Steel Design Guide

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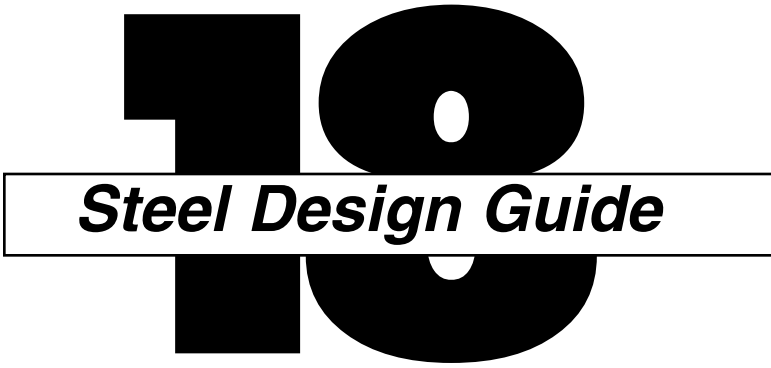
Steel-Framed Open-Deck Parking Structures



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Preface

This design guide is specifically focused on structural engineering issues in the design of open-deck parking structures and does not deal in depth with parking usage or geometric topics. General parking topics and their implementation in steel-framed parking structures are covered in a separate publication, *Innovative Solutions in Steel: Open-Deck Parking Structures* (formerly titled *A Design Aid for Open-Deck Steel-Framed Parking Structures*), also published by the American Institute of Steel Construction.

This design guide approaches the development of steel-framed parking structures in the same sequence as a designer would approach the design development. For this reason, the discussion of the steel framing system is deferred until after the section dealing with deck selection. The issues discussed in this design guide are:

- Deck Systems
- Framing Systems
- Mixed Use Structures
- Fire Protection Requirements
- Barriers and Facades
- Stairs and Elevators
- Corrosion Protection
- Structural Maintenance

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Chapter 1
Introduction

1.1 Overview of Open-Deck Parking Structures

Steel-framed parking structures are increasing in popularity. The recent trend toward steel has prompted industry analyst Dale Denda of the Parking Market Research Company to comment that "exposed steel-frame construction is back as a recognized option for multi-story parking structures." (*Parking Today*, June 2001)

Recent advances in coating technologies and design innovations need to be evaluated and considered for the parking structure. In addition, the structural engineer needs to be able to intelligently evaluate the merits of various framing systems in order to provide professional guidance to garage owners and other members of the project team.

Today, owners and architects are choosing steel framing systems for their lower construction costs, reduced life-cycle costs, rapid construction, long term durability and a clean, open feel conducive to personal security. It falls to the structural engineer to optimize these benefits in the final design by taking advantage of high-performance coatings, innovative structural techniques, reduced structure weight (often at least 20 percent) and enhanced seismic performance.

Today's parking structure framing systems primarily fall into three categories:

- Cast-in-place concrete framing supporting a post-tensioned concrete deck
- Precast/Prestressed concrete framing supporting precast double tees
- Fabricated structural steel framing supporting a post-tensioned cast-in-place, conventionally reinforced concrete deck on stay-in-place metal form or precast deck

Other deck systems have been utilized in various areas of the country including concrete filigree panels (a precast panel form system) and short-span reinforced concrete on removable forms. Structural steel framing has been used to support all of these types of concrete deck systems. This allows the structural designer to choose the optimal deck system for a given project and still enjoy the benefits of a steel framing system.

1.2 Major Components of Interest to a Structural Engineer

In order to effectively design an open-deck steel-framed parking structure the structural engineer will need to evaluate a number of issues. These include:

- Relevant provisions of the governing building code for the location of the parking structure
- The geometry of the parking stalls as a function of optimum bay sizing
- The possible configuration of ramp systems to allow for smooth traffic flow within the parking structure

These three design components are introduced and discussed as part of the general parameters affecting parking design in a separate publication, *Innovative Solutions in Steel: Open-Deck Parking Structures* (formerly titled *A Design Aid for Open-Deck Steel-Framed Parking Structures*), also published by the American Institute of Steel Construction. They are summarized in this introductory section as they impact structural design.

Nine components of the structural design process have been identified and a separate section has been allocated to each. These are:

- Deck Systems
- Framing Systems
- Mixed-Use Structures
- Fire Protection Requirements
- Barriers and Facades
- Stairs and Elevators
- Corrosion Protection
- Structural Maintenance

Four appendices are included that provide design examples, additional resources relating to high-performance coating systems, discussion of the benefits of steel-framed parking structures and additional resources for the designer of a parking structure.

1.3 Code Considerations

1.3.1 Code Applicability

Over the past several decades designers have been faced with a variety of differing building codes based on the location of the constructed project. Variations existed between model building codes and local jurisdictions within areas of adoption of model building codes. The International Code

Table 1-1 Relevant Code Sections for Open-Deck Parking Structures

Topic	IBC	NFPA 88A
Structure Classification	406.3.3.1	3.3.2.2
Clear Height	406.2.3	
Guards	406.2.4	
Vehicle Barriers	406.2.5	
Vehicle Ramps	406.2.6	
Floor Surface	406.2.7	4.3
	406.3.4	
Mixed Use Separation	406.2.7	4.1.2
	406.3.4	4.1.4
		30.8.1.2 (NFPA 5000)
Area and Height	406.3.5	4.7.3
	406.3.6	
Sprinkler Systems	406.3.10	
Prohibitions	406.3.13	
Design Loads	ASCE 7-98 Table 4-1	
Load Reductions	1607.9.1	

Council released the International Building Code in 2000, consolidating three previously separate and regional model building codes: the BOCA National Building Code, the ICBO Uniform Building Code, and the SBCCI Southern Building Code. In 2002, the National Fire Protection Association released NFPA 5000 as an alternative model building code. NFPA 5000 (Section 6.4.2.55) specifies that all types of parking structures conform to NFPA 88A. Designers should verify which model building code and what local amendments are applicable for a planned parking structure.

1.3.2 Relevant Code Sections for Open-Deck Parking Structures

For a listing of the relevant code sections for open-deck parking structures, see Table 1-1.

1.3.3 Code Definitions

Care must be taken in understanding the provision of the codes based on the definition of certain terms. These include:

Height. The IBC defines the height of a parking structure as the vertical distance from the grade plane to the highest roof surface.

Openness. The IBC defines required openness for a parking structure as having uniformly distributed openings on two or more sides of the structure comprising at least 20 percent of the total perimeter wall area of each tier and the aggregate length of the openings should constitute a minimum of 40 percent of the perimeter of the tier. NFPA defines openness as having distributed openings to the atmosphere of not less than 1.4 ft^2 for each linear foot of its exterior perimeter. The openings should be uniformly distributed over 40 percent of the perimeter or uniformly over two opposing sides.

1.3.4 Fire Protection and Height

Currently, model building codes do not require fire protection for structural steel members in an open-deck parking structure less than 75 ft in height as long as any point on any parking tier is within 200 ft of an open side. It should be noted that the height of a parking structure is measured to the top of the deck for the top parking tier, not to the top of any facades or parapet walls (this is based on the treatment of the top tier as the "roof" of the parking structure with parking allowed on the roof).

It is possible for a steel-framed parking structure to exceed the 75-ft limitation based on the square footage of each tier and the number of open sides, although parking structures seldom attain this height for operational reasons. Table 1-2 presents the parameters used in determining maximum height and tier area under both the NFPA Building Code and International Building Code. The prospective owner of a parking structure should consult with the local building code official to determine any local modifications of the relevant code provisions.

Table 1-2 NFPA Building Code and International Building Code Guidelines for Height and Tier Area Perimaters

	NFPA 88A Type II (000)		IBC Type IIB	
Fire Resistive Requirement	None		None	
Definition of Open Side	1.4 sq ft of each linear foot distributed along 40% of perimeter		50% of interior wall area of exterior wall	
	sq ft/tier	# of tiers	sq ft/tier	# of tiers
2 sides open	unlimited[1]	height<=75 ft	50,000	8
3 sides open	unlimited[1]	Height<=75 ft	62,500	9
4 sides open	unlimited[1]	Height<=75ft	75,000	9
Exception[1]			unlimited	height<=75 ft

[1]the distance from any point on the deck may not be greater than 200 feet from an open side

Table 1-3 Minimum Number of Accessible Spaces

Number of Parking Spaces	Minimum Number of Accessible Spaces
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 to 300	7
301 to 400	8
401 to 500	9
501 to 1,000	2% of total
1,001 and over	20 plus 1 for each 100 over 1,000

When evaluating tier area and structure height, the impact of any future vertical expansion should be taken into account.

When parking is being provided on the lower floors of a mixed-use structure, the lower parking floors must be fire separated from the upper floors and fire rated.

1.3.5 ADA Guidelines

The Americans with Disabilities Act establishes design guidelines for addressing the needs of persons with disabilities to access all newly constructed structures. Current ADA guidelines impacting parking include:

- The provision, size and location of a required number of physically disabled accessible spaces
- The provision, size and location of physically disabled van access
- Ramp slopes
- Signage
- Trip hazards
- Exit paths

Table 1-3 indicates the required minimum number of accessible spaces in any parking facility. These spaces must be at least 8 ft wide with a 5-ft-wide accessible aisle adjacent to the space. Two accessible spaces may share the same accessible aisle if the spaces utilize 90° parking. Angled parking spaces must each have their own accessible aisle. Ceiling clearances are not impacted by accessible spaces and should conform to a 7 ft, 2 in. minimum or any applicable local codes. Accessible spaces are required to be the closest spaces to all accessible building entrances.