

SELECTING THE STRUCTURAL SYSTEM

*This section will help you
select a structural system for
the preliminary design of a
building.*

Building Code Criteria for the Selection of Structural Systems	17	Design Criteria: Summary Chart	22
Design Criteria for the Selection of Structural Systems	18	Practical Span Ranges for Structural Systems	25
		Live Load Ranges for Structural Systems	26

BUILDING CODE CRITERIA FOR THE SELECTION OF STRUCTURAL SYSTEMS

When choosing a structural system for a building, you must first determine the range of structural systems that the relevant building code allows. Each of the model building codes on which most North American codes are based requires you to do this by determining first the Use Group into which a building falls, then consulting tables, formulas, and nu-

merous detailed provisions of the code that prescribe the maximum height and floor area to which a building of a given Use Group may be built using each of a range of code-defined Construction Types. To streamline this laborious process for purposes of preliminary design, simplified tables of height and area limitations

for the four model building codes are compiled on pages 287–433. You should consult the indexes on pages 7–11 first to determine which code governs in the area where your building will be built and the Use Group into which that code places your building. The Construction Type or Types into which each structural system falls are identified on pages 435–447.

DESIGN CRITERIA FOR THE SELECTION OF STRUCTURAL SYSTEMS

If you wish to create a building with a highly irregular form:

Choose systems with simple floor and roof framing that are fabricated mostly on site, such as

Sitecast concrete using any slab system without beams or ribs (pages 105–121)

Light gauge steel framing (pages 86–89)

Platform frame (pages 47–63)

Masonry construction with either concrete slab or wood light floor framing (pages 69–83)

If you wish to leave the structure exposed while retaining a high fire-resistance rating:

Choose structural systems that are inherently resistant to fire and heat, including

All concrete systems (although ribbed systems may require added thickness in the ribs or slab, or an applied fireproofing) (pages 105–133)

Heavy timber frame (pages 47–67)

Mill construction (pages 69–83)

Structural steel is extremely susceptible to loss of strength in a fire and usually must be protected with a fire-resistive finishing system.

For further information on the fire resistance of various structural systems and uses for which they are permitted, see pages 435–447.

18

If you wish to allow column placements that deviate from a regular grid:

Use systems that do not include beams or joists in the floor and roof structure, such as

Sitecast concrete two-way flat plate or flat slab (pages 116–119)

Metal space frame

If you wish to minimize floor thickness to reduce total building height or to reduce floor spandrel depth on the building facade:

The thinnest floor systems are concrete slabs without ribs, preferably prestressed, such as

Sitecast concrete two-way flat plate or flat slab, especially when post-tensioned (pages 116–119)

Precast prestressed hollow core or solid slab (pages 130–131)

Posttensioned one-way solid slab (pages 112–113)

If you wish to minimize the area occupied by columns or bearing walls:

Consider long-span structural systems, such as

Heavy wood trusses (pages 64–65)

Glue laminated wood beams (pages 60–61)

Glue laminated wood arches (pages 66–67)

Conventional steel frame (pages 85–103)

Open-web steel joists (pages 98–99)

Single-story rigid steel frame (pages 100–101)

Steel trusses (pages 102–103)

Sitecast concrete waffle slab, particularly when posttensioned (pages 120–121)

Precast concrete single or double tees (pages 132–133)

You may also wish to consider other long-span systems, such as specially fabricated steel beams, suspended systems, arches, vaults, and shells.

DESIGN CRITERIA FOR THE SELECTION OF STRUCTURAL SYSTEMS

If you wish to allow for changes to the building over time:

Consider short-span one-way systems that permit easy structural modification, such as

Light gauge or conventional steel frame (pages 85-103)

Any wood system, including those incorporating masonry construction (pages 47-77)

Sitecast concrete one-way solid slab or one-way joist construction, excluding posttensioned (pages 112-115)

Precast concrete solid or hollow core slab (pages 130-131)

If you wish to permit construction under adverse weather conditions:

Select a system that does not depend on on-site chemical processes (such as the curing of concrete or mortar) and that can be erected quickly, such as

Any steel system (pages 85-103)

Any wood system (pages 47-67)

Precast concrete systems, particularly those that minimize the use of sitecast concrete toppings and grouting (pages 123-133)

If you wish to minimize off-site fabrication time:

Consider systems in which the building is constructed on site from easily formed, relatively unprocessed materials, such as

Any sitecast concrete system (pages 105-121)

Light gauge steel framing (pages 86-89)

Platform frame (pages 47-63)

Any masonry system (pages 70-77)

If you wish to minimize on-site erection time:

Consider systems using highly preprocessed, prefabricated or modular components, such as

Single-story rigid steel frame (pages 100-101)

Conventional steel frame, particularly with hinge connections (pages 85-103)

Any precast concrete system (pages 123-133)

Heavy timber frame (pages 47-67)

If you wish to minimize construction time for a one- or two-story building:

Consider systems that are lightweight and easy to form, or prefabricated and easy to assemble, such as

Any steel system (pages 85-103)

Heavy timber frame (pages 47-67)

Platform frame (pages 47-63)

(continued)

DESIGN CRITERIA FOR THE SELECTION OF STRUCTURAL SYSTEMS

If you wish to minimize construction time for a 4- to 20-story building:

Choose from the following systems

Precast concrete (pages 123-133)

Conventional steel frame (pages 85-103)

Once the structural components for either of the above systems are prefabricated, on-site erection proceeds quickly.

Any sitecast concrete system (pages 105-121)

The absence of lead time for the prefabrication of components in these systems allows construction of the building to begin on-site at the earliest time.

If you wish to minimize construction time for a building 30 stories or more in height:

Choose a system that is strong, lightweight, prefabricated, and easy to assemble

Steel frame (pages 85-103)

Systems of precast and sitecast concrete are also becoming an economical alternative to steel frame construction in some regions.

The structural design of high-rise buildings is a specialized task, and the necessary consultants should be sought out as early as possible in the design process.

20 *If you wish to minimize the need for diagonal bracing or shear walls:*

Choose a system that is capable of forming rigid joints, such as

Any sitecast concrete system, particularly those with beams or deepened slabs around the columns (pages 105-121)

Steel frame with welded rigid connections (pages 85-103)

Single-story rigid steel frame (pages 100-101)

When depending on a rigid frame for lateral stiffness, the sizes of the framing members often must be increased to resist the added bending stresses produced in such systems.

If you wish to minimize the dead load on the building foundation:

Consider lightweight or short span systems, such as

Any steel system (pages 85-103)

Any wood system (pages 47-67)

If you wish to minimize structural distress due to unstable foundation conditions:

Frame systems without rigid joints are recommended, such as

Steel frame, with bolted connections (pages 85-103)

Heavy timber frame (pages 58-61)

Precast concrete systems (pages 123-133)

Platform framing (pages 47-63)

Welded steel frame, masonry bearing wall, and sitecast concrete frame are particularly to be avoided.

DESIGN CRITERIA FOR THE SELECTION OF STRUCTURAL SYSTEMS

If you wish to minimize the number of separate trades and contracts required to complete the building:

Consider systems that incorporate many of the functions of a complete wall system in one operation, such as

Masonry construction including Mill or Ordinary construction (pages 70-83)

Precast concrete loadbearing wall panel systems (pages 126-127)

If you wish to provide concealed spaces within the structure itself for ducts, pipes, wires, and other building mechanical systems:

Consider systems that naturally provide convenient hollow spaces, such as

Truss and open-web joist systems (pages 62-65, 98-99, 102-103)

Light gauge steel framing (pages 86-89)

Platform frame (pages 47-63)

Light gauge steel framing and platform frame construction are often applied as finish or infill systems in combination with other types of building structure to provide such spaces. For more information on the integration of building services and the structural system, see pages 168-183 and 196-215.

DESIGN CRITERIA: SUMMARY CHART

	WOOD AND MASONRY				STEEL			
	Pages 47-63	Pages 47-67	Pages 69-83	Pages 69-83	Pages 86-89	Pages 100-101	Pages 86-103	Pages 85-103
GIVE SPECIAL CONSIDERATION TO THE SYSTEMS INDICATED IF YOU WISH TO:	Platform Frame	Timber Frame	Ordinary Construction	Mill Construction	Light Gauge Steel Framing	Single-Story Rigid Steel Frame	Steel Frame—Hinged Connections	Steel Frame—Rigid Connections
Create a highly irregular building form	●		●		●			
Expose the structure while retaining a high fire-resistance rating		●		●				
Allow column placements that deviate from a regular grid								
Minimize floor thickness								
Minimize the area occupied by columns or bearing walls						●	●	●
Allow for changes in the building over time	●	●	●	●	●		●	●
Permit construction under adverse weather conditions	●	●			●	●	●	●
Minimize off-site fabrication time	●		●	●	●			
Minimize on-site erection time		●				●	●	●
Minimize construction time for a one- or two-story building	●	●			●	●	●	●
Minimize construction time for a 4- to 20-story building							●	●
Minimize construction time for a building 30 stories or more in height							●	●
Avoid the need for diagonal bracing or shear walls						●		●
Minimize the dead load on a foundation	●	●			●	●	●	●
Minimize structural distress due to unstable foundation conditions	●	●					●	
Minimize the number of separate trades needed to complete a building			●	●				
Provide concealed spaces for ducts, pipes, etc.	●		●		●			

PRACTICAL SPAN RANGES FOR STRUCTURAL SYSTEMS

This chart gives practical span ranges for various structural systems. Greater or lesser spans may be possible in some circumstances. Page references are included where a system is covered in greater detail elsewhere in this book.

STRUCTURAL SYSTEM			Span Range															
			10' 3 m	20' 6 m	30' 9 m	50' 15 m	100' 30 m	200' 60 m	300' 90 m	500' 150 m								
WOOD	Joists	54-55	█															
	Decking	52-53	█	█														
	Solid Beams	58-59	█	█	█													
	Rafter Pairs	56-57	█	█	█	█												
	Light Floor Trusses	62-63	█	█	█	█												
	Light Roof Trusses	62-63		█	█	█	█											
	Glue Laminated Beams	60-61	█	█	█	█	█											
	Heavy Trusses	64-65			█	█	█	█	█									
	Glue Laminated Arches	66-67			█	█	█	█	█	█								
	Domes					█	█	█	█	█	█							
BRICK & CONCRETE MASONRY	Lintels	74-75	█															
		82-83	█															
	Arches	77			█	█	█	█	█	█	█							
STEEL	Corrugated Decking	94-95	█	█														
	Light Gauge Joists	88-89	█	█	█													
	Beams	96-97	█	█	█	█												
	Open-Web Joists	98-99	█	█	█	█	█											
	Single-Story Rigid Frame	100-101			█	█	█	█										
	Heavy Trusses	102-103			█	█	█	█	█	█								
	Arches and Vaults					█	█	█	█	█								
	Space Frame					█	█	█	█	█	█	█						
	Domes					█	█	█	█	█	█	█	█					
	Cable-Stayed Suspension					█	█	█	█	█	█	█	█	█	█	█	█	█
SITECAST CONCRETE	One-Way Slabs	112-113	█	█														
	Two-Way Slabs	116-119	█	█	█													
	One-Way Joists	114-115		█	█	█												
	Waffle Slab	120-121			█	█												
	Beams	110-111	█	█	█	█												
	Folded Plates and Shells					█	█	█	█									
	Domes					█	█	█	█	█								
	Arches					█	█	█	█	█								
PRECAST CONCRETE	Slabs	130-131	█	█	█													
	Beams	128-129		█	█	█												
	Double Tees	132-133	█	█	█	█												
	Single Tees	132-133			█	█	█	█										
PNEUMATIC	Air Inflated		█	█	█													
	Air Supported				█	█	█	█	█	█	█	█	█	█	█	█	█	█

LIVE LOAD RANGES FOR BUILDING OCCUPANCIES

LIVE LOAD RANGES FOR BUILDING OCCUPANCIES

OCCUPANCY	Light Loads		Medium Loads		Heavy Loads	Very Heavy Loads
	20 psf 1.0 kPa	60 psf 2.9 kPa	100 psf 4.8 kPa	150 psf 7.2 kPa	250 psf 12.0 kPa	
Assembly Areas		Fixed seats	Movable seats			
			Stage areas			
Building Corridors		Private	Public			
Garages		Passenger cars		Trucks and buses		
Hospitals		Private rooms	Operating rooms			
			Laboratories			
Hotels and Multifamily Housing		Private rooms	Public rooms			
Libraries			Reading rooms	Stacks		
Manufacturing				Light	Heavy	
Office Buildings		Offices	Lobbies			
One- and Two-Family Dwellings	Attics	Bedrooms				
		Living spaces				
Outdoor Areas				Pedestrian	Veicular	
Roof Loads	No snow	Moderate snow	High mountains			
			Pedestrian			
Storage Areas				Light	Heavy	
Schools		Classrooms	Assembly	Shops		
Stores			Retail	Wholesale		
Miscellaneous Public Facilities		Penal institutions	Bowling alleys	Gymnasiums Dance halls	Armories	
		Cell blocks	Poolrooms	Dining rooms Restaurants Stadiums Skating rinks	Drill rooms	

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STRUCTURAL SYSTEM		Pages	Light Loads	Medium Loads	Heavy Loads	Very Heavy Loads
WOOD	Platform Frame	47-63				
	Timber Frame	47-67				
MASONRY	Ordinary Construction	69-83				
	Mill Construction	69-85				
STEEL	Light Gauge Steel Framing	86-89				
	Single-Story Rigid Steel Frame	100-101			(Roof loads only)	
	Conventional Steel Frame	85-103				
STRECAST CONCRETE	One-Way Solid Slab	112-113				
	One-Way Beam and Slab	112-113				
	One-Way Joist	114-115				
	Two-Way Flat Plate	116-117				
	Two-Way Flat Slab	118-119				
	Waffle Slab	120-121				
	Two-Way Beam and Slab	116-117				
PRECAST CONCRETE	Solid Slab	130-131				
	Hollow Core Slab	130-131				
	Double Tee	132-133				
	Single Tee	132-133				

Use the charts on these two pages to identify appropriate structural systems based on the activities planned within the building. Read the chart on the facing page first to determine the approximate live load range associated with the expected building use. Once a load range has been determined, consult the chart on this page to select systems that are recommended within that range. Roof loads are also covered to aid in the selection of roof structural systems.

If a building will have multiple uses, read from the chart for the higher load range. Or, if the different uses will be physically separate within the building, the load ranges for each use may be applied to the appropriate areas.