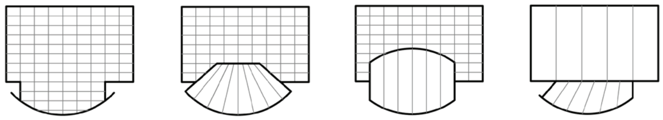
STRUCTURAL STEEL DESIGN TIPS

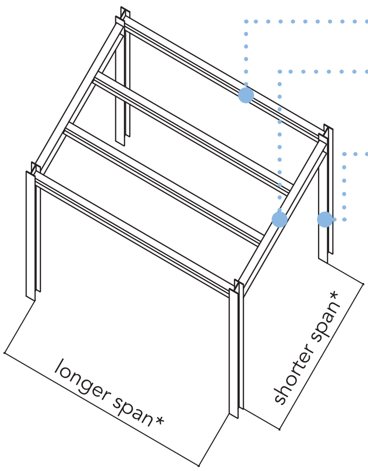
Quick Estimates and Rules of Thumb for Architecture Students

BAY LAYOUT

W24×55 is 24 in. deep and weighs 55 lb/ft of member length.



Plan and structural diagram options for the same building outline can create exciting options in architectural expression, especially if steel is exposed.



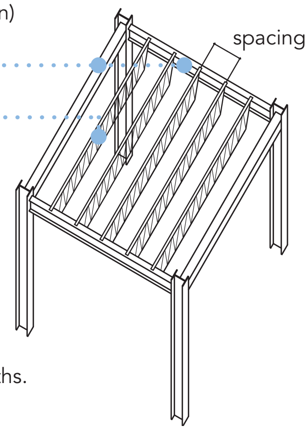
Beam (framing to transfer floor load to girder)

Girder (a beam that transfers the load of several beams to columns)

Column (vertical support that transfers girder loads to the foundation)

Girder or Beam

Joist or **Truss** (framing that transfers floor loads to a girder or primary beam)



*The most efficient and economical bays have a 1:1.25–1.5 width proportion and an area of 750–1,250 ft² with infill beams spanning the long direction to have closer girder and beam depths. Spacing should consider the type of deck and spans. (Ruby, p. 15)

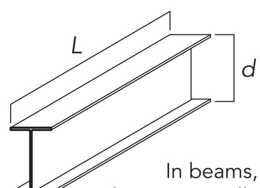
BEAM DEPTHS

W-shape beam depth estimate

Beam: ½ in. depth (*d*) per foot of span (*L*), so 30 ft span means 15 in. beam depth (W16)

Girder or Beam with heavy loads: Use above estimate, but round up one size (W18)

Roof Purlin: Use above estimate for beams, but round down one size (W14)

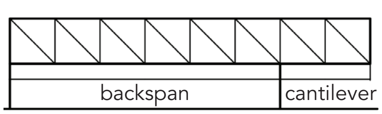


In beams, there is typically more vertical depth than width

System	Typ. Span Range	Spacing	Typ. Shapes
Steel Girder	20–40 ft	—	W12–W30
Steel Beam	25–45 ft	10–15 ft	W12–W24
Open Web Joist	10–60 ft	2–5 ft	—
Steel Truss	40–300 ft	10–20 ft	—
Roof Purlins	Per truss spacing	Each truss node	—
Space Frame	80–300 ft	Typ. modules are 4 ft, 5 ft, 8 ft, 12 ft	—

(C.O. & Z, p. 243), (I & R, p. 3), and (A & I, p. 427)

CANTILEVERS



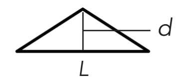
Cantilevers are typically ⅓ the length of the backspan. Longer cantilevers require deeper, heavier structure for strength and servicability.

TRUSSES

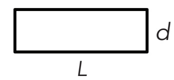
Appropriate for long spans (>50 ft)

Truss depth estimates

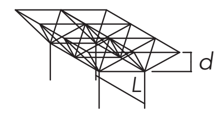
triangular or arched
3–4 in. depth (*d*) per foot of span (*L*)



rectangular
1–1½ in. depth (*d*) per foot of span (*L*)

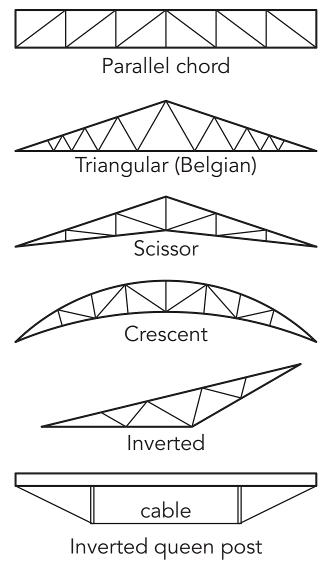


space truss
1 in. depth (*d*) per foot of span (*L*)

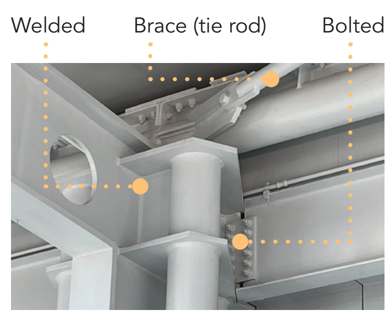


(A & I, p. 427)

Some truss examples



CONNECTIONS



Lateral, tension, and compression forces must travel from beams, braces, and columns down to foundations through connections.

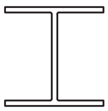
COLUMNS

W-Shapes (Wide-flange)

Column Size Estimates (larger numbers mean larger columns)

One-story:	W6, W8, W10
Low-to-mid-rise:	W8, W10, W12
High-rise:	W12, W14

(Ruby, pp 15–17)

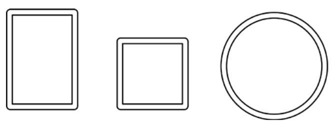


W-shape columns typically have square proportions in plan.

HSS (Hollow Structural Sections)

Column Size Estimates (the number refers to the external dimension)

One-story:	HSS4, HSS6
Low-rise:	HSS8, HSS10



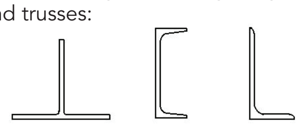
Denver Botanic Gardens: Freyer Newman Center

photo: Ashley Murphy

Columns can be custom-designed for architectural expression.

MISCELLANEOUS TIPS

Other common structural steel shapes used for elements like lateral bracing, stair stringers, girts, and trusses:

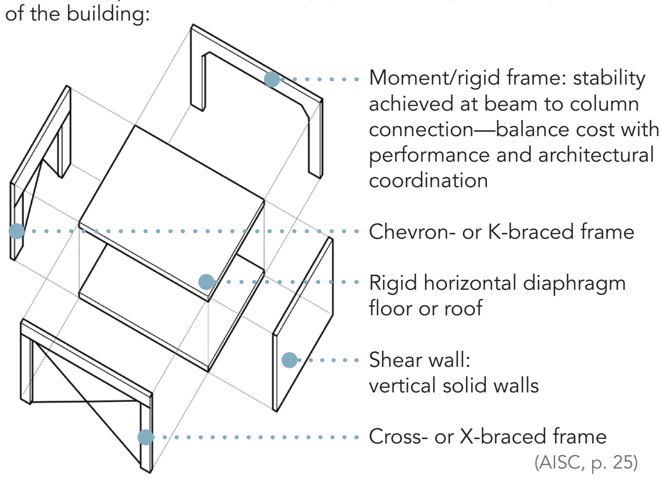


Steel Decking Depth Estimates

Steel roof decking depth without concrete	1½ in. and 3 in. typ.
Composite floor deck with poured concrete depth	1½–3 in. deck plus 2–4 in. concrete

LATERAL SYSTEMS

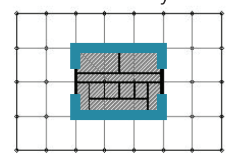
Common types of lateral bracing systems that go the height of the building:



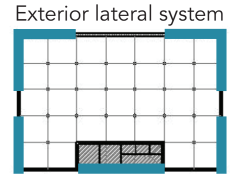
(AISC, p. 25)

Integrate **lateral systems** into the plan with other solid elements like exit stairs, bathrooms, storage, and elevator or mechanical shafts:

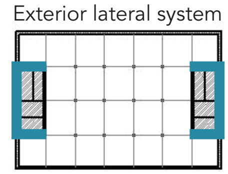
Interior core
Interior lateral system



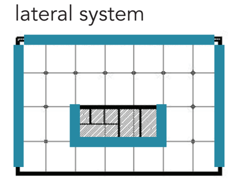
Exterior core
Exterior lateral system



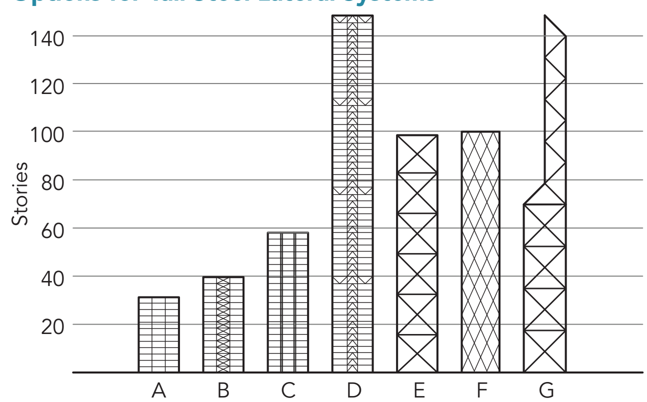
Exterior cores
Exterior lateral system



Interior core
Exterior and interior lateral system



Options for Tall Steel Lateral Systems



Interior Systems

A Moment/rigid frame
B Braced rigid frame
C Shear wall and frame
D Outrigger

Exterior Systems

E Steel braced tube
F Diagrid
G Space truss

References

AISC. (2019). *Designing with Structural Steel: A Guide for Architects*, American Institute of Steel Construction.

Allen, E. and Iano, J. (2013). *Fundamentals of Building Construction: Materials and Methods.* (6th ed.). John Wiley & Sons, Inc.

Ching, F., Onouye, B., & Zuberbuhler, D. (2009). *Building Structures Illustrated: Patterns, Systems and Design* (1st ed.). John Wiley & Sons, Inc.

Ioannides, S. & Ruddy, J. (2000). "Rules of Thumb for Steel Design." *Modern Steel Construction*, February

Ruby, D. (2008). Design Guide 23: *Constructability of Structural Steel Buildings*. American Institute of Steel Construction.

U.S. structural steel contains 93–98% recycled steel scrap when produced by electric arc furnaces (EAF).

Additional Resources

Allen, E. and Iano, J. (2012). *The Architect's Studio Companion: Rules of Thumb for Preliminary Design*. John Wiley & Sons, Inc.

Ambrose, J. & Tripeny, P. (2012). *Building Structures* (3rd ed.). John Wiley & Sons, Inc.

Ambrose, J. & Tripeny, P. (2016). *Simplified Engineering for Architects and Builders* (12th ed.). John Wiley & Sons, Inc.

Ching, F. (2008). *Building Construction Illustrated* (4th ed.). John Wiley & Sons, Inc.

These estimates and rules of thumb are for preliminary design estimates only using the most common elements; actual conditions may result in refined solutions. Layout and sizing need to be verified by a licensed professional through structural analysis.

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