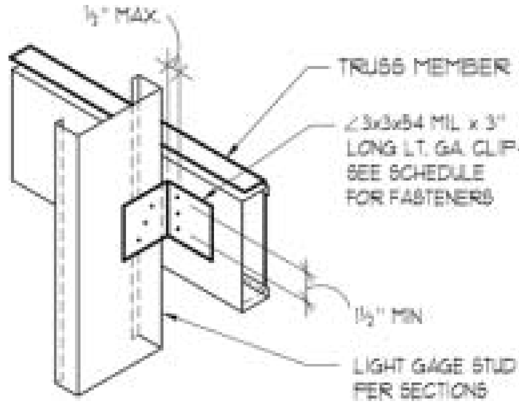


Figure A-20 Typical connection detail

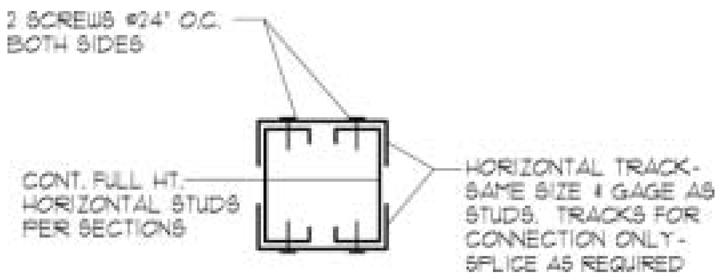


Figure A-21 Typical box beam detail

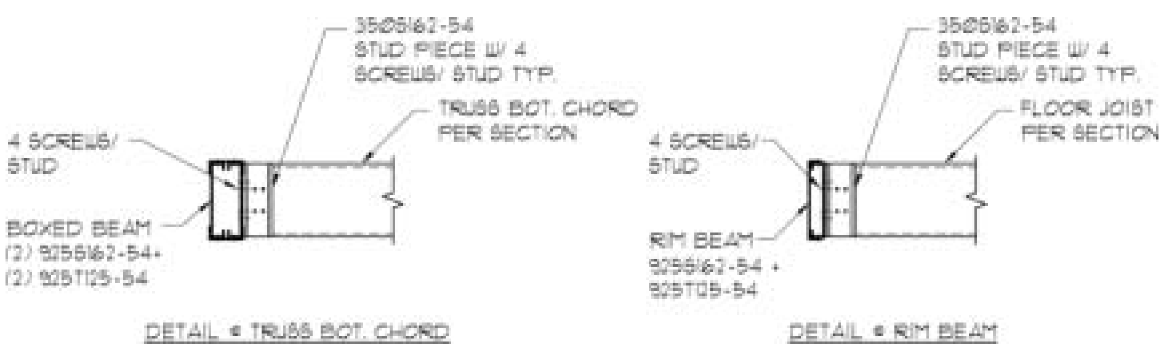


Figure A-22 Typical beam connection detail

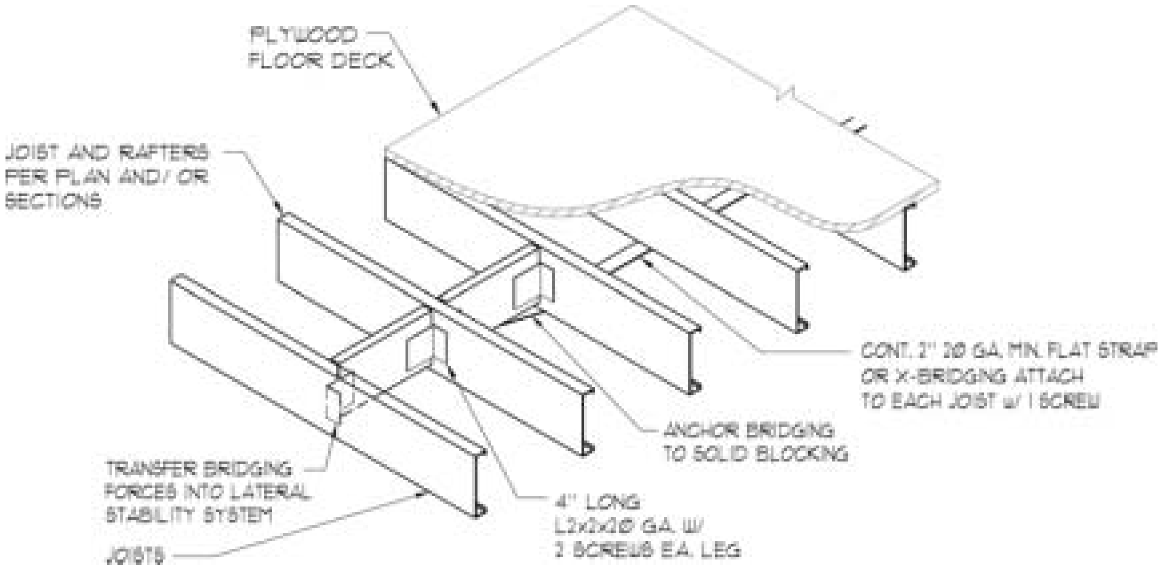


Figure A-23 Typical floor bracing detail

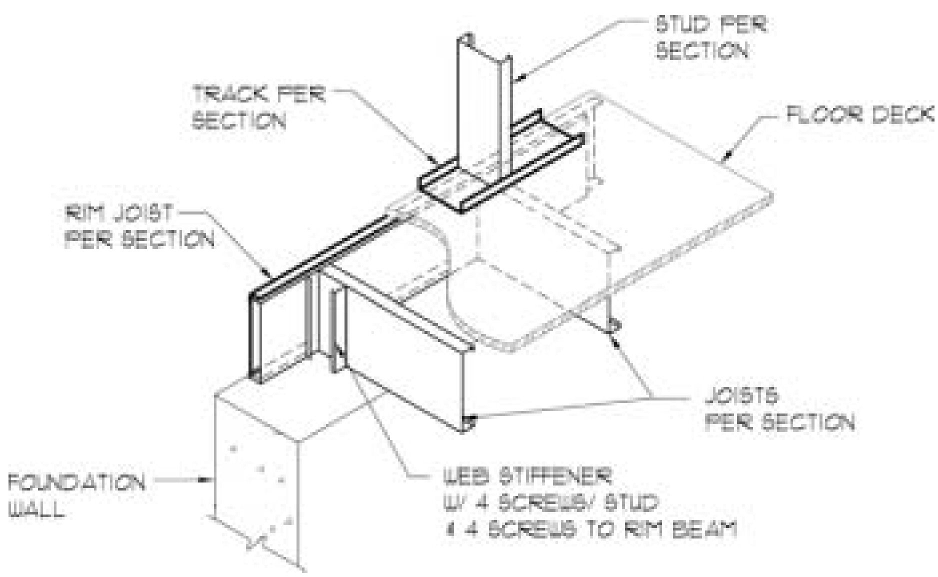


Figure A-24 Typical rim joist connection detail

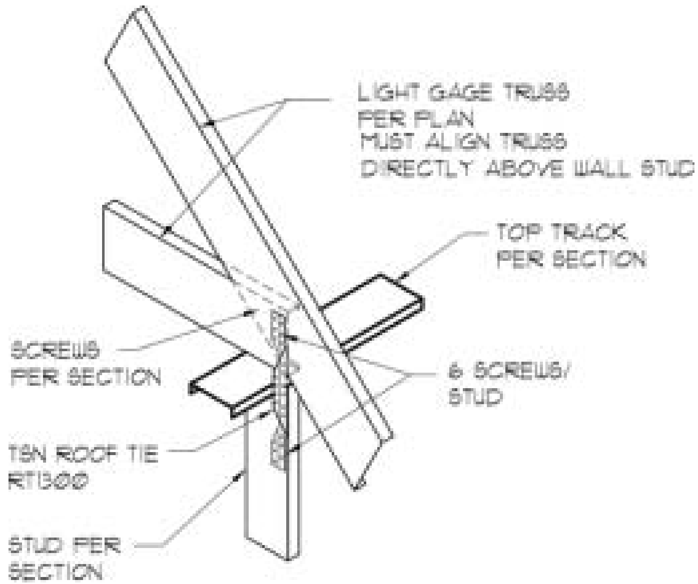


Figure A-25 Typical roof truss connection detail

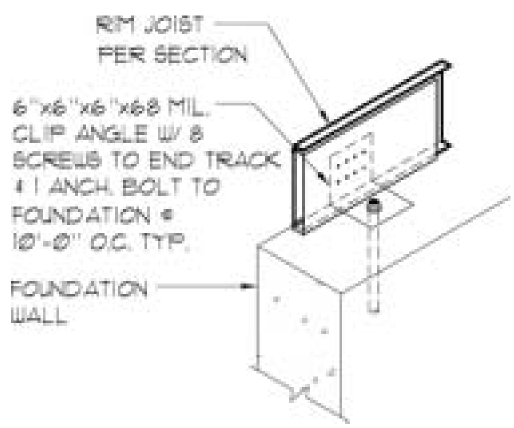


Figure A-26 Typical foundation edge detail

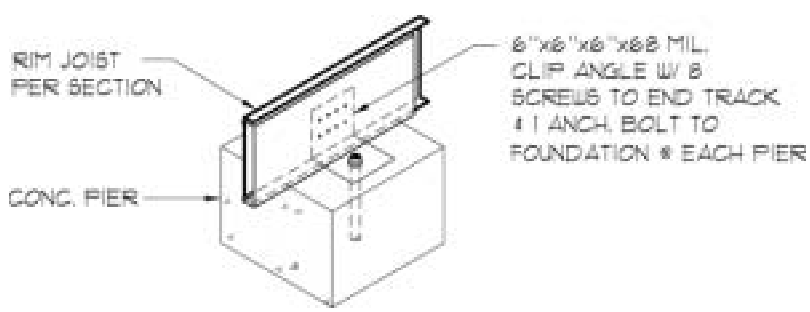


Figure A-27 Typical detail at pier

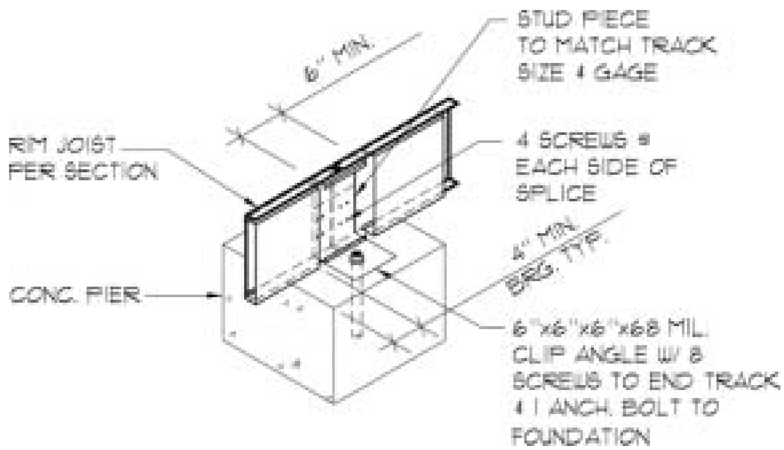


Figure A-28 Typical rim beam splice detail

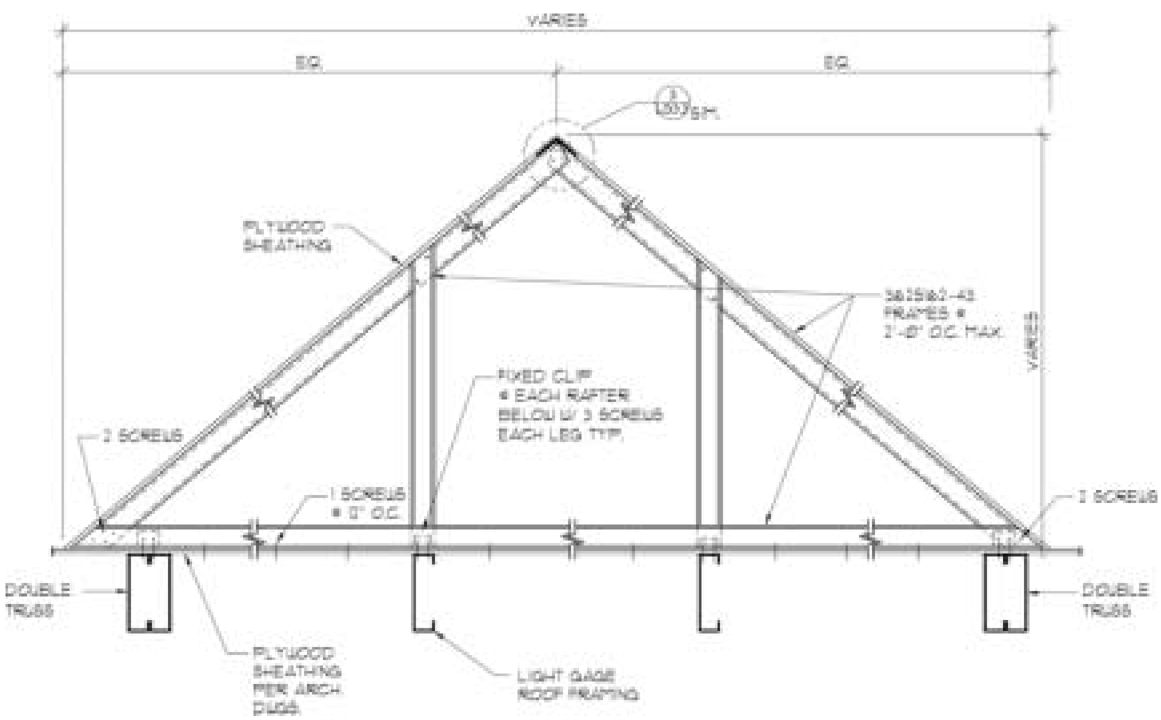


Figure A-29 Typical overbuild frame detail

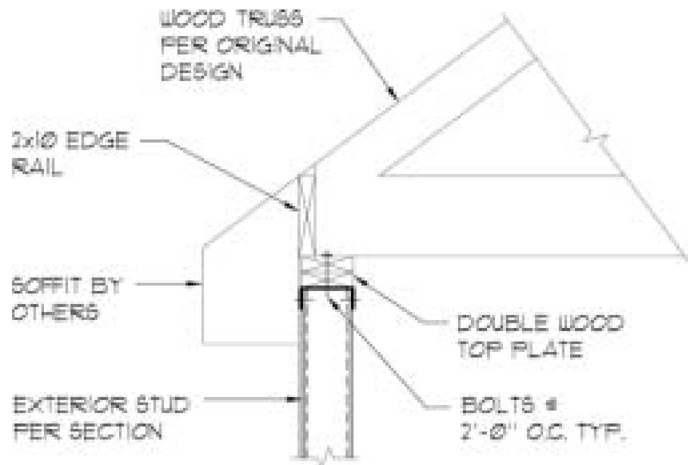


Figure A-30 Optional wood truss connection detail

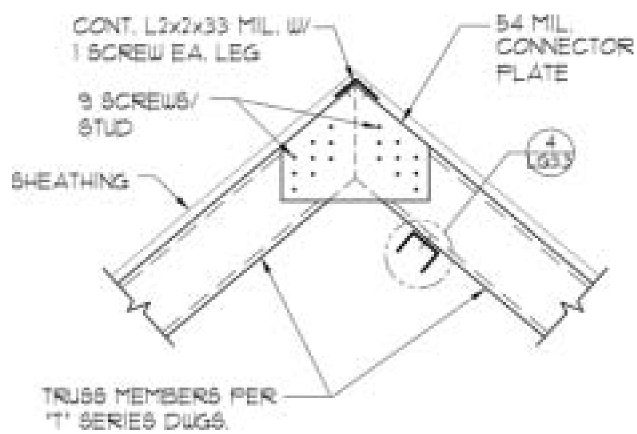


Figure A-31 Typical truss connection detail

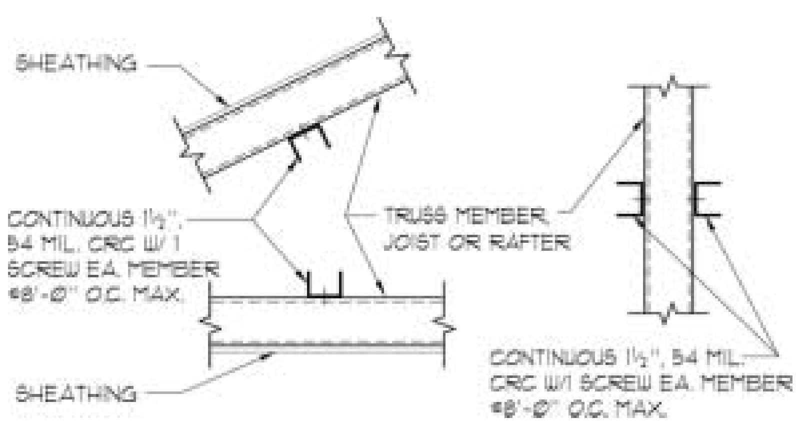


Figure A-32 Typical truss bridging details

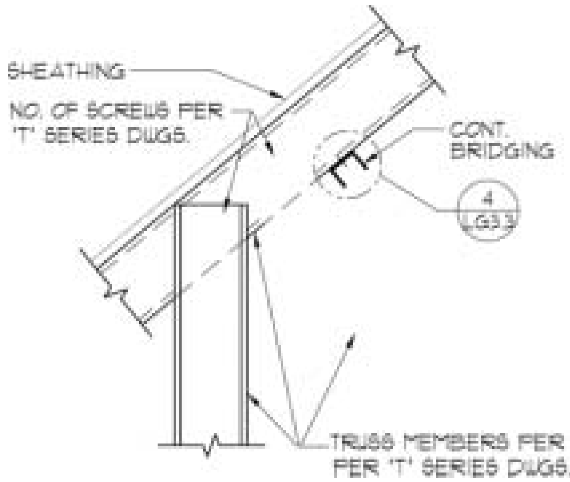


Figure A-33 Typical truss connection detail

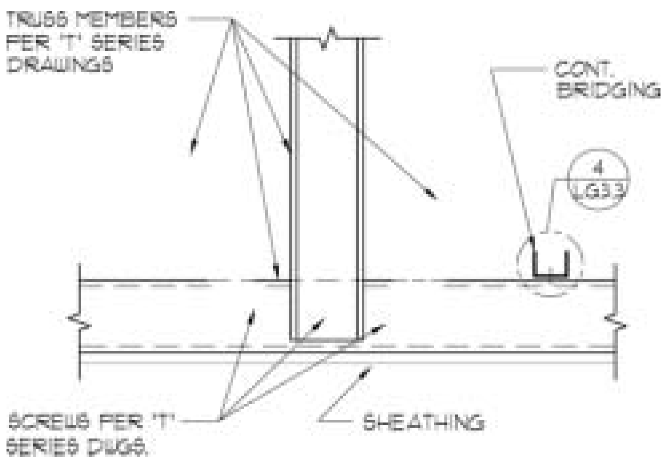


Figure A-34 Typical truss connection detail

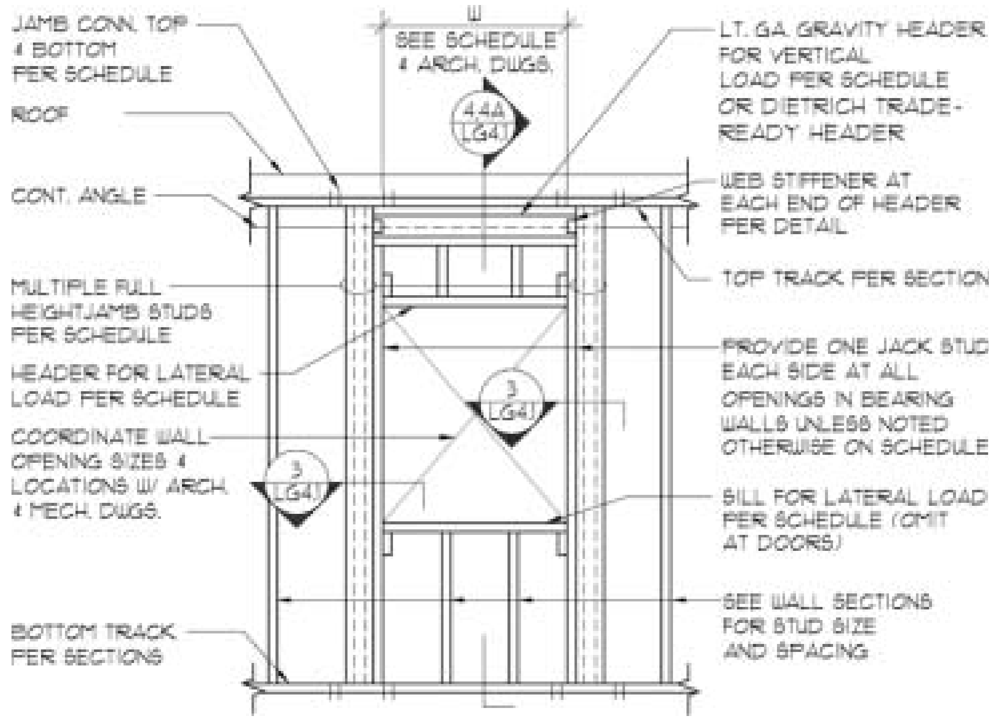


Figure A-35 Typical exterior light-gage bearing stud elevation at opening

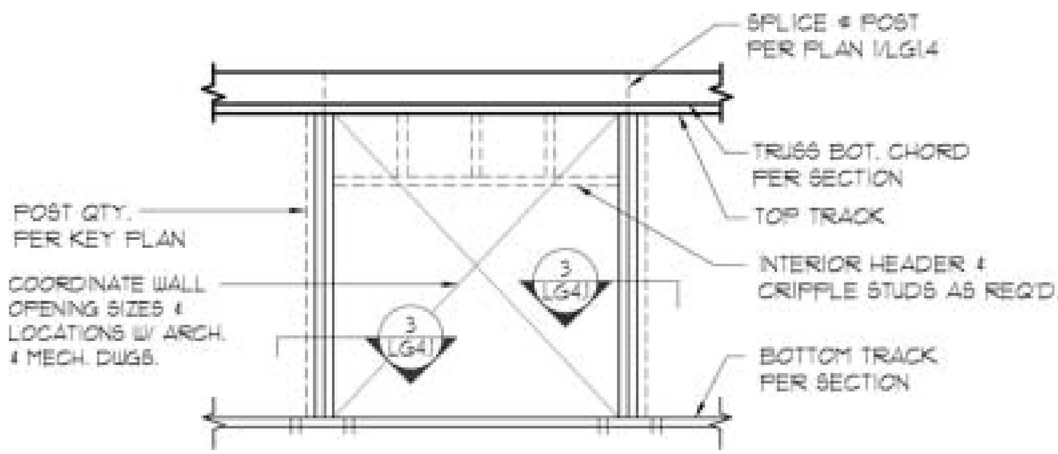


Figure A-36 Typical interior light-gage bearing stud elevation at opening

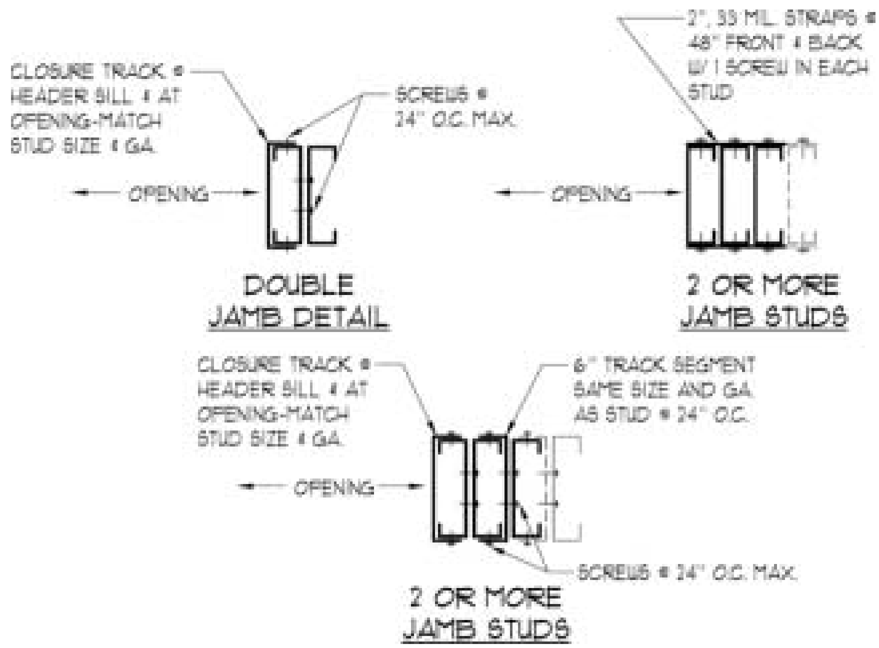


Figure A-37 Alternate jamb details

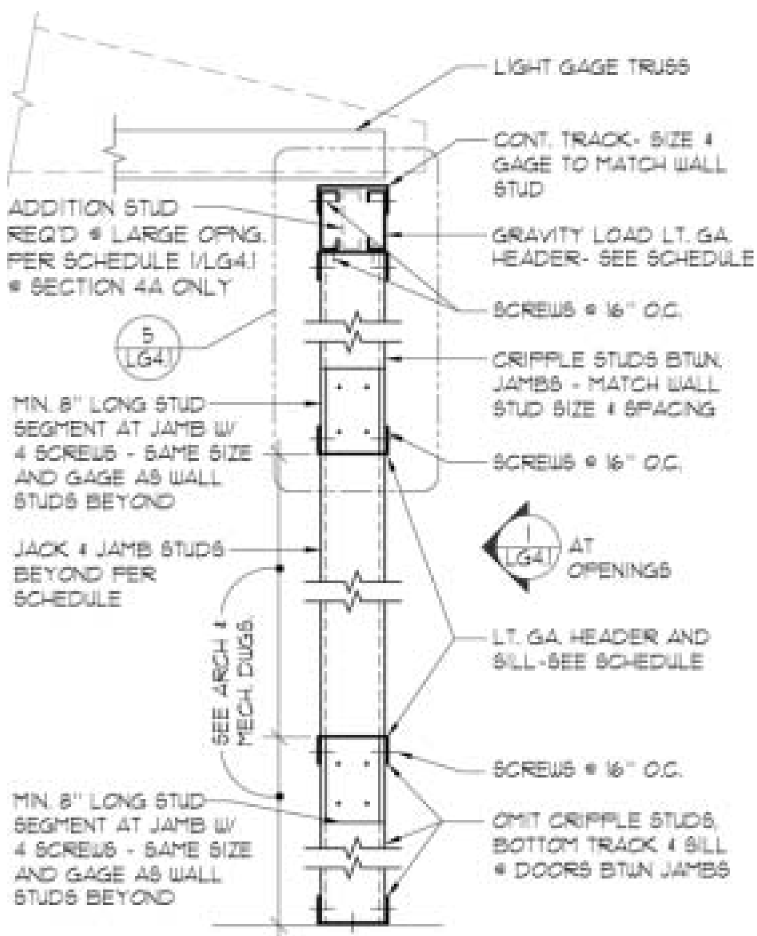


Figure A-38 Typical bearing wall opening section

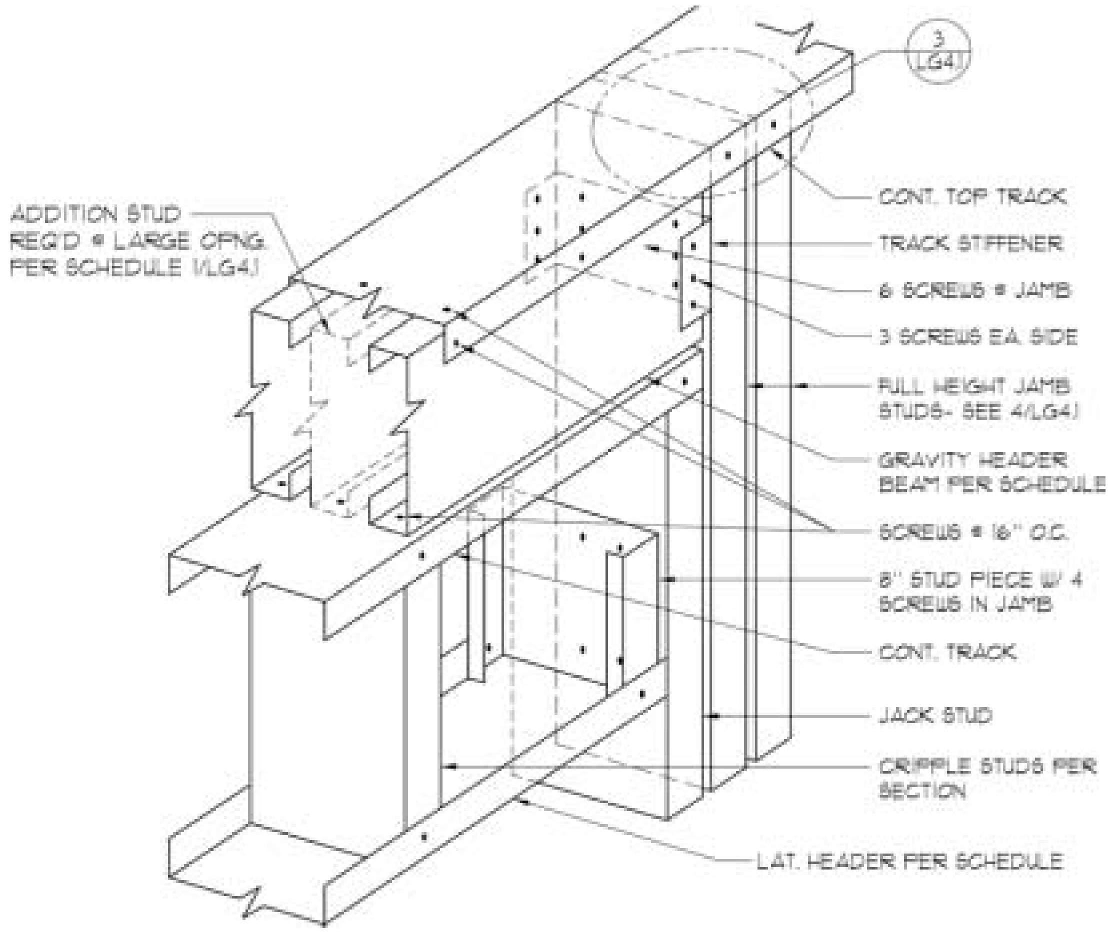


Figure A-39 Header to jamb connection detail

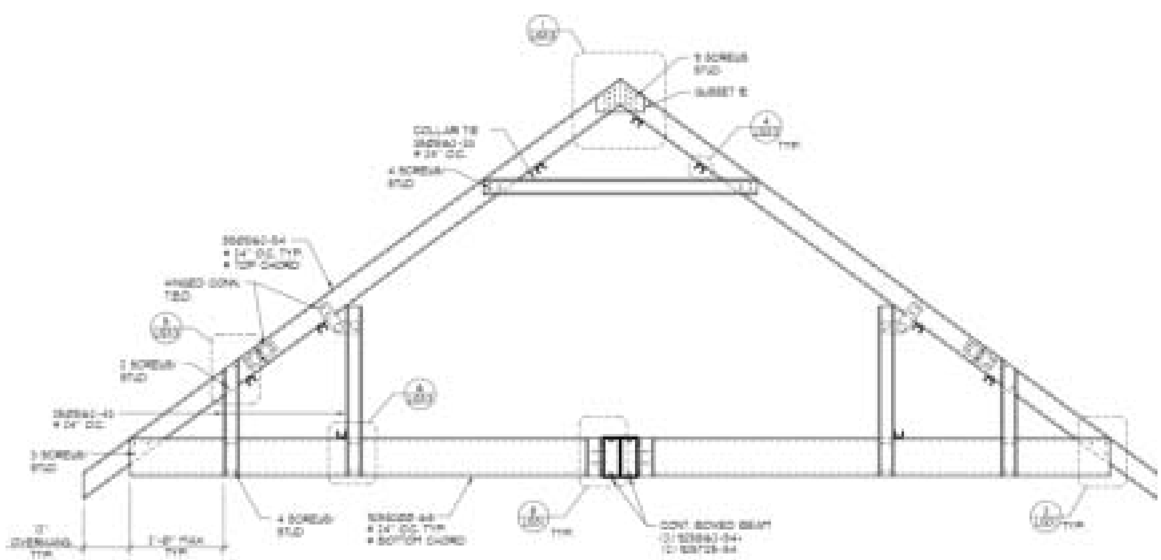


Figure A-40 Truss section

APPENDIX B

RESOURCES

Organizations serving this market:

Steel Framing Alliance
1201 15th Street, N.W., Suite 320
Washington, D.C. 20005
(202) 785-2022
FAX: (202) 785-3856
www.steelframingalliance.com

Description: The Steel Framing Alliance (SFA) serves the full spectrum of companies and individuals that make up the steel framing industry by providing market data and statistics, education and training programs, information and tools on construction, design and applications, research and testing, and informational and marketing programs to support the development of the steel framing industry. In addition to direct development and delivery of these programs, the SFA sponsors or works in close cooperation with other key organizations within the steel framing and construction industries.

Key contacts: Larry Williams, President
Janice Duncan, Membership

Steel Stud Manufacturers Association
8 S. Michigan Avenue
Chicago, IL 60603
(312) 456-5590
FAX: (312) 580-0165
www.ssma.com

Description: The Steel Stud Manufacturers Association (SSMA) is comprised of companies that fabricate studs, track, channel, joists, and connectors used in steel framed construction. Together, members of the SSMA produce nearly 80 percent of all metal studs in the United States. The SSMA provides technical support and published design guides and engineering details for engineers and architects, as well as maintaining technical specifications and standards for the cold-formed steel studs.

Key contacts: Augie Sisco, Executive Director
Don Allen, Technical Director, (202) 263-4488

Center for Cold-Formed Steel Structures
Butler-Carlton Civil Engineering Hall
University of Missouri-Rolla
Rolla, MO 65409
(573) 341-4481

FAX: (573) 341-4476
http://web.umr.edu/~ccfss/

Description: The Center for Cold-Formed Steel Structures is the nexus of technical and design information for the cold-formed steel industry, providing educational programs, design guides, technical services, and research. Two unique programs offered by the Center include the Short Course on Cold-Formed Steel Design, the industry's most intensive technical educational program, and the Cold-Formed Steel Specialty Conference that provides experts from around the world with a forum for sharing information and ideas about cold-formed steel elements and design. The Center serves as the industry's central reference library for research and technical documents.

American Iron & Steel Institute
1140 Connecticut Avenue, N.W., 7th Floor
Washington, D.C. 20036
(202) 452-7100
FAX: (202) 452-6573
www.steel.org

Description: The American Iron & Steel Institute provides the underpinning of the industry's design and construction standards through its maintenance of the cold-formed steel framing specification, its ANSI-accredited design standards, and implementation of these documents through the building codes.

Key contacts: Helen Chen
Jay Larson, (610) 691-6334

Information and resources on a full-spectrum of steel framing subjects can be obtained as follows:

Business Planning Information

- Data and statistics on the residential and commercial framing industries.
- Updates on new product developments, services, and industry news
  Source: Steel Framing Alliance
  Contact: Larry Williams
  American Iron & Steel Institute
  Contact: Jay Larson

Engineering and Design

- Seminars and educational programs
  Source: Center for Cold-Formed Steel Structures
  Contact: Roger LaBoube
  Steel Framing Alliance
  Contact: Maribeth Rizzuto

- Directory of Engineers / Architects
  Source: Steel Framing Alliance
  Contact: Janice Duncan

- Technical inquiries

Source: Center for Cold-Formed Steel Structures (design and specifications)
Contact: Roger LaBoube
Steel Stud Manufacturers Association (stud and track characteristics)
Contact: Don Allen
NAHB Research Center / Toolbase Hotline (general inquiries)
(800) 898-2842

Á Engineering Details
Source: Steel Framing Alliance
Contact: Janice Duncan (also available at www.steelframingalliance.com)
Steel Stud Manufacturers Association
Contact: Augie Sisco (or www.ssma.com)

Á Codes and Standards
Source: American Iron & Steel Institute
Contact: (202) 452-7100 (or www.steel.org)

Training and Education
Á Builders / Framers
Á Code organizations / local jurisdictions
Source: Steel Framing Alliance
Contact: Maribeth Rizzuto

Á Publications
Source: Steel Framing Alliance
Contact: Janice Duncan (or www.steelframingalliance.com)

Sourcing material, tools, equipment
Source: Steel Framing Alliance
Searchable online directory at www.steelframingalliance.com

Manufacturing, Technology, Research, and Innovation
Source: Steel Framing Alliance
The SFA has two teams that evaluate, prioritize, and manage research programs that are identified by members and others in the industry. All research is directed to resolve a technical or construction-related barrier, advance the development of building standards, or provide information needed to capitalize on market development opportunities. Publications and results are made available in the form of design guides and standards, seminars, and research reports.
Contact: Jay Larson, American Iron & Steel Institute