# CHAPTER 1

# INTRODUCTION

1. PURPOSE AND SCOPE. This document provides design guidance on the use of cold-formed steel systems for both load-bearing (Chapter 2) and nonload-bearing (Chapter 4) applications. Also, criteria are provided to use load-bearing systems in shear wall (Chapter 3) applications. The nonload-bearing application guidance in Chapter 4 also includes provisions for the masonry wythe and moisture protection of complete masonry veneer/steel stud curtain wall systems.

2. APPLICABILITY. These instructions are applicable to all elements responsible for the design of military construction. Exceptions to this criteria will require Corps of Engineers Headquarters (CEMP-ET) approval.

3. REFERENCES. Appendix A contains a list of references used in these instructions.

4. PARTNERING EFFORT. This document is the result of partnering between industry and Government with emphasis on Green Building Technology. Designers should require materials, products and innovative construction methods and techniques which are environmentally sensitive, take advantage of recycling and conserve natural resources. Funding for this effort came from the Green Building Program.

5. DESIGN CONCERNS UNIQUE TO COLD-FORMING.

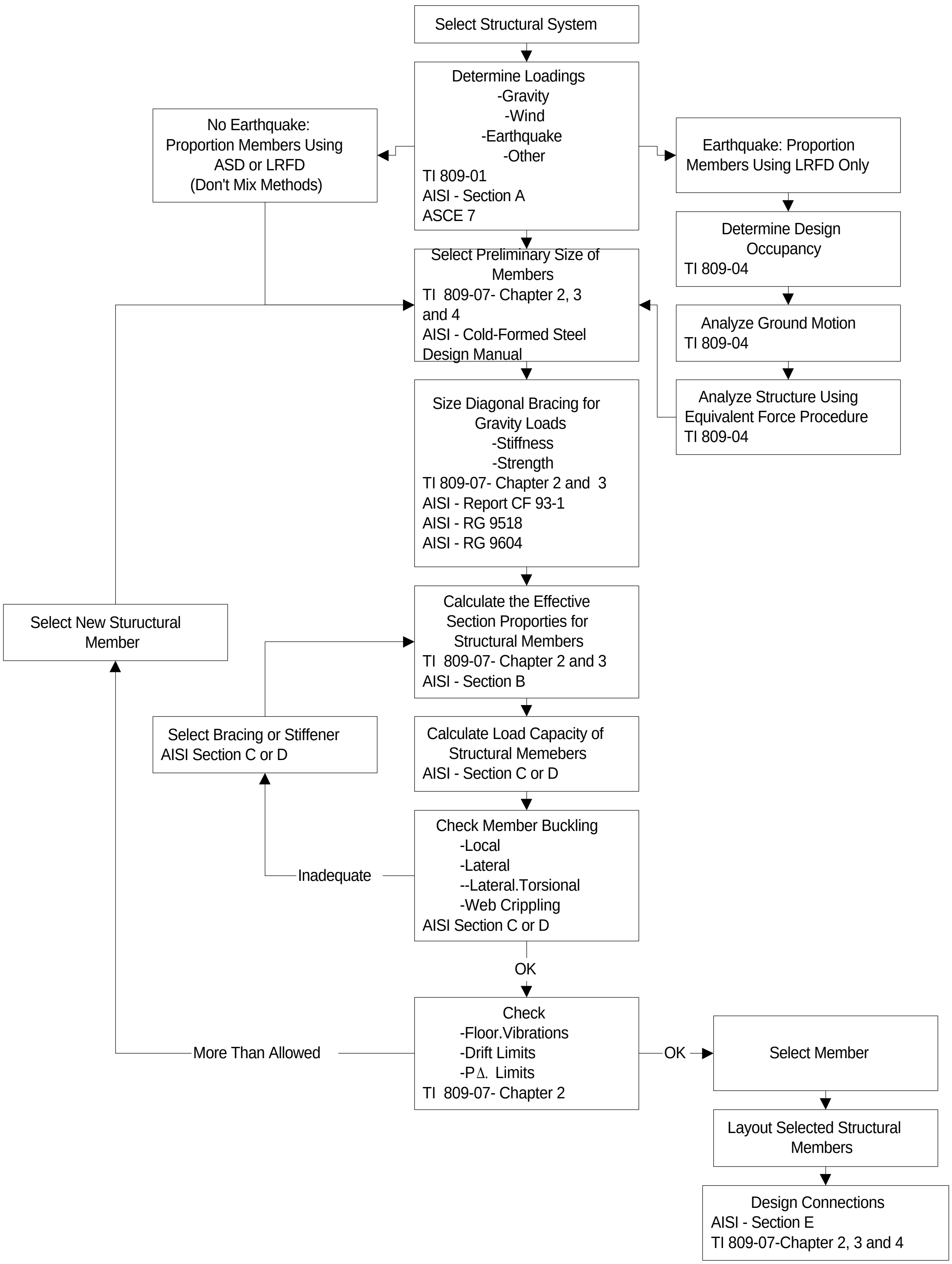
a. General. The AISI Specification is applicable to sheet and strip steels with thicknesses of 6.35 mm (¼ in) or less, but steel plates and bars up to 25.4 mm (1 in) can successfully be used as structural shapes. Designers working with cold-formed steel products will account for several unique conditions not normally found in AISC steel designs as outlined below:

- Effective section properties are based on the design stress of the loading condition being analyzed,
- Lateral-torsional buckling is a special buckling condition unique to the cold-formed design of compression members,
- Local buckling of section elements, and the lateral buckling of members is different than typically found in AISC steel design,
- Connections can be assembled using welds, screws, or bolts. Crimping is not allowed as well as powder driven pins. However, powder driven pins can be used to attach wall tracks to concrete floors, foundations, and steel superstructures,
- A Deign Process for Load-bearing Cold-Formed Steel Systems Flowchart is shown as Figure 1-1.

b. Seismic Design The seismic design guidance provided in Chapter 3 will only be used for Performance Objective 1A (Life Safety Performance Objective Level defined in TI 809-04) for all seismic ground motion levels and enhanced Performance Objectives (2A, 2B and 3B) for Seismic Design Categories A and B. The definition of performance objectives and seismic design categories are provided in TI 809-04, Seismic Design for Buildings.

Seismic design with cold-formed steel has two inherent problems with the material itself. The first is light gauge thickness of the cold-formed steel materials and the second is the material strength variability. The objective of seismic design guidance is to ensure ductile building system performance in the large seismic event and elastic response in the small event or wind loading. Ductile building performance requires that selected ductile components yield, but continue to carry loads and absorb energy through significant plastic response. At the same time potentially brittle failure modes, such as column buckling or connection failure must be prevented. The design challenge for cold-formed steel is to ensure that building components, and in particular shear panel components, be proportioned

Figure 1-1: Design Process for Loadbearing Cold-Formed Steel Systems



relative to each other and detailed to ensure the ductile response. In this guidance, this is accomplished by ensuring that the diagonal straps yield and respond plastically through significant displacement, without risk of damage to brittle connections or column buckling.

Seismic design guidance is provided on three levels:

- Tabular data for prototype shear panels in terms of the maximum story shear and maximum and minimum gravity load. These terms are defined in Chapter 3 and the shear panel configurations and data are provided in Appendix E.
- Detailed guidance for shear loads using shear panels with diagonal straps as primary lateral load resisting element. This guidance is provided in Chapter 3, with background guidance taken from other sources in Appendix C and an example problem illustrating the guidance in Appendix D. The spreadsheet, http://owww.cecer.army.mil/techreports/wilcfsxl.post.pdf program used in the example problem is available as a design tool for shear panel design.
- A test procedure and the acceptance criteria for other shear panel configurations is provided in Appendix F.

6. USES OF COLD-FORMED STEEL.

a. General. Cold-formed steel systems have been used in industry and within the government for many decades. The primary areas of usage include: standing seam roof systems, doors, roof and floor joists, decking and floor systems, ventilation and ceiling systems, interior wall partitions and exterior fascia, metal buildings, lighting poles, guardrail, and corrugated steel pipe. These TI provide guidance necessary for designers to develop loadbearing steel systems.

b. Steel Framing Systems. These systems can be used in: wall, floor, and roof trusses of low rise offices, single family homes, and multi-family housing structures. Cold-formed systems should be galvanized for the local environmental conditions, and be pre-punched for routing utility services through walls. A rubber or plastic grommet must be provided in each pre-punched hole that utilities are passing through to prevent corrosion between dissimilar metals in the wall stud cavity.

7. COLD-FORMED SUPPLIERS. Cold-formed manufacturers perform the following services for the commercial customers: provide framing details, develop design information on the structural capacity of their members, help specify the job's materials, and deliver precut materials. Government designers should specify the design properties of each structural member; studs, track, heads, jambs, jack studs, etc. These properties include member depth, width and design thickness for each section.

8. RESPONSIBILITIES

a. Designers. Cold-formed steel framing involves the use of engineered products outlined in an overall engineered system. Cold-formed steel framing is ideally suited for structural applications such as curtain wall framing, load-bearing wall framing, floor framing, rigid frames, trusses, and roof rafter framing.

(1) Selecting Member Strength. Designers are responsible for specifying which products are to be used as well as which standards the products must meet. The products must meet all of the design requirements which normal engineering practice requires. Axial load capacity of compression members, flexure, torsion, shear, and web crippling in beams, and combined stresses in columns, etc. must be examined.

- Designers are to specify all materials by nominal uncoated thickness, effective section properties, and member loads. Loads should include moment and shear diagrams, and axial load with eccentricity.
- All connections (member-to-member and member-to-structure) are to be examined carefully taking into account all relevant physical strengths and properties as well as proper transfer of all loads to the supporting structure.

- Design selected walls to provide frame stability and lateral load resistance.
- Engineered methods such as diaphragm shear walls or diagonal steel strapping are used to provide frame stability and transfer lateral loads through the structure into the foundation. Provide additional studs as required to resist the vertical component of the loads from the diagonal bracing.
- Wall bridging is designed to provide resistance to minor axis bending and rotation of studs.
- Diaphragm rated components can be substituted for bridging; however, they must be installed prior to loading of the wall. If components are installed on one side of the wall only, then the flanges on the other side of the studs must be bridged with suitable bridging. Bridging can be removed or left in place when diaphragm rated components are installed.
- Provide for structure movement as indicated and necessary by design or code requirements.

(2) Member Specification. The primary specification for the design of the individual components is the AISI Specification for the Design of Cold-Formed Steel Structural Members. Other considerations, which the designer specifies, include:

- Member or Stud size, spacing, and depth.
- Deflection criteria, maximum spacing, minimum gage, wind loads.
- Studs are spaced to suit the design requirements and limitations of collateral materials.
- Allow for additional studs at panel intersections, corners, doors windows, control joints, etc.

b. Manufacturers. Lightweight steel framing involves the use of engineered products in an engineered system. Manufacturers provide technical product information, including physical and structural properties, and manufacturing standards that the designer can use to specify the appropriate structural products.

- Samples. Samples are representative pieces of all framing component parts and accessories;
- Certification. Certification is a statement from the manufacturer certifying that the materials conform to the appropriate requirements as outlined in the contract documents;

c. Contractor. The Contractor is responsible for providing the finished structure in strict compliance with the contract documents and cold-formed steel shop drawings. Included in the contractor's responsibilities are the following:

- Shop Drawings of details and attachments to adjoining work.
- Drawings showing plans, elevations, sections, and details.
- shop coatings
- steel thickness
- size, location, spacing of fasteners for attaching framing to itself
- details of attachment to the structure
- accessories and their installation
- and critical installation procedures

d. Contractor Quality Control. The Contractors Quality Control (CQC) Manager inspects Corps of Engineers projects. This effort outlines the contractor's inspection document requirements. The following Quality Assurance Documents are to be maintained by the CQC Manager:

- The manufacturer and product delivery dates,
- the contractor's staff and qualifications,
- compliance to testing standards for members, erection tolerances, and fasteners,

- submittal registers, erection drawings, production drawings,
- designer of record approvals, and CQC inspection reports,
- designer of record notes to the field on handling, storage, installation and special inspections by design engineering staff during construction,
- designer of record limitations and permissible deviations,
- qualifications of field welders,
- process for getting designer of record approval for applying attachments to metal stud systems,
- final inspection and approval of framing systems (this could be accomplished through the local building code group).

9. MATERIALS. The marking standard used in the following material does not have a metric equivalent. Materials marked to the following standard are for field acceptance of the delivered materials. Designers are to use the nominal uncoated material thickness as shown on the drawings and within the specification.

a. Markings. The Metal Lath / Steel Framing Association (ML/SFA), Metal Stud Manufacturers Association (MSMA), the AISI Residential Advisory Group (RAG), and the Prescriptive Standard for Steel Framing, accepted by the Council of American Building Officials (CABO), have adopted a standard method of marking all cold-formed steel members. The markings will be on the web of the section and will be repeated throughout the length at a maximum of 1219 mm (48 inches) on center. There is no defined size or method of marking, but the markings must be legible and easily read. The product marking will include the following information:

(1) Manufacturer identification. Manufacturer's Name, Company Logo or emblem will be displayed to clearly identify the product manufacturer.

(2) Minimum delivered uncoated steel thickness. Material thickness without coatings or galvanizing is represented in mils of the decimal thickness value for example 0.84 mm (33 mil);

(3) Protective coating designator. The galvanizing coat designator will indicate the amount level of protection being provided such as: G-40-EQ, G-60-EQ, or G-90-EQ, where EQ is an equivalent protective coating to the designated galvanized coating.

(4) Minimum yield strength. Material strength in kips per square inch (ksi)

b. Nomenclature.

(1) Standard Nomenclature for Manufacturer's Catalogs:

(a) The first set of numbers will represent the depth of the section to two decimal places without the use of a decimal point.

(b) A Letter following the depth of the section will define the shape of the section per the following:

"S" = CEE shaped Stud
"U" = Channel shaped Stud
"T" = Track
"F" = Furring Channel

(c) The second set of numbers will represent the flange width to two decimal places without the use of a decimal point.

(d) The last set of numbers will be the minimum delivered thickness in mils and be preceded by a dash (-).

Example: 362S162-33 = 92 mm (3-5/8") CEE Stud with a 41 mm (l-5/8") Flange – 0.84 mm (33 mils) Thickness

(2) Standard Minimum Delivered Uncoated Metal Thicknesses are shown in Table 1-1:

| Table 1-1: Standard Minimum Delivered Uncoated Metal Thickness | | | | | |
|---|---|---|---|---|---|
| Nominal / Design Thickness | | | Minimum / Delivered Thickness | | |
| Gage | Soft Metric | Decimal | Soft Metric | Decimal | Mils |
| 26 | 0.437 mm | 0.0172" | 0.414 mm | 0.0163" | 16 |
| 25 | 0.478 mm | 0.0188" | 0.455 mm | 0.0179" | 18 |
| 22 | 0.719 mm | 0.0283" | 0.686 mm | 0.0270" | 27 |
| 20 | 0.879 mm | 0.0346" | 0.836 mm | 0.0329" | 33 |
| 18 | 1.146 mm | 0.0451" | 1.087 mm | 0.0428" | 43 |
| 16 | 1.438 mm | 0.0566" | 1.367 mm | 0.0538" | 54 |
| 14 | 1.811 mm | 0.0713" | 1.720 mm | 0.0677" | 68 |
| 12 | 2.583 mm | 0.1017" | 2.454 mm | 0.0966" | 97 |
| 10 | 3.150 mm | 0.1240" | 2.997 mm | 0.1180" | 118 |
| From ICBO: Acceptance Criteria for Steel Studs, Joists, and Tracks, AC46, April 1998. | | | | | |

(3) Standard Flange and Return Lips for CEE Studs:
0.46 mm & 0.69 mm (18 & 27 Mil) minimum thickness = 32 mm (1-1/4") Flange with 4.8 mm (3/16") Lip.
Any Thickness = 35 mm (1-3/8") Flange with 9.5 mm (3/8") Lip.
Any Thickness = 41 mm (1-5/8") Flange with 13 mm (1/2") Lip.
Any Thickness = 51 mm (2") Flange with 16 mm (5/8") Lip.
Any Thickness = 64 mm (2-1/2") Flange with 16 mm (5/8") Lip.

(4) Standard Track Flange Sizes: 25 mm (1"), 32 mm (1-1/4"), 38 mm (1-1/2") and 51 mm (2")

(5) Standard "U" Channels: Web x Leg x Minimum Thickness
29 mm (3/4") x 13 mm (l/2") x 1.37 mm (54 Mil)
38 mm (1-1/2") x 13 mm (1/2") x 1.37 mm (54 Mil)
51 mm (2") x 13 mm (1/2") x 1.37 mm (54 Mil)

(6) Standard Hat Furring Channels: Depth x Minimum Thickness
22 mm (7/8") x 0.46, 0.69,0.84, 1.09 mm (18, 27, 33, and 43 Mil)
38 mm (1-1/2") x 0.46, 0.69,0.84, 1.09 mm (18, 27, 33, 43, and 54 Mil)

c. Strain Hardening.

(1) General. The cold working of steel stresses it beyond its elastic limit and leaves a residual strain. After the cold working, the steel has an increased yield stress. This process of raising the yield stress is known as cold working. The amount of strain hardening is relative to the amount of cold working. In normal roll forming, the cold working is nominal, the steel remains ductile and it makes a modest improvement in the allowable stress of the section. Extensive cold working of steel can cause it to loose its ductility and become brittle, but normally, this condition is not associated with common roll formed products.

(2) Cold Reducing and Rerolling of Steel. Steel mills have the capability to cold reduce the steel sheet to meet the specified thickness before shipment to the manufacturer. Some manufacturers can reroll the steel sheet to again reduce the sheet thickness. Within the AISI Specification this is known as Other Steel. This practice is allowed by the AISI Specification if the rerolled steel meets the ductility criteria of the AISI Section A3.3. Therefore, the manufacturer is strain hardening the material.

Depending on the degree of rerolling that occurs, the material will have a higher steel yield strength, less ductility, and a more rounded stress-strain curve above the yield point of the steel than would be seen in the virgin steel sheet materials. Design guidance that is provided in chapter 3 recognizes this material property variability. Diagonal bracing materials are to be ASTM A653 steel without rerolling, and will be a Category I submittal for approval by the designer of record.

d. Damaged Materials.

(1) General. Steel framing materials can be rejected for the following reasons: physical damage (dents, cuts, twists, buckles); corrosion; length; metal thickness; yield stress; protective coating or forming. Physical damage and corrosion are easily identified. Length variations and forming problems are relatively easy to identify with standard measuring devices. The metal thickness must be checked with a micrometer and one must know what the required thickness should be. The yield strength and protective coating can only be checked through testing.

(2) Tolerances and Coatings. The allowable physical tolerances and standard protective coatings for steel framing products can be found in current ASTM Standards. ASTM C-645 covers tolerances and standard protective coatings for nonstructural partition framing and ASTM C-955 covers the same information for structural framing. The yield strength for structural framing is normally specified in the project specifications or on the drawings. Special protective coating requirements are also specified in the project specifications.

e. Fire Resistance Rating.

(1) General. Fire rating of assemblies denotes a length of time that a given assembly will resist fire penetration under controlled laboratory conditions; Table 1-2 lists many Fire Rated Assemblies. These fire-rating tests are performed in accordance with the existing consensus standards of ASTM or ANSI. A fire rating is only valid for the tested assembly. Although most materials cannot be added or changed in a fire rated assembly, stronger steel framing sections can be used. The specified depth and gauge of steel framing in a tested assembly are considered minimums. The fire rating will still apply to the assembly when steel framing members that are deeper and/or heavier than the specified members, are used.

(2) Fire Tests. There are numerous fire rated assemblies for interior walls, exterior walls, floors, ceilings, and roofs, incorporating steel framing. Various laboratories throughout the country have performed fire rating tests of loadbearing steel stud walls. Currently, within the AISI Residential Advisory Group (RAG), a task group has been assigned to compile a listing of all available fire rated assemblies, using steel framing. The following sources list many fire rated assemblies that can be used if cold-formed design.

- Fire-Resistance Ratings of Load-Bearing Steel Stud Walls (AISI, Publication Z-4)
- Fire Design Manual (Gypsum Association)

**Table 1-2: Fire Rated Assemblies**

The following table depicts various fire rated assemblies incorporating steel framing components.

| Test Reference | Fire Rating | Type of Assembly | Agency | Components |
|---|---|---|---|---|
| FM 24676.4<br>FC 224 | 2 HR | Floor/Ceiling | FM 1975 | -64 mm (2 ½") concrete (note B)<br>-14 mm (9/16") 0.36 mm (28 GA) deck and mesh<br>-184 mm (7 ¼") X 1.15 mm (18GA) joists, 610 mm (24") OC<br>-2 layers 16 mm (5/8") G.W.B. ceiling |
| FM 29135<br>FC 245 | 1 HR | Floor/Ceiling | FM 1977 | -51 mm (2") concrete<br>-41 mm (1 5/16"), 0.56 mm (24 GA) deck<br>-152 mm (6") X 1.15 mm (18 GA) joists, 610 mm (24") OC<br>-1 layer 13 mm (½") G.W.B. ceiling |
| L 524 | 1 HR | Floor/Ceiling | UL 1988 | -Min 184 mm (7 ¼") X 1.15 mm (18 GA), steel stud, 610 mm (24") OC<br>-Use any of the floor systems indicated in the UL test |
| P 511 | 1 HR | Roof/Ceiling | UL 1988 | -Min 184 mm (7 ¼") X 1.15 mm (18 GA), Steel Joist, C Shape, 51 mm (2") Flange Minimum, 610 mm (24" OC)<br>-See test for roof/ceiling components |
| P 512 | 1 HR | Roof/Ceiling | UL 1988 | -Min 184 mm (7 ¼") X 1.15 mm (18 GA), Steel Joist, C Shape, 610 mm (24") OC<br>-See test for roof/ceiling components |
| U 418 | ¾ HR | Bearing Wall | UL 1988 | See test |
| U 418 | 1 HR | Bearing Wall | UL 1988 | -2 layers 13 mm (½") thick, G.W.B, one side<br>-89 or 140 mm (3 ½" or 5 ½") X 1.15 mm (18 GA) steel stud, 610 mm (24") OC<br>-See test for exterior component |
| U 418 | 2 HR | Bearing Wall | UL 1988 | -3 layers 13 mm (½") thick, G.W.B, one side<br>-89 or 140 mm (3 ½" or 5 ½") X 1.15 mm (18 GA) steel stud, 610 mm (24") OC<br>-See test for exterior component |
| U 425 | ¾, 1 HR | Bearing Wall Interior | UL 1988 | See test |
| U 425 | 1 ½ HR | Bearing Wall Interior | UL 1988 | -2 layers 13 mm (½") thick, G.W.B, each side<br>-89 mm (3 ½") X 0.87 mm (20 GA) steel stud, 610 mm (24" OC) |
| U 425 | 2 HR | Bearing Wall Interior | UL 1988 | -3 layers 13 mm (½") thick, G.W.B<br>-89 mm (3 ½") X 0.87 mm (20 GA) steel stud, 610 mm (24") OC |
| U 425 | ¾, 1, 1 ½ HR | Bearing Wall Exterior | UL 1988 | See test |
| U 425 | 2 HR | Bearing Wall Exterior | UL 1988 | -3 layers 13mm (½") thick, G.W.B, interior side<br>-89 mm (3 ½") X 0.87 mm (20 GA) steel stud, 610 mm (24") OC<br>-See test for exterior component |
| U 426 | 3 HR | Bearing Wall | UL 1988 | -4 layers 13 mm (½") thick, G.W.B, each side<br>-89 mm (3 ½") X 0.87 mm (20 GA) steel stud, 610 mm (24") OC |
| U 434 | 1 HR | Bearing Wall | UL 1988 | -1 layer 16 mm (5/8") thick, G.W.B, interior side<br>-89 mm (3 ½") X 0.87 mm (20 GA) steel stud, 610 mm (24") OC<br>-22 mm (7/8") thick Portland Cement Plaster |

Notes:
A: UL denotes Underwriters Laboratories, Inc., and FM denotes Factory Mutual Research Corporation.
B: Lightweight concrete measured from top flute of deck.