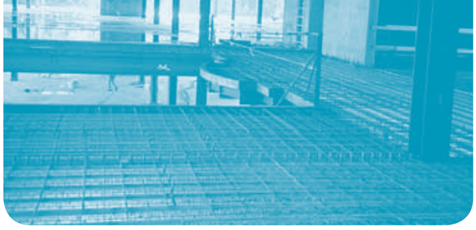
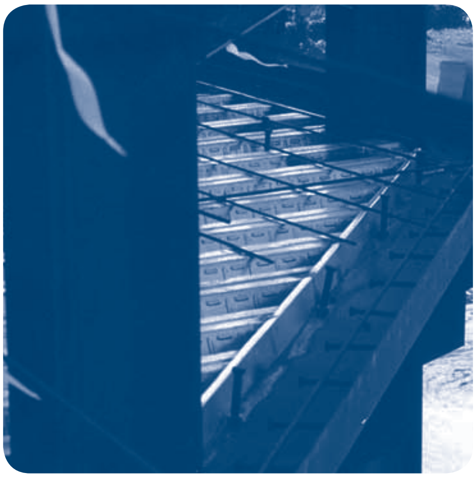




Cold-Formed Steel Design

FOURTH EDITION



Wei-Wen Yu and Roger A. LaBoube

Cold-Formed Steel Design

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Fourth Edition

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PREFACE

This fourth edition of the book has been prepared to provide readers with a better understanding of the analysis and design of the thin-walled, cold-formed steel structures that have been so widely used in building construction and other areas in recent years. It is a revised version of the first author's book, *Cold-Formed Steel Design,* third edition, published by John Wiley & Sons, Inc. in 2000. All the revisions are based on the 2007 edition of the North American Specification with Supplement No.1, which combines the allowable strength design (ASD), the load and resistance factor design (LRFD), and the limit states design (LSD) methods.

The material was originally developed for graduate courses and short courses in the analysis and design of cold-formed steel structures and is based on experience in design, research, and development of the American Iron and Steel Institute (AISI) and North American design criteria.

Throughout the book, descriptions of the structural behavior of cold-formed steel members and connections are given from both theoretical and experimental points of view. The reasons and justification for the various design provisions of the North American specification are discussed at length. Consequently the text not only will be instructive for students but also can serve as a major source of reference for structural engineers and researchers.

Of the published book's 15 chapters, Chapters 1–9 and 13 have been completely revised according to the combined ASD/LRFD/LSD North American specification and framing standards. Other chapters have been updated on the basis of available information. Chapter 15 is a new chapter on the direct-strength method.

Chapter 1 includes a general discussion of the application of cold-formed steel structures and a review of previous and recent research. It also discusses the development of design specifications and the major differences between the design of cold-formed and hot-rolled steel structural members. Because of the many research projects in the field that have been conducted worldwide during the past 35 years, numerous papers have been presented at various conferences and published in a number of conference proceedings and engineering journals. At the same time, new design criteria have been developed in various countries. These new developments are reviewed in this chapter.

Since material properties play an important role in the performance of structural members, the types of steels and their most important mechanical properties are described in Chapter 2. In addition to the revision of Table 2.1, new information on the use of low-ductility steel for concentrically loaded compression members has been included in Section 2.4. Section 2.6 includes additional information on fatigue strength.

In Chapter 3, the strength of thin elements and design criteria are discussed to acquaint the reader with the fundamentals of local buckling and postbuckling strength of thin plates and with the basic concepts used in design. This chapter has been completely revised to include detailed information on design bases for ASD, LRFD, and LSD with a revised Table 3.1, the unstiffened elements with stress gradient, the uniformly compressed elements with intermediate stiffeners, and noncircular holes.

Chapter 4 deals with the design of flexural members. Because the design provisions were revised extensively during 2001–2007, this chapter has been completely rewritten to cover the design of beams using ASD, LRFD, and LSD methods. It includes new and revised design information on inelastic reserve capacity of beams with unstiffened elements, distortional buckling strength, shear strength of webs, web crippling strength and combination with bending, bearing stiffeners in C-section beams, bracing requirements, and beams having one flange fastened to a standing seam roof system.

The design procedures for compression members are discussed in Chapter 5. This chapter has been brought up to date by including new design information on distortional buckling strength, built-up members, bracing requirements, and Z-section members having one flange fastened to a standing seam roof.

In 2007, the North American specification introduced the second-order analysis approach as an optional method for stability analysis. A new Section 6.6 has been added in Chapter 6 to deal with this alternative method. In addition, revisions have also been made on the design of beam–columns using ASD, LRFD, and LSD methods.

Chapter 7 covers the design of closed cylindrical tubes. This revised chapter reflects the rearrangement of design provisions in the North American specification and minor changes made in the 2007 edition of the specification.

Like the member design, the design of connections has been updated in Chapter 8 using the ASD, LRFD, and LSD methods with additional and revised design provisions for bearing strength between bolts and connected parts, combined shear and tension in bolts, block shear strength, revised design information on screw connections, and power-actuated fasteners.

Because various types of structural systems, such as shear diaphragms and shell roof structures, have become increasingly popular in building construction, Chapter 9 contains design information on these types of structural systems. It includes the new standard for the cantilever test method for shear diaphragms and the revised design procedure for wall studs. A new Section 9.5 has been added for metal roof systems.

The sectional properties of standard corrugated sheets are discussed in Chapter 10 because they have long been used in buildings for roofing, siding, and other applications. Minor revisions have been made in Section 10.4.

Steel decks are widely used in building construction. Consequently the updated information in Chapter 11 on their use in steel-deck-reinforced composite slabs and composite beams is timely.

Chapter 12 contains an introduction to the design of cold-formed stainless steel structural members supplementing the information on cold-formed carbon steel structural members in other chapters. This chapter has been updated on the basis of the revised Structural Engineering Institute/American Society of Civil Engineers (SEI/ASCE) Standard 8-02 and recent research findings for the design of cold-formed stainless steel structural members.

During recent years, cold-formed steel members have been used increasingly for residential and commercial construction. The previous Chapter 14 has been completely rewritten based on new and revised framing standards. This chapter has been changed to Chapter 13 using the new title of Light-Frame Construction.

The increasing use of computers for design work warrants the brief introduction that is given in the revised Chapter 14 for the computer-aided design of cold-formed steel structures.

In 2004, a new Appendix 1 was added in the North American specification for the use of the direct-strength method to determine the nominal axial strength for columns and flexural strength for beams. These alternative design procedures are discussed in the new Chapter 15. Also discussed in this chapter are the Commentary on Appendix 1, the *Direct Strength Method Design Guide*, and design examples.

It is obvious that a book of this nature would not have been possible without the cooperation and assistance of many individuals, organizations, and institutions. It is based primarily on the results of continuing research programs on cold-formed steel structures that have been sponsored by the American Iron and Steel Institute (AISI), the ASCE, the Canadian Sheet Steel Building Institute (CSSBI), the Cold-Formed Steel Engineers Institute (CFSEI) of the Steel Framing Alliance (SFA), the Metal Building Manufacturers Association (MBMA), the Metal Construction Association (MCA), the National Science Foundation (NSF), the Rack Manufacturers Institute (RMI), the Steel Deck Institute (SDI), the Steel Stud Manufacturers Association (SSMA), and other organizations located in the United States and abroad. The publications related to cold-formed steel structures issued by AISI and other institutions have been very helpful for the preparation of this book.

The first author is especially indebted to his teacher, the late Professor George Winter of Cornell University, who made contributions of pronounced significance to the building profession in his outstanding research on cold-formed steel structures and in the development of AISI design criteria. A considerable amount of material used in this book is based on Dr. Winter's publications.

Our sincere thanks go to Mr. Robert J. Wills, Vice President, Construction Market Development, Steel Market Development Institute (a business unit of the American Iron and Steel Institute), for permission to quote freely from the North American Specification, Commentary, Design Manual, Framing Standards, Design Guides, and other AISI publications. An expression of appreciation is also due to the many organizations and individuals that granted permission for the reproduction of quotations, graphs, tables, and photographs. Credits for the use of such materials are given in the text.

We wish to express our sincere thanks to Mr. Don Allen, Mr. Roger L. Brockenbrough, Dr. Helen Chen, Mr. Jay W. Larson, Professor Teoman B. Pekoz, Professor Benjamin

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We are very grateful to Mrs. Christina Stratman for her kind assistance in the preparation of this book. Thanks are also due to Miss Domenica Cambio and Miss Mingyan Deng for their careful typing and preparation of drawings. The financial assistance provided by the Missouri University of Science and Technology through the first author's Curators' Professorship and the sponsors for the Wei-Wen Yu Center for Cold-Formed Steel Structures is appreciated.

This book could not have been completed without the help and encouragement of the authors' wives, Yuh-Hsin Yu and Karen LaBoube, as well as for their patience, understanding, and assistance.

Wei-Wen Yu
Roger A. LaBoube

Rolla, Missouri
March 2010

Cold-Formed Steel Design

CHAPTER 1

Introduction

1.1 GENERAL REMARKS

In steel construction, there are two main families of structural members. One is the familiar group of hot-rolled shapes and members built up of plates. The other, less familiar but of growing importance, is composed of sections cold formed from steel sheet, strip, plate, or flat bar in roll-forming machines or by press brake or bending brake operations.[1.1,1.2,1.3*] These are cold-formed steel structural members. The thickness of steel sheet or strip generally used in cold-formed steel structural members ranges from 0.0149 in. (0.378 mm) to about $\frac{1}{4}$ in. (6.35 mm). Steel plates and bars as thick as 1 in. (25.4 mm) can be cold formed successfully into structural shapes.[1.1,1.4,1.314,1.336,1.345]

Although cold-formed steel sections are used in car bodies, railway coaches, various types of equipment, storage racks, grain bins, highway products, transmission towers, transmission poles, drainage facilities, and bridge construction, the discussions included herein are primarily limited to applications in building construction. For structures other than buildings, allowances for dynamic effects, fatigue, and corrosion may be necessary.[1.314,1.336,1.345]

The use of cold-formed steel members in building construction began in about the 1850s in both the United States and Great Britain. However, such steel members were not widely used in buildings until around 1940. The early development of steel buildings has been reviewed by Winter.[1.5–1.7]

Since 1946 the use and the development of thin-walled cold-formed steel construction in the United States have been accelerated by the issuance of various editions of the "Specification for the Design of Cold-Formed Steel Structural Members" of the American Iron and Steel Institute (AISI).[1.267,1.345] The earlier editions of the specification were based largely on the research sponsored by AISI at Cornell University under the direction of George Winter since 1939. It has been revised subsequently to reflect the technical developments and the results of continuing research.[1.267,1.336,1.346]

In general, cold-formed steel structural members provide the following advantages in building construction:

1. As compared with thicker hot-rolled shapes, cold-formed light members can be manufactured for relatively light loads and/or short spans.
2. Unusual sectional configurations can be produced economically by cold-forming operations (Fig. 1.1), and consequently favorable strength-to-weight ratios can be obtained.
3. Nestable sections can be produced, allowing for compact packaging and shipping.
4. Load-carrying panels and decks can provide useful surfaces for floor, roof, and wall construction, and in other cases they can also provide enclosed cells for electrical and other conduits.
5. Load-carrying panels and decks not only withstand loads normal to their surfaces, but they can also act as shear diaphragms to resist force in their own planes if they are adequately interconnected to each other and to supporting members.

Figure 1.1 Various shapes of cold-formed sections.[1.1]

*The references are listed at the back of the book.

Compared with other materials such as timber and concrete, the following qualities can be realized for cold-formed steel structural members[1.8,1.9]:

1. Lightness
2. High strength and stiffness
3. Ease of prefabrication and mass production
4. Fast and easy erection and installation
5. Substantial elimination of delays due to weather
6. More accurate detailing
7. Nonshrinking and noncreeping at ambient temperatures
8. Formwork unneeded
9. Termite proof and rot proof
10. Uniform quality
11. Economy in transportation and handling
12. Noncombustibility
13. Recyclable material

The combination of the above-mentioned advantages can result in cost saving in construction.

1.2 TYPES OF COLD-FORMED STEEL SECTIONS AND THEIR APPLICATIONS

Cold-formed steel structural members can be classified into two major types:

1. Individual structural framing members
2. Panels and decks

The design and the usage of each type of structural members have been reviewed and discussed in a number of publications.[1.5–1.75,1.267–1.285,1.349,1.358]

1.2.1 Individual Structural Framing Members

Figure 1.2 shows some of the cold-formed sections generally used in structural framing. The usual shapes are channels (C-sections), Z-sections, angles, hat sections, I-sections, T-sections, and tubular members. Previous studies have indicated that the sigma section (Fig. 1.2*d*) possesses several advantages such as high load-carrying capacity, smaller blank size, less weight,

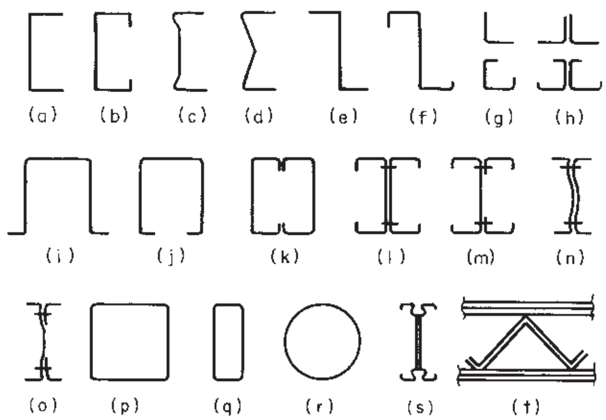

Figure 1.2 Cold-formed sections used in structural framing.[1.6]

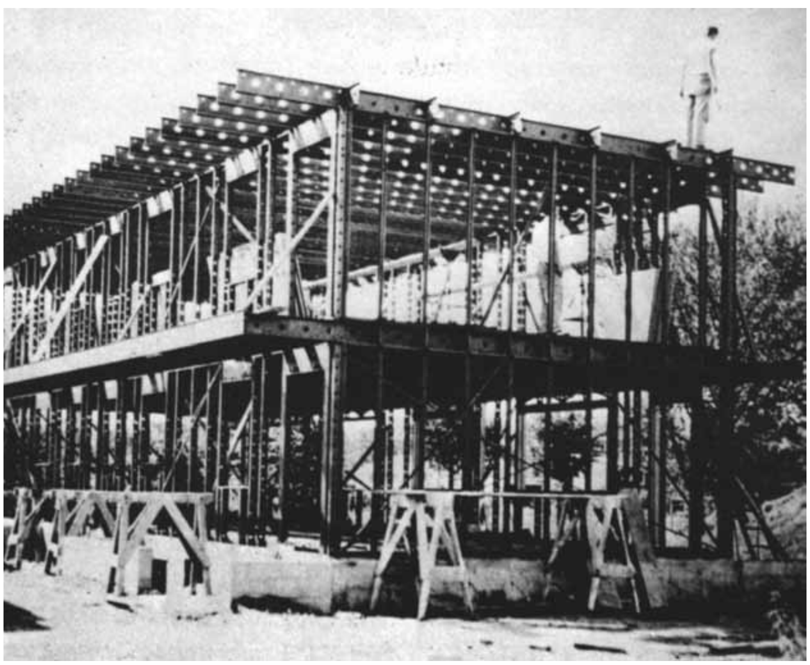

Figure 1.3 Building composed entirely of cold-formed steel sections. (Courtesy of Penn Metal Company.)[1.7]

and larger torsional rigidity as compared with standard channels.[1.76]

In general, the depth of cold-formed individual framing members ranges from 2 to 12 in. (50.8 to 305 mm), and the thickness of material ranges from 0.048 to about $\frac{1}{4}$ in. (1.22 to about 6.35 mm). In some cases, the depth of individual members may be up to 18 in. (457 mm), and the thickness of the member may be $\frac{1}{2}$ in. (12.7 mm) or thicker in transportation and building construction. Cold-formed steel plate sections in thicknesses of up to about $\frac{3}{4}$ or 1 in. (19.1 or 25.4 mm) have been used in steel plate structures, transmission poles, and highway sign support structures.

In view of the fact that the major function of this type of individual framing member is to carry load, structural strength and stiffness are the main considerations in design. Such sections can be used as primary framing members in buildings up to six stories in height.[1.278] In 2000, the 165-unit Holiday Inn in Federal Way, Washington, utilized eight stories of axial load bearing cold-formed steel studs as the primary load-bearing system.[1.357] Figure 1.3 shows a two-story building. In tall multistory buildings the main framing is typically of heavy hot-rolled shapes and the secondary elements may be of cold-formed steel members such as steel joists, studs, decks, or panels (Figs. 1.4 and 1.5). In this case the heavy hot-rolled steel shapes and the cold-formed steel sections supplement each other.[1.264]

As shown in Figs. 1.2 and 1.6–1.10, cold-formed sections are also used as chord and web members of open web steel joists, space frames, arches, and storage racks.

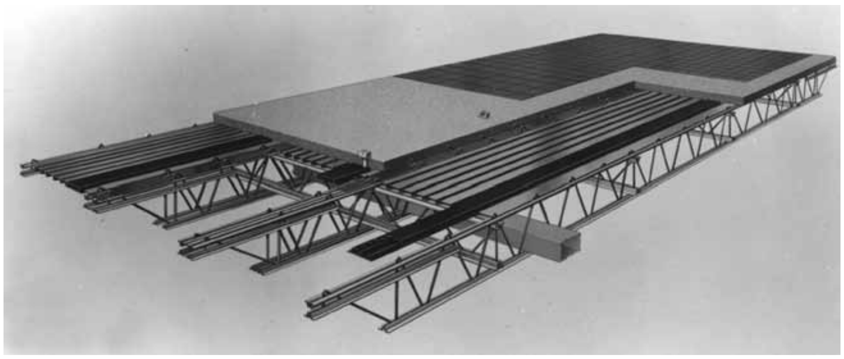

Figure 1.4 Composite truss–panel system prefabricated by Laclede Steel Company.

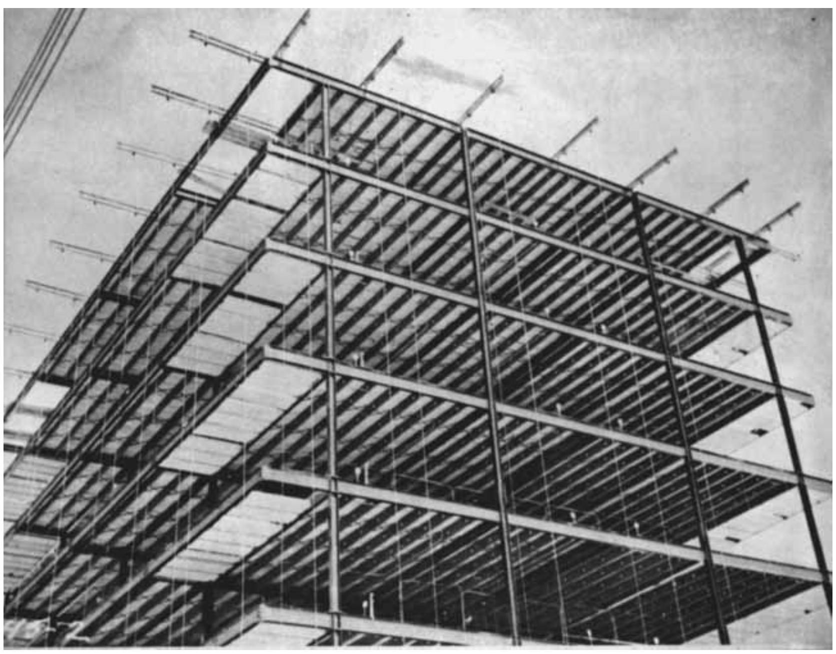

Figure 1.5 Cold-formed steel joists used together with hot-rolled shapes. (Courtesy of Stran-Steel Corporation.)

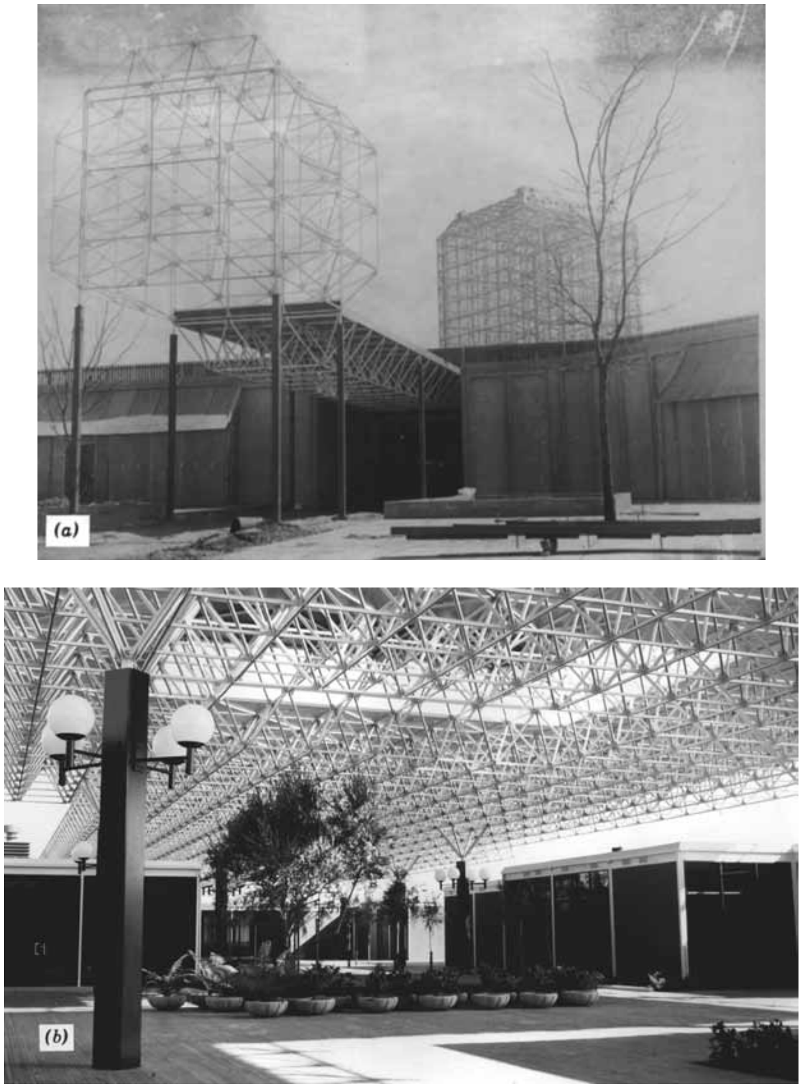

Figure 1.6 Cold-formed steel sections used in space frames. (Courtesy of Unistrut Corporation.)

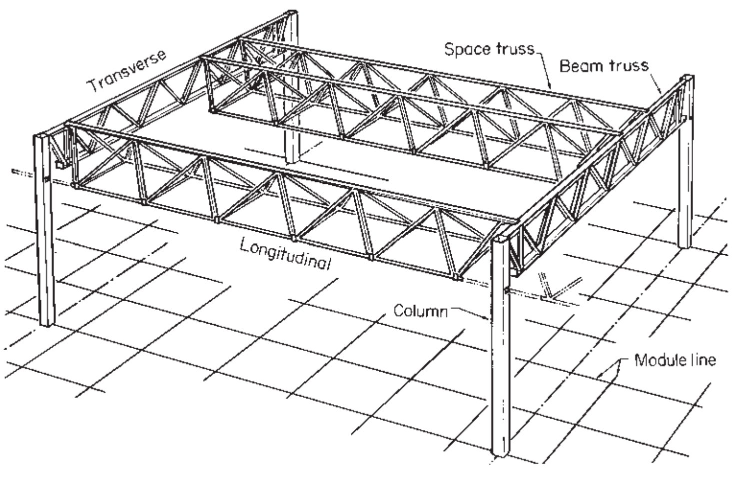

Figure 1.7 Cold-formed steel members used in space grid system. (Courtesy of Butler Manufacturing Company.)

Figure 1.8 Cold-formed steel members used in a $100 \times 220 \times 30$-ft ($30.5 \times 67.1 \times 9.2$-m) triodetic arch. (Courtesy of Butler Manufacturing Company.)

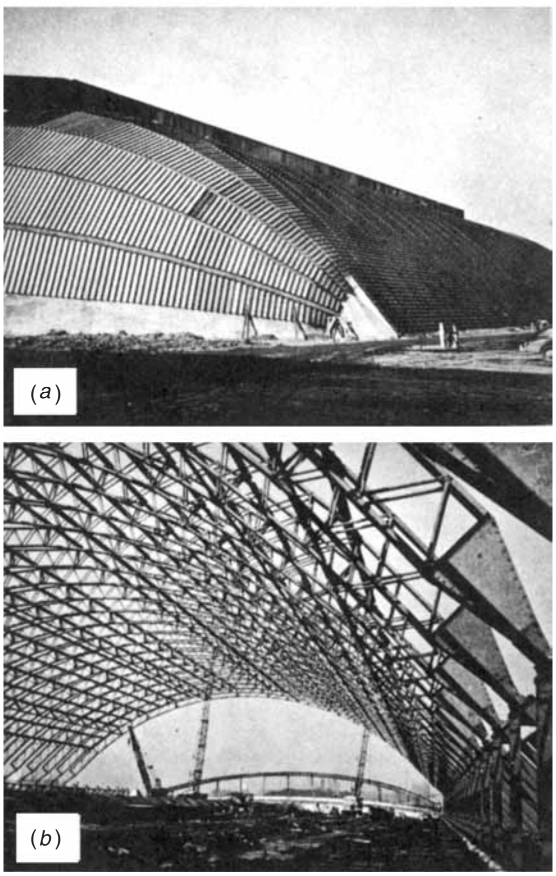

Figure 1.9 Hangar-type arch structures using cold-formed steel sections. (Courtesy of Armco Steel Corporation.)[1.6]

1.2.2 Panels and Decks

Another category of cold-formed sections is shown in Fig. 1.11. These sections are generally used for roof decks, floor decks, wall panels, siding material, and bridge forms. Some deeper panels and decks are cold formed with web stiffeners.

The depth of panels generally ranges from $1\frac{1}{2}$ to $7\frac{1}{2}$ in. (38.1 to 191 mm), and the thickness of materials ranges from 0.018 to 0.075 in. (0.457 to 1.91 mm). This is not to suggest that in some cases the use of 0.012-in. (0.305-mm) steel ribbed sections as load-carrying elements in roof and wall construction would be inappropriate.

Steel panels and decks not only provide structural strength to carry loads, but they also provide a surface on which flooring, roofing, or concrete fill can be applied, as shown in Fig. 1.12. They can also provide space for electrical conduits, or they can be perforated and combined with sound absorption material to form an acoustically conditioned ceiling. The cells of cellular panels are also used as ducts for heating and air conditioning.

In the past, steel roof decks were successfully used in folded-plate and hyperbolic paraboloid roof construction,[1.13,1.22,1.26,1.30,1.34,1.35,1.72,1.77–1.84] as shown in Figs. 1.13 and 1.14. The world's largest cold-formed steel primary structure using steel decking for hyperbolic paraboloids, designed by Lev Zetlin Associates, is shown in Fig. 1.15.[1.82] In many cases, roof decks are curved to fit the shape of an arched roof without difficulty. Some roof decks are shipped to the field in straight sections and curved to the radius of an arched roof at the job site (Fig. 1.16). In other buildings, roof decks have been designed as the top chord of prefabricated open web steel joists or roof trusses (Fig. 1.17).[1.85,1.86] In Europe, TRP 200 decking (206 mm deep by 750 mm pitch) has been used widely. In the United States, the standing seam metal roof has an established track record in new construction and replacement for built-up and single-ply systems in many low-rise buildings.

Figure 1.10 Rack structures. (Courtesy of Unarco Materials Storage.)

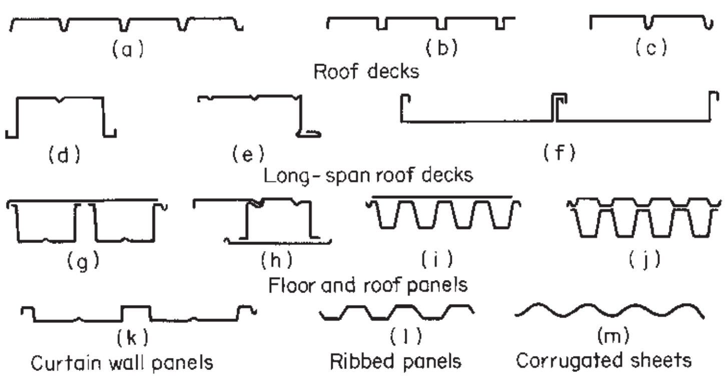

Figure 1.11 Decks, panels, and corrugated sheets.

Figure 1.11 also shows corrugated sheets which are often used as roof or wall panels and in drainage structures. The use of corrugated sheets as exterior curtain wall panels is illustrated in Fig. 1.18*a*. It has been demonstrated that corrugated sheets can be used effectively in the arched roofs of underground shelters and drainage structures.[1.87–1.89]

The pitch of corrugations usually ranges from $1\frac{1}{4}$ to 3 in. (31.8 to 76.2 mm), and the corrugation depth varies from $\frac{1}{4}$ to 1 in. (6.35 to 25.4 mm). The thickness of corrugated steel sheets usually ranges from 0.0135 to 0.164 in. (0.343 to 4.17 mm). However, corrugations with a pitch of up to 6 in. (152 mm) and a depth of up to 2 in. (50.8 mm) are also available. See Chapter 10 for the design of corrugated steel sheets based on the AISI publications.[1.87,1.88] Unusually deep corrugated panels have been used in frameless stressed-skin construction, as shown in Fig. 1.18*b*. The

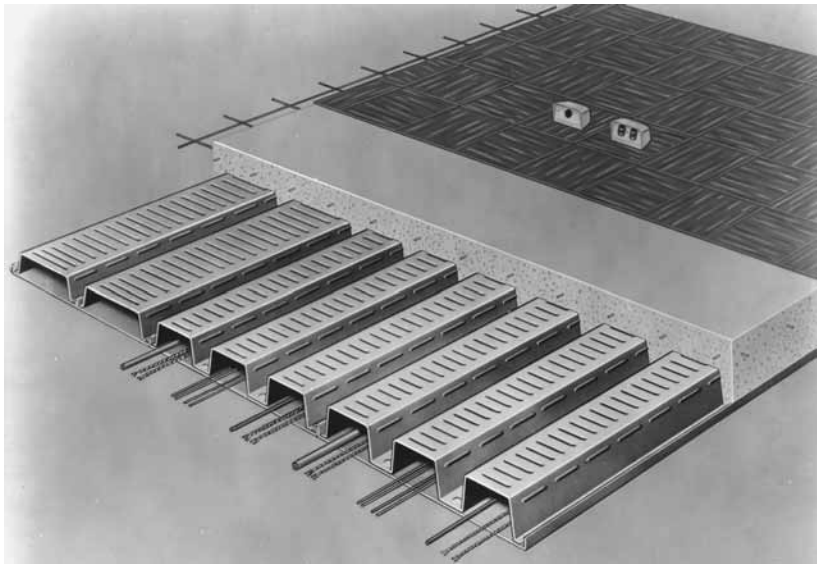

Figure 1.12 Cellular floor panels. (Courtesy of H. H. Robertson Company.)

Figure 1.13 Cold-formed steel panels used in folded-plate roof. (Courtesy of H. H. Robertson Company.)

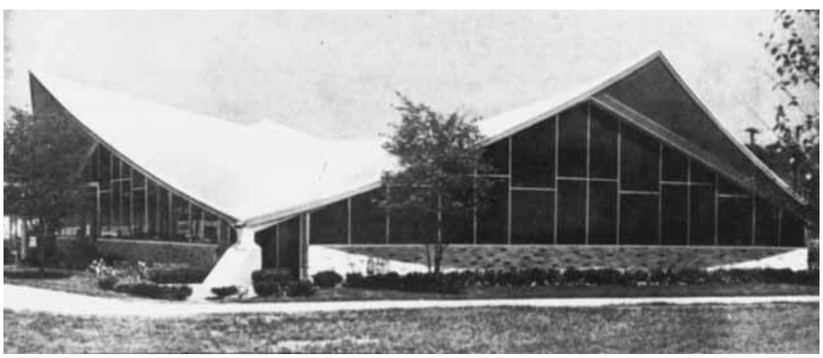

Figure 1.14 Hyperbolic paraboloid roof of welded laminated steel deck. (Reprinted from *Architectural Record,* March 1962. Copyright by McGraw-Hill Book Co., Inc.)[1.79]

Figure 1.15 Superbay hangar for American Airlines Boeing 747s in Los Angeles. (Courtesy of Lev Zetlin Associates, Inc.)[1.82]

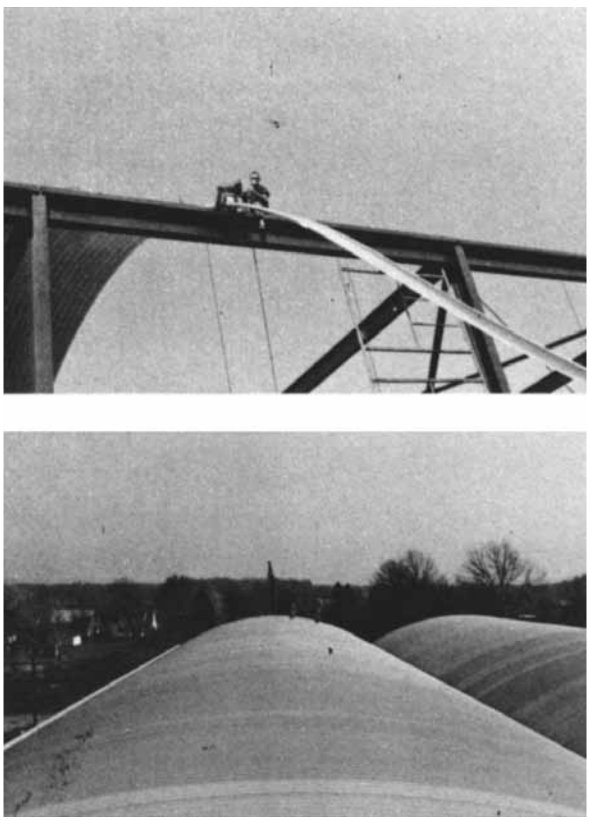

Figure 1.16 Arched roof curved at job site. (Courtesy of Donn Products Company.)

self-framing corrugated steel panel building proved to be an effective blast-resistant structure in the Nevada tests conducted in 1955.[1.90]

Figure 1.19 shows the application of standing seam roof systems. The design of beams having one flange fastened to a standing seam roof system and the strength of standing seam roof panel systems are discussed in Chapter 4.

In the past four decades, cold-formed steel deck has been successfully used not only as formwork but also as reinforcement of composite concrete floor and roof slabs.[1.55,1.91–1.103] The floor systems of this type of composite steel deck-reinforced concrete slab are discussed in Chapter 11.

1.3 STANDARDIZED METAL BUILDINGS AND INDUSTRIALIZED HOUSING

Standardized single-story metal buildings have been widely used in industrial, commercial, and agricultural applications. Metal building systems have also been used for community facilities such as recreation buildings, schools, and churches[1.104,1.105] because standardized metal building provides the following major advantages:

1. Attractive appearance
2. Fast construction
3. Low maintenance
4. Easy extension
5. Lower long-term cost

Figure 1.17 Steel deck is designed as the top chord of prefabricated open web steel joists. (Courtesy of Inland-Ryerson Construction Products Company.)

In general, small buildings can be made entirely of cold-formed sections (Fig. 1.20), and relatively large buildings are often made of welded steel plate rigid frames with cold-formed sections used for girts, purlins, roofs, and walls (Fig. 1.21).

The design of preengineered standardized metal buildings is often based on the *Metal Building Systems Manual* issued by the Metal Building Manufacturers Association (MBMA).[1.360] The 2006 edition of the MBMA manual is a revised version of the 2002 manual. The new manual includes (a) load application data [International Building Code (IBC) 2006 loads], (b) crane loads, (c) serviceability, (d) common industry practices, (e) guide specifications, (f) AISC-MB certification, (g) wind load commentary, (h) fire protection, (i) wind, snow, and rain data by U.S. county, (j) a glossary, (k) an appendix, and (l) a bibliography. In addition, MBMA also published the *Metal Roof Systems Design Manual*.[1.361] It includes systems components, substrates, specifications and standards, retrofit, common industry practices, design, installation, energy, and fire protection.

The design of single-story rigid frames is treated extensively by Lee et al.[1.107] In Canada the design, fabrication, and erection of steel building systems are based on a standard of the Canadian Sheet Steel Building Institute (CSSBI).[1.108]

Industrialized housing can be subdivided conveniently into (1) panelized systems and (2) modular systems.[1.109,1.278] In panelized systems, flat wall, floor, and roof sections are prefabricated in a production system, transported to the site, and assembled in place. In modular systems, three-dimensional housing unit segments are factory built, transported to the site, lifted into place, and fastened together.

In the 1960s, under the School Construction Systems Development Project of California, four modular systems of school construction were developed by Inland Steel Products Company (modular system as shown in Fig. 1.17), Macomber Incorporated (V-Lok modular component system as shown in Fig. 1.22), and Rheem/Dudley Buildings (flexible space system).[1.110] These systems have been proven to be efficient structures at reduced cost. They are successful not only for schools but also for industrial and commercial buildings throughout the United States.

In 1970 Republic Steel Corporation was selected by the Department of Housing and Urban Development under the Operation Breakthrough Program to develop a modular system for housing.[1.111] Panels consisting of steel facings with an insulated core were used in this system.

Building innovation also includes the construction of unitized boxes. These boxes are planned to be prefabricated of room size, fully furnished, and stacked in some manner to be a hotel, hospital, apartment, or office building.[1.25,1.112] For multistory buildings these boxes can be supported by a main framing made of heavy steel shapes.

In the past, cold-formed steel structural components have been used increasingly in low-rise buildings and residential steel framing. Considerable research

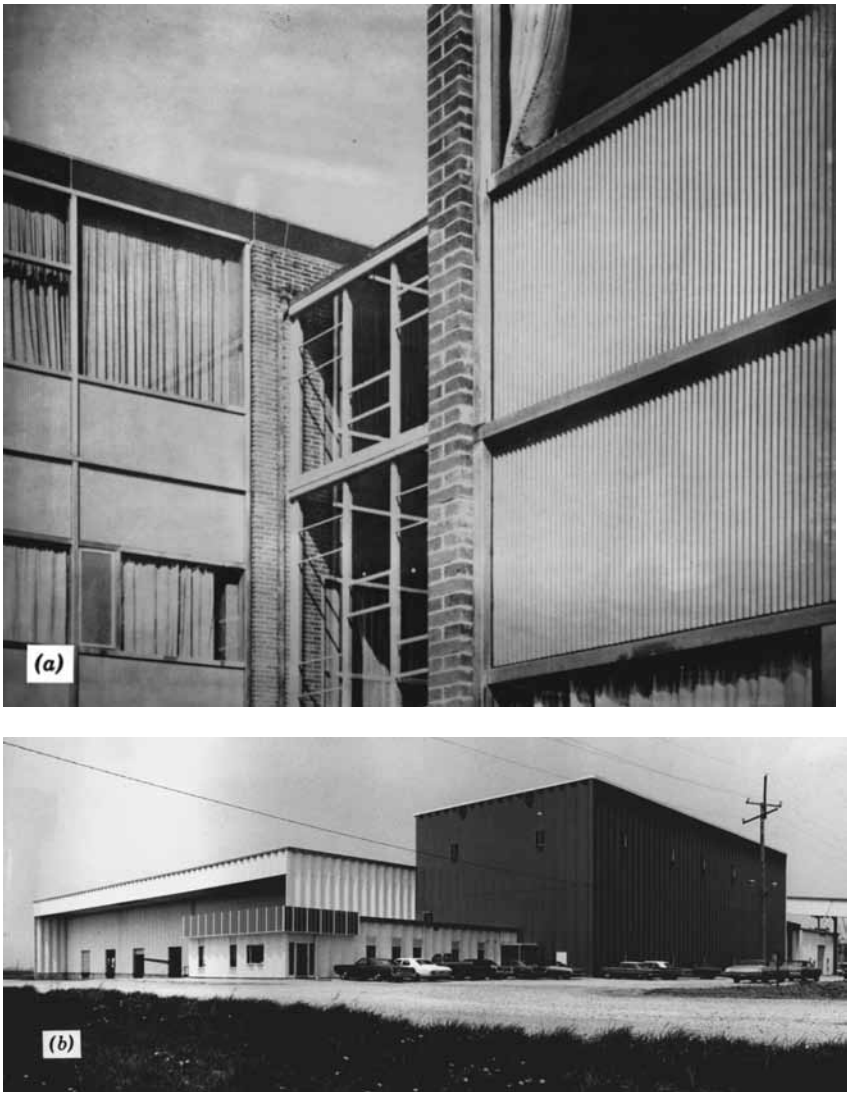

Figure 1.18 (*a*) Exterior curtain wall panels employing corrugated steel sheets.[1.87] (*b*) Frameless stressed-skin construction. (Courtesy of Behlen Manufacturing Company.)

Figure 1.19 Application of standing seam roof systems. (Courtesy of Butler Manufacturing Company.)

and development activities have been conducted continuously by numerous organizations and steel companies.[1.21,1.25,1.27,1.28,1.113–116,1.280–1.301] In addition to the study of the load-carrying capacity of various structural components, recent research work has concentrated on (1) joining methods, (2) thermal and acoustical performance of wall panels and floor and roof systems, (3) vibrational response of steel decks and floor joists, (4) foundation wall panels, (5) trusses, and (6) energy considerations. Chapter 13 provides some information on recent developments, design standards, and design guide for cold-formed steel light-frame construction.

In Europe and other countries many design concepts and building systems have been developed. For details,

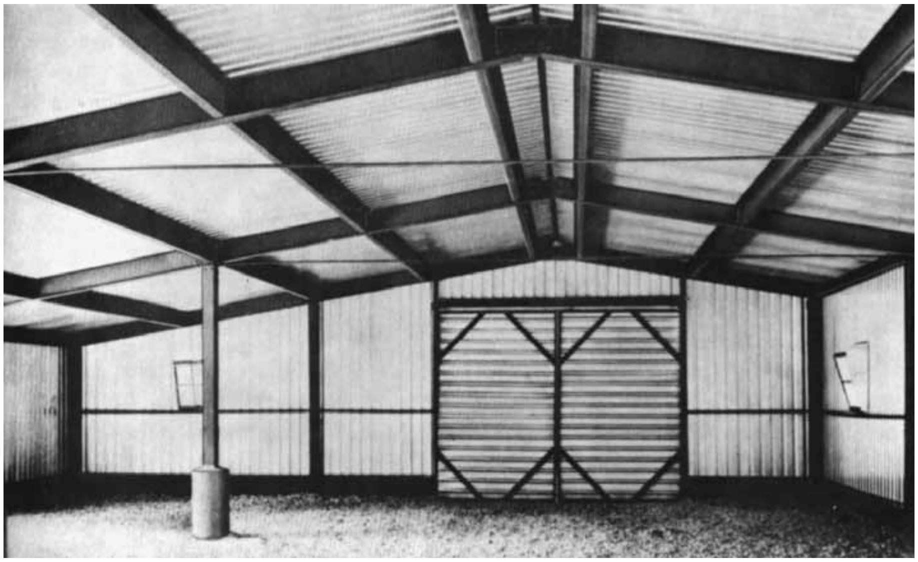

Figure 1.20 Small building made entirely of cold-formed sections. (Courtesy of Stran-Steel Corporation.)[1.6]

Figure 1.21 Standardized building made of fabricated rigid frame with cold-formed sections for girts, purlins, roofs, and walls. (Courtesy of Armco Steel Corporation.)

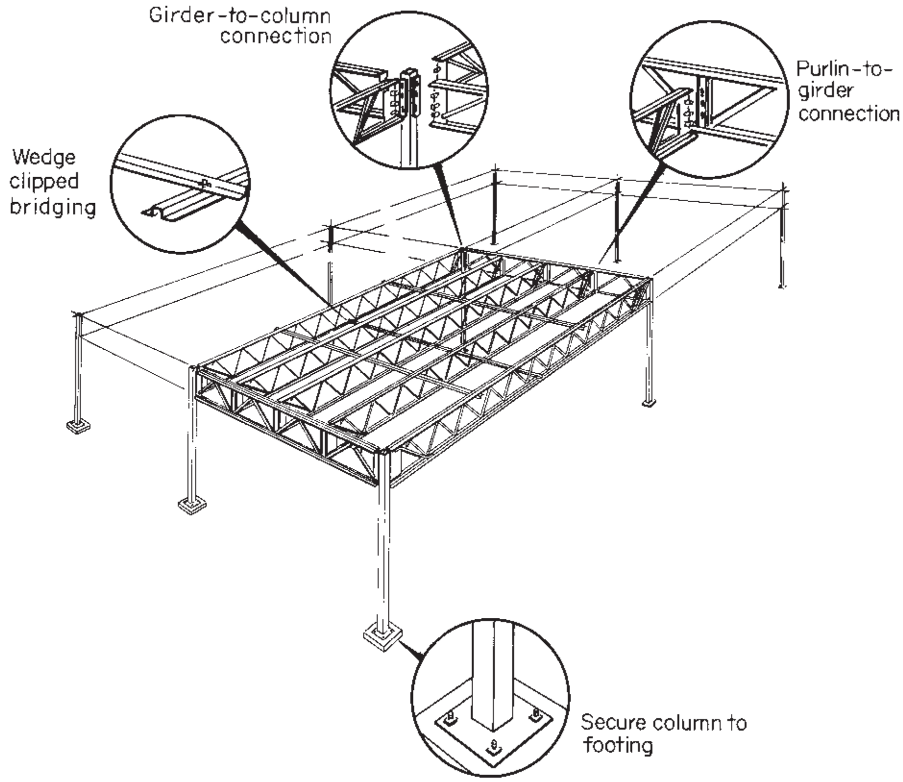

Figure 1.22 V-Lok modular component system. (Courtesy of Macomber Incorporated.)

see Refs. 1.25, 1.40–1.43, 1.117, 118, 1.268, 1.270, 1.271, 1.273, 1.275, 1.290, 1.293, and 1.297.

1.4 METHODS OF FORMING

Three methods are generally used in the manufacture of cold-formed sections such as illustrated in Fig. 1.1:

1. Cold roll forming
2. Press brake operation
3. Bending brake operation

1.4.1 Cold Roll Forming[1.1,1.119]

The method of cold roll forming has been widely used for the production of building components such as individual structural members, as shown in Fig. 1.2, and some roof, floor, and wall panels and corrugated sheets, as shown in Fig. 1.11. It is also employed in the fabrication of partitions, frames of windows and doors, gutters, downspouts, pipes, agricultural equipment, trucks, trailers, containers, railway passenger and freight cars, household appliances, and other products. Sections made from strips up to 36 in. (915 mm) wide and from coils more than 3000 ft (915 m) long can be produced most economically by cold roll forming.

The machine used in cold roll forming consists of pairs of rolls (Fig. 1.23) which progressively form strips into the final required shape. A simple section may be produced by as few as six pairs of rolls. However, a complex section may require as many as 15 sets of rolls. Roll setup time may be several days.

The speed of the rolling process ranges from 20 to 300 ft/min (6 to 92 m/min). The usual speed is in the range of 75–150 ft/min (23–46 m/min). At the finish end, the completed section is usually cut to required lengths by an automatic cutoff tool without stopping the machine. Maximum cut lengths are usually between 20 and 40 ft (6 and 12 m).

As far as the limitations for thickness of material are concerned, carbon steel plate as thick as $\frac{3}{4}$ in. (19 mm) can be roll formed successfully, and stainless steels have been roll formed in thicknesses of 0.006–0.30 in. (0.2–7.6 mm). The size ranges of structural shapes that can be roll formed on standard mill-type cold-roll-forming machines are shown in Fig. 1.24.

The tolerances in roll forming are usually affected by the section size, the product type, and the material thickness.

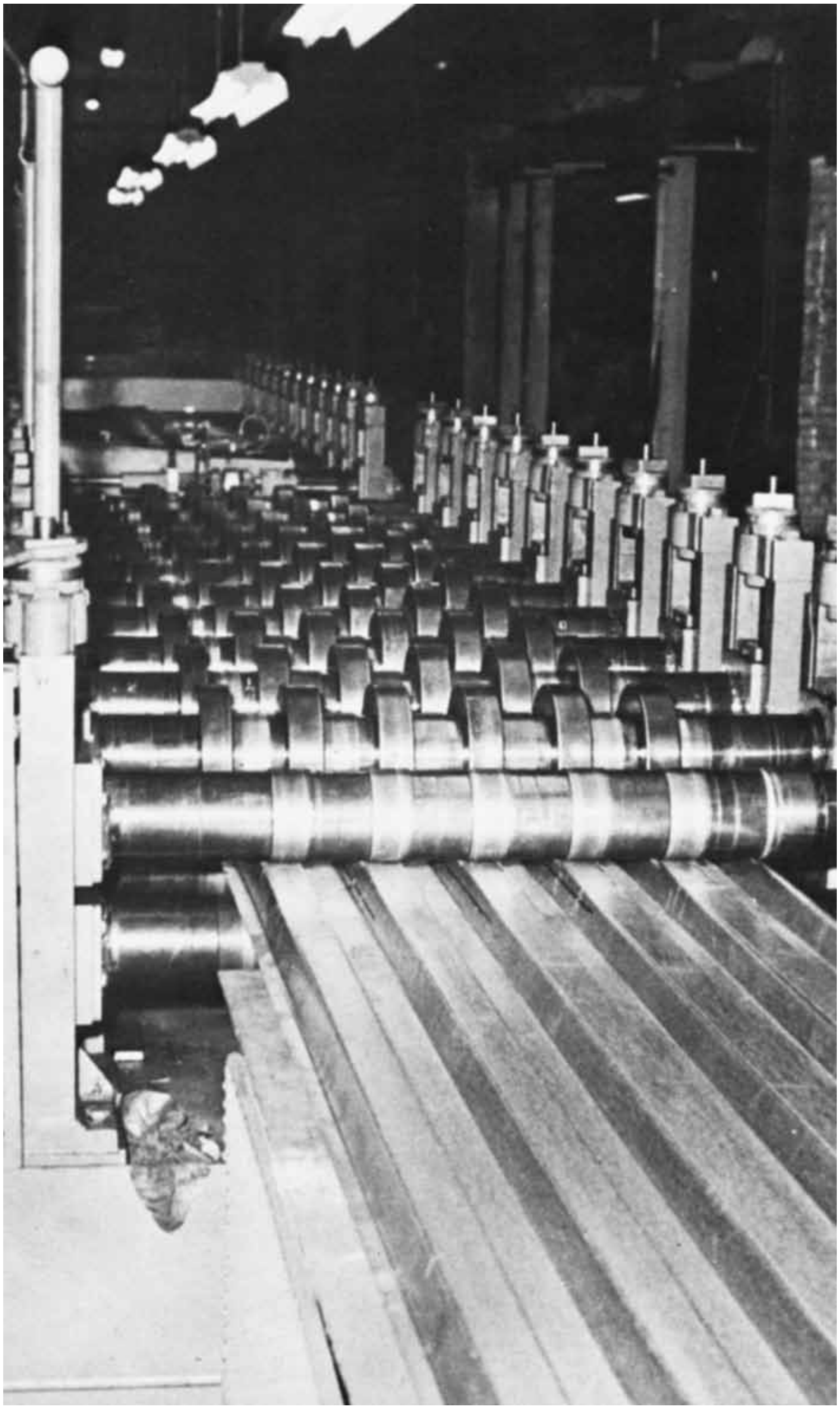

Figure 1.23 Cold-roll-forming machine.

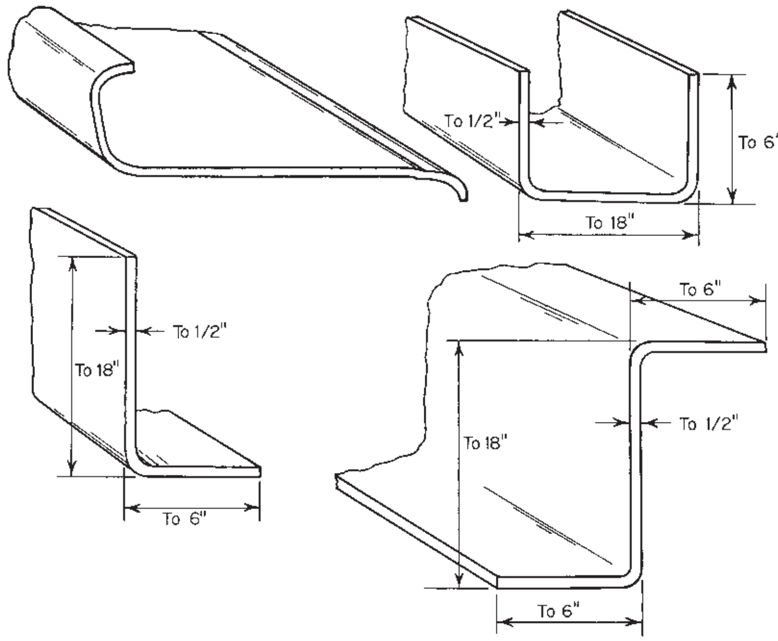

Figure 1.24 Size ranges of typical roll-formed structural shapes.[1.1]

The following limits are given by Kirkland[1.1] as representative of commercial practice, but they are not necessarily universal:

Piece length, using automatic cutoff	$\pm\frac{1}{64}$–$\frac{1}{8}$ in. (0.4–3.2 mm)
Straightness and twist	$\frac{1}{64}$–$\frac{1}{4}$ in. (0.4–6.4 mm) in 10 ft (3 m)
Cross-sectional dimensions	
Fractional	$\pm\frac{1}{64}$–$\frac{1}{16}$ in. (0.4–1.6 mm)
Decimal	±0.005–0.015 in. (0.1–0.4 mm)
Angles	$\pm 1^\circ$–2°

Table 1.1 gives the fabrication tolerances as specified by the MBMA for cold-formed steel channels and Z-sections to be used in metal building systems.[1.360] All symbols used in the table are defined in Fig. 1.25. The same tolerances are specified in the standard of the CSSBI.[1.108] For light steel framing members, the AISI framing standard S200-07 on general provisions[1.400] includes manufacturing tolerances for structural members. These tolerances for studs and tracks are based on the American Society for Testing and Materials (ASTM) standard C955-03. See Table 1.2 and Fig. 1.26. For additional information on roll forming, see Ref. 1.119.

Table 1.1 MBMA Table on Fabrication Tolerances[1.341]

	Tolerances, in.	
Dimension	+	−
Geometry		
D	$\frac{3}{16}$	$\frac{3}{16}$
B	$\frac{3}{16}$	$\frac{3}{16}$
D	$\frac{3}{8}$	$\frac{1}{8}$
θ_1	3°	3°
θ_2	5°	5°
Hole location		
E_1	$\frac{1}{8}$	$\frac{1}{8}$
E_2	$\frac{1}{8}$	$\frac{1}{8}$
E_3	$\frac{1}{8}$	$\frac{1}{8}$
S_1	$\frac{1}{16}$	$\frac{1}{16}$
S_2	$\frac{1}{16}$	$\frac{1}{16}$
F	$\frac{1}{8}$	$\frac{1}{8}$
P	$\frac{1}{8}$	$\frac{1}{8}$
L	$\frac{1}{8}$	$\frac{1}{8}$
Chamber, C	$\frac{1}{4}\left(\frac{\text{L ft}}{10}\right)$, in.	
Minimum thickness t	$0.95 \times$ design t	

Note: 1 in. = 25.4 mm.