Aurora Parking & Mobility Enterprise

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Parking Facility Design Guidelines

Includes best management practices and policies for the design, operation, and maintenance of parking facilities for the new program. This section includes design requirements, sustainability practices, ADA requirements, and maintenance guidelines.

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Parking Facility Design Guidelines

Contents

Parking Facility Design Guidelines

The Facility Design Guidelines are intended to document industry best practices and design standards for the construction of new parking facilities. As the City of Aurora implements the new Parking and Mobility Program, it may be necessary to design and construct new parking facilities. This document provides a guide and set of best management practices to support the design of those facilities. It should be noted that the Iliff and Hotel/Conference Center garages were designed before the development of this document. While those facility design characteristics may differ from this document, they were presumed to be designed to industry standards and requirements.

The design principles focus on community-centric facilities that are environmentally sustainable and provide a safe and secure feel for users. The design guidelines provide information about typical design standards, sustainable design and operations practices, technology integration, Americans with Disabilities Act (ADA) compliance, pedestrian considerations, signage, and wayfinding.

One of the key elements in the design guidelines is the introduction of design concepts that are focused on transit-oriented development (TOD) design policies. In general, those design policies follow these rules of thumb:

- **Mix Uses to Support Transit** – This includes promoting compatible uses in the TOD area to promote active transportation and reduce parking needs, including uses that are able to share a single parking supply by distributing peak demands throughout the day and promoting use of alternative modes.
- **Support Higher Intensity and Density of Land Use** – This includes the design of efficient parking facilities that minimize the parking footprint in the area and promote use by multiple users through shared parking, space allocation, and desirable walking distances.
- **Inclusion of Pedestrian and Cycling Amenities** – Facilities should include amenities for bicyclists and alternative mode users, while minimizing impacts to the pedestrian environment to promote area walkability.
- **Transportation Demand Management (TDM)** – The facilities and design practices, as well as area development policies, should promote active use of alternative modes, reducing the need for vehicular demand. One particular strategy is to minimize the number of spaces provided and price spaces at a market rate, which will force area users to make smarter decisions about how they access an area.
- **Community Design** – While this principle will likely apply more to TOD design, it can be applied to facility design through the introduction of mixed uses at the facility, including ground-level retail and wrapped office or residential uses. This mixture of uses helps to ensure that the parking facility is more integrated within the fabric of the surrounding community and is less likely to impact walkability and TOD design.

Design Guidelines

The design guidelines are presented below and organized by the following categories:

- Location
- Project delivery
- Site requirements
- Site constraints
- Concept design
- Structural design
- Circulation and ramping
- Access design
- Parking geometrics
- Pedestrian requirements
- Bicycle requirements
- Accessible parking requirements
- Signage and wayfinding
- Drainage
- Open or enclosed parking structures
- Other considerations

LOCATION

The sections below address requirements and preferences for appropriate location of parking facilities.

Behind or Beside Buildings

For new uses, surface and structured parking should be placed behind buildings, where possible. Locating parking areas underground, to the side, or behind buildings decreases the visual impact of parking and creates a more "pedestrian friendly" environment, encouraging walking and the use of other alternative transportation modes.

If locating parking areas behind buildings is not possible, locating parking to the side of buildings is the next best choice. Only when it has been demonstrated that neither of these locations is feasible should parking areas be located in front of buildings. Underground parking is also encouraged if it is economically feasible.

In approving where a parking area should be located in relation to the street, the Parking and Mobility Manager will consider existing site constraints, such as the location of existing buildings, or sites with multiple street frontages where it is impractical to locate parking behind or beside buildings relative to all street frontages.

Motorcycle and Carpool Parking

Motorcycle and carpool parking spaces must be located as close as possible, but not closer than spaces for disabled persons, to building entrances to encourage these modes of travel.

PROJECT DELIVERY

There are four primary project delivery methods commonly used to design and construct parking structures. Two Design Professional's Handbooks published by the American Council of Engineering Companies (ACEC) are helpful references—the Design-Build Project Delivery and the Design/Contract-Build Project Delivery.

Each delivery method is described on the following pages, along with a graphical depiction of the contractual relationships for each:

- **Design-Bid-Build (D-B-B)** projects are those for which the owner selects and contracts with the lead designer (parking consultant or architect/engineer [A/E]). They, in turn, represent the owner in defining the project and preparing drawings and specifications to meet the owner's needs for competitive bidding to contractors. Often on public projects, the owner is required to select the lowest "responsive and responsible" bid, with the contractor's qualifications often not given consideration. The D-B-B method is sometimes referred to as the "traditional" process and is still the most common method.
- **Design-Bid-Build with a Construction Manager (CM)** is where the owner selects and contracts with the A/E who represents the owner in defining the project and preparing drawings and specifications to meet the owner's needs for bidding. Additionally, the owner retains a construction manager (CM) who works with the A/E during the design phases, sets the project schedule, and performs construction cost estimates. The CM bids the work to subcontractors for the various trades. This is a better method than D-B-B for projects where the owner wants expedited or phased construction.
- **Design-Build (D-B)** is where the owner retains a D-B contractor who in turn retains the A/E so there is a single entity responsible for both design and construction. Often the owner prepares or retains another A/E to prepare D-B criteria documents as described below. Often, the owner can select the D-B team based on qualifications and cost, consistent with the bidding documents. There has been more interest in D-B type projects recently because of owners who perceive benefits regarding cost, schedule, and risk management.
- **Design-Contract-Build (D-C-B)** are projects where the owner selects and contracts with the A/E. The A/E prepares preliminary documents that are the basis for the owner contracting with the contractor early in the design process, rather than waiting for final design documents to be prepared as for D-B-B. This method combines the advantages of the D-B-B and D-B methods while reducing many disadvantages to allow the owner to have the most qualified A/E and contractor involved in their project from the design phase through the completion of construction.

Successful parking structure projects have been completed using all four of the construction methods discussed above. Understanding the advantages and disadvantages of each and following a process to address them will help ensure that the completed project is a success for the user, owner, community, designer, and builder.

Design-Build

In recent years, there has been an increasing interest and use of D-B in parking structure construction. Legislation has been enacted in many states to allow D-B to be used by public entities because prior laws required publicly funded construction contracts to be awarded based upon completed design documents.

ADVANTAGES OF D-B:

- Owner has a single point of responsibility for design and construction
- Potential for better design and construction coordination because the A/E is working for the contractor
- Owner does not have to arbitrate disputes between the A/E and contractor
- Owner reduces their risk because the D-B contractor is responsible for errors or omissions in the design documents
- Could be less administrative burden on the owner
- Potential for accelerated schedule because the contractor is onboard at the beginning of the process and because of the overlapping of design and construction work
- Potential for lower costs due to the contractor being in greater control of the project and the accelerated schedule
- Costs are well defined earlier in the process

DISADVANTAGES OF D-B:

The D-B contractor has the incentive to complete projects faster and less expensively, which can mean reduced quality of materials and workmanship.

- The owner has less involvement and control of the design because the A/E represents the D-B contractor's best interests, not the owner's. Not only is this a disadvantage for the owner, but it creates a difficult conflict of interest for the A/E.
- The owner does not benefit from independent advice and input from the A/E and contractor
- Greater definition of the project is required up front to define goals, objectives, and minimum requirements for project function, appearance, quality, materials, operation, etc. prior to bidding to D-B teams
- More risk for D-B teams, which can negate the potential cost-saving opportunities

When owners decide that D-B is right for their project, they can have a better chance of achieving a successful project utilizing the following recommended procedures regarding the D-B delivery method:

- The owner should retain an A/E at project initiation to prepare the D-B criteria documents. This allows the owner to have more input into the concept design and set standards and criteria for the project. Also, due to the uniqueness of parking structures, it is important to have the A/E led by a parking consultant or for a parking consultant to have a significant role on the design team.
- D-B criteria documents should clearly define the project scope, function, appearance, quality, materials, and operations. The level of completeness of these documents varies, but generally they are in the 10% to 30% range (between Schematic Design and Design Development level of completeness).
- The owner should use a very transparent selection process to hire the D-B contractor, using the D-B criteria documents as the basis of the Request for Qualifications/Proposals (RFQ/RFP).

- The selection process should consider the D-B teams' technical qualifications and experience in addition to cost. Typically, there is a weighting of selection criteria such as the experience and expertise of the firms and key personnel making up the team, experience of the team working together, technical merits of design, project appearance, and quality and safety programs of the contractor, references, schedule, and cost. The selection criteria and weighting should be defined in the RFQ/RFP.
- The owner's A/E who prepared the D-B criteria documents should continue on during the final design and construction to represent the owner's interest and help ensure that the design and construction are completed in conformance with the D-B criteria documents.
- As an alternative to using the D-B method, the D-C-B or CM methods can often result in a project that meets the owner's best interests because:
- The A/E contracts to the owner, thus representing their interests, not the contractors, which should enhance quality
- Design decisions can more easily be made that are in the best long-term interest of the owner, considering factors that will provide the lowest life-cycle maintenance or operational cost, rather than emphasizing those that just provide the lowest first cost or schedule advantage
- The CM or contractor is onboard early in the design process so the A/E and contractor collaborate during design, enhancing innovation and opportunities to consider the contractor's cost saving ideas
- Similar schedule and cost advantages compared to D-B
- Less risk for all parties as responsibilities can be allocated where they most belong

SITE REQUIREMENTS

Large and rectangular shaped sites are ideal for parking structures. Although flat sites are generally more economical to develop, sloped sites can provide design opportunities such as access on different levels and/or no ramping between levels. For a reasonably efficient parking layout, double-loaded parking "bays" range in width from about 54 to 60 feet, depending upon the angle of parking and the width of the parking space. The overall width of the structure should be determined based upon multiples of the chosen parking bay width. An ideal length for a parking structure is at least 240 feet. Longer sites provide the opportunity to park along the end bays, which provides more parking spaces, improves efficiency, and lowers the cost per space. A longer site also allows for shallower ramps which provide improved user comfort.

Generally, parking bays should be oriented parallel to the longer dimension of the site and preferably in the predominate direction of pedestrian travel. Walking distance tolerances from parking to a primary destination are typically 200 to 300 feet for shoppers, 500 to 800 feet for core area employees, and 1,500 to 2,000 feet for special event patrons and students.

SITE CONSTRAINTS

Other site issues to be considered when evaluating a potential site for a suitable parking facility include the following:

- **Site Survey –** A topographic survey of the site is a very important precursor to develop a conceptual plan. The site survey should delineate property lines, easements, and utility lines.
- **Site Slope –** The topographic information will define the slope of the site. Sometimes the slope of a site can used to reduce internal ramping in a parking structure, resulting in significantly lower costs. A parking structure that is built into a hillside can also reduce the visual mass of the facility.
- **Geotechnical and Soils –** Obtaining a soils report with sample borings and a geotechnical analysis early in the design process is prudent. If soils with poor bearing capacity are present on the site, the added cost for using deep foundations can be significant.
- **Codes and Ordinances –** Municipal ordinances often specify setbacks, building height, bulk limitations, floor area ratio to site area, etc. that can significantly affect the allowable area on a site for a parking structure. The local planning organization may also impose development guidelines that must be followed.

CONCEPT DESIGN

An overall design principle to keep in mind is that parking structures are for people. Designing to accommodate the users of a particular structure will help produce a better parking structure. The following are aspects of the design that should be considered during the conceptual design phase:

- Different user types will have different needs
- Some user types may need to be physically separated to ensure revenue control or for security reasons
- Different users require different pedestrian circulation systems
- Parking space widths and circulation geometry needs vary depending on the user type
- Some vehicular circulation systems are better for specific user types:
  - Residential – Regular users enter and exit two times a day
  - Education – May have peak loads in and out
  - Hotel – Overnight guests, possibly event parking as well
  - Office – Low turnover—regular users enter and exit two times a day
  - Health Care Visitors – Wayfinding very important—need to accommodate elderly drivers and passengers
  - Health Care Staff – Shift time overlap, loading, and security issues particularly at night
  - Retail – High turnover and wayfinding to and from vehicle important for occasional users
  - Elderly or Families with Small Children – Wayfinding again important, and may need larger spaces and more elevators
  - Events – Easy quick loading and unloading of structure, multiple vehicular paths, consider revenue collection method – typically flat fee on entry, provide queuing space, and consider pedestrian flow to event to avoid users having to cross traffic

Durability Design

It is recommended to perform an analysis in the schematic design phase to determine which durability

elements should be included in the design of a parking structure. These elements include sealers, deck coatings, concrete additives, corrosion inhibitors, and epoxy-coated reinforcement. Durable parking structures also require quality concrete (low water-to-cement ratio), adequate concrete cover, proper concrete curing, and good drainage. The A/E or Contractor can help consider the tradeoffs between initial costs and long-term maintenance costs as a result of implementing durable elements. Enhanced durability systems should be provided in areas with severe exposure, such as supported structures near vehicular entries and snow storage areas on the roof level. Deck coatings (membrane) are recommended over occupied space and over electrical and storage rooms.

The design of a parking structure should, at a minimum, conform to the intent of American Concrete Institute's Guide for the Design of Durable Parking Structures (ACI 362). The design life of a parking structure should be 60 years.

Mixed-Use Facility Design

Definition[1]: combine more than one use in a common building footprint. Besides parking, uses can include restaurant, retail, office, and housing. In addition, although not common, mixed uses can include plazas or athletic fields on the top level of parking structures and maintenance facilities. Almost any building use can be combined with parking.

Consider a mixed-use facility when:

- Standalone parking is not the highest and best use of available land
- The cost of land is too high for parking as a use
- Shared use of nearby parking facilities is not feasible

Incorporating Other Land Uses

Many cities today are encouraging or requiring the design of parking structures that enhance the urban environment. Design Guidelines have been established that require parking structures to have level façades on the street sides (no exposed ramps) and pedestrian-active uses on the ground level. Even if not required by local code, there has been a trend in recent years away from stand-alone, single-purpose parking structures. This is an important consideration as most new parking structures are not financially self-supporting. When selecting a site for the development of a parking structure, the site that offers the best possibility for ground-floor retail space should be an important consideration.

- New parking structures should incorporate other land uses whenever physically and financially possible.
- First-level commercial space will increase first level floor-to-floor heights and may necessitate adjustments to the structure's ramping scheme.
- Designs should minimize the impact of commercial space on the first-level circulation system.
- Designs may need to consider loading dock space and trash space in the parking structure.
- Restaurant space will need adequate ventilation, which may impact parking efficiency on the levels above the space.
- Entry and exit locations should be adequately positioned to account for adjacent traffic patterns and roadway conditions. Entries and exits should provide for easy identification and access from adjacent streets.

- Parking demand for the integrated land uses should be included in the parking supply and demand analysis for the structure.
- If there is no current market for additional commercial space, the parking facility could be designed to accommodate additional land uses in the future when market conditions warrant.

Considerations for Vertical Stacking

- Retail should be located on the ground level, with parking above.
- Office should be located above parking, with the parking being either above or below grade.
- Housing should be located above parking, with the parking being above or below grade.
- Any of these uses can be combined, but the locations should follow these general rules of thumb.

Structural Design

The following are advantages and disadvantages of the three primary structural systems commonly used in parking structures today:

- Cast-in-place concrete
- Precast concrete
- Steel framed

Cast-in-Place

ADVANTAGES OF CAST-IN-PLACE CONSTRUCTION:

- Monolithic construction means fewer sealant joints
- Positive drainage is easier to achieve
- Post-tensioning forces reduces slab cracking
- Floor vibration imperceptible
- Flexible column spacing (20 feet to 27 feet)
- Generally no shear walls
- Lower maintenance cost
- Wide beam spacing creates more open feeling with perception of higher ceiling
- Accommodates parking structures on irregular sites, beneath buildings, and underground

DISADVANTAGES OF CAST-IN-PLACE CONSTRUCTION:

- Potentially higher construction cost
- Quality control is more difficult to attain due to exposed weather conditions
- May require architectural cladding to improve exterior aesthetics
- Less adaptable to winter construction in cold climates
- Longer on-site construction schedule
- Congestion of reinforcing at beam column joints
- Larger on-site staging requirement

Precast Construction

ADVANTAGES OF PRECAST CONSTRUCTION:

- Column spacing up to 48’.
- Enhanced quality control because members are fabricated at a plant
- Potentially lower construction cost in some regions
- Shorter on-site construction schedule
- More adaptable to winter construction
- Architectural façade spandrels also serve as structural load bearing elements

DISADVANTAGES OF PRE-CAST CONSTRUCTION:

- More joints create higher long-term maintenance costs

- The close spacing of the double tee stems creates the perception of lower ceiling height
- Double tee stems can block signage and interfere with lighting distribution
- Shear walls affect architecture at the exterior

Steel Construction

ADVANTAGES OF STEEL CONSTRUCTION:

- Generally no shear walls
- Can be performed by local subcontractors
- Shorter on-site construction schedule
- Potentially lower construction cost
- Easily accommodates vertical expansion

DISADVANTAGES OF STEEL CONSTRUCTION:

- Reduced column spacing of 18' to 22'
- Erection concerns due to mixing foundation, steel, and precast subcontractors
- Not recommended where the steel is required to be fire rated by the building code
- Depending upon code requirements, steel structure may need to be fireproofed
- Steel painting for corrosion protection
- Maintenance of steel paint system
- Steel delivery times can fluctuate
- Extensive bird roosting ledges on the beam flanges and/or reduce visibility at the interior
- Reduced drainage slopes
- More bird roosting ledges
- Might not be performed by local subcontractors

Circulation and Ramping

The basic circulation element for a parking structure is the continuous ramp with parking on both sides of the drive aisle. In continuous ramp structures, some of the parking bays are sloped in order for traffic to circulate from one level to another. Only on a sloping site that permits direct access to each level from the exterior roadways are ramps unnecessary; but they still may be desirable for internal circulation.

The basic criteria for choosing a circulation system are the simplicity or complexity of the system and the architectural compatibility. Ingress and egress capacities are also a consideration in the selection of a circulation system. Some circulation systems provide the opportunity for level façades which may be desirable.

When parking on a ramp, a slope of 5% or less is preferred, although parking ramp slopes up to 7% are tolerated by the public in very dense urban areas. Parking ramp slopes used as a means of egress should not exceed an 8% slope, as required by the International Building Code (IBC)[2]. Additional requirements apply to cross slopes and to slopes used as an accessible means of egress.

Non-parking ramps are often employed at airports, casinos, large retail structures, for special event structures, and on small and irregularly shaped sites. Non-parking ramps consist of circular helixes (most common), express ramps (external), and speed ramps (internal). Non-parking ramp slopes should have a maximum slope in the 12% to 14% range. Non-parking ramp slopes up to 20% are sometimes considered if covered or equipped with snow-melt systems.

Parking structures with non-parking ramps tend to be less efficient in terms of square feet of structure

[2] *2012 International Building Code*

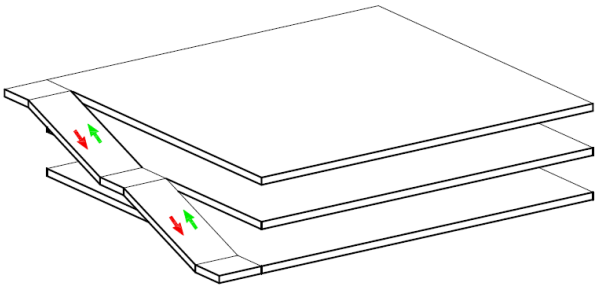


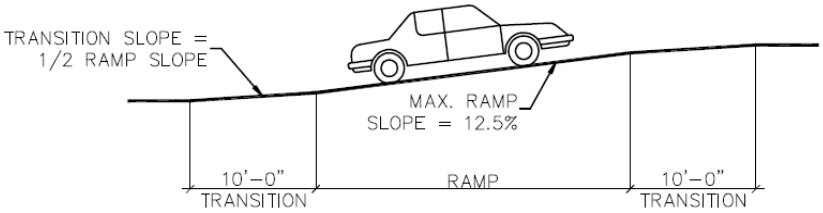
Figure 1 – Non-Parking Ramp

per sparking space, which directly increases the construction cost per parking space.

A grade difference of 8% or more requires transition slopes so vehicles do not bottom out. A minimum 10'-0" long transition slope is recommended at the top and bottom of the ramp, where the transition slope percent is one-half of the ramp slope. For instance, two 10'-0" transition ramps sloped at 6.25% would be required at the bottom and the top of a ramp sloped at 12.5%.

Circulation and queuing areas must have turning radii that are adequate for the type of vehicles that will be using the site. Refer to the design criteria of the American Association for State Highway and Transportation Officials (AASHTO) or the Institute of Transportation Engineers (ITE) for the specific dimensions.

Figure 2 – Recommended Slope Transition



One-Way vs. Two-Way Traffic

One of the primary factors in the design of parking structure is determining the traffic flow—one-way or two-way. Typically, a parking bay for a one-way traffic flow is narrower than for a two-way flow. The available site dimensions will influence the parking bay width and thus also influence the circulation pattern. There are advantages and disadvantages to both circulation patterns. One-way traffic flow should never be combined with 90° parking. In parking facilities with one-way traffic flow, the angle of the parking stalls establishes the direction of vehicle traffic.

ADVANTAGES OF ONE-WAY TRAFFIC FLOW:

- Easier for parkers to enter/exit parking spaces
- Vehicles are more likely to be centered in angled spaces
- Less circulation conflict and reduced potential for accidents
- Better visibility when backing out of a stall
- Separation of inbound and outbound traffic and improved flow capacity of the circulation system
- The intended traffic flow is self-enforcing
- One-way traffic allows the angle of parking to be changed to accommodate changes in vehicle sizes

ADVANTAGES OF TWO-WAY TRAFFIC FLOW:

- Wider drive aisles allow parkers to pass other vehicles
- Wider drive aisles are safer for pedestrians
- Better angle of visibility when searching for a parking space
- Traffic flow follows its own pattern rather than one that is forced
- Two-way traffic and 90° parking makes more efficient use of parking aisles (more spaces in a run).

» Two-way parking facilities can essentially operate as one-way facilities when there is heavy directional traffic

Single-Threaded Design

In order to develop a reasonably efficient free-standing parking structure, the minimum dimensions needed are about 122 feet in width by 155 feet in length. A width of 122 feet allows for a two-bay facility with two-way traffic flow and 90° parking. A facility with two-way traffic and a five-foot rise along each bay requires approximately 155 feet in length for a minimum floor-to-floor height of about ten feet. That is, one 360° turn within the facility equates to a vertical rise of ten feet. A structure in this configuration has sloping floors along both façade sides. However, sloping floors can make façade treatments challenging. On larger sites that allow a structure length of about 255 feet, one bay can be sloped rising 10 feet with opposite façade having a "level" floor.

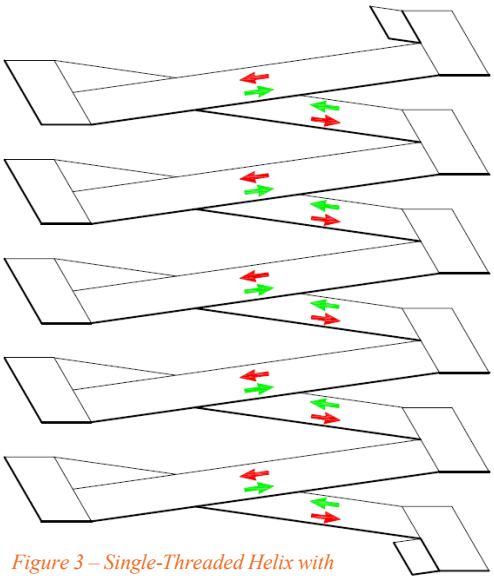


Figure 3 – Single-Threaded Helix with Sloping Floors

Because of the number of 360º turns needed to ascend in a single threaded structure, the number of levels (floors) should preferably be limited to a maximum of six; otherwise, the number of turns required and the number of spaces passed becomes inconvenient. A structure with a two-bay single-thread design has a maximum of approximately 750 spaces. The isometric diagram to the right represents a two-bay single-threaded helix.

PRINCIPAL ADVANTAGES OF A SINGLE-THREADED HELIX:

» Repetitive and easy to understand for users

» Potentially more flat-floor parking and level façade elements

» Better visibility across the structure, which enhances security

PRINCIPAL DISADVANTAGES OF A SINGLE-THREADED HELIX:

» More revolutions required going from bottom to top and top to bottom

» Two-way traffic bays have less flow capacity than one-way traffic bays. Traffic in both directions is impeded by vehicles parking and vacating a space.

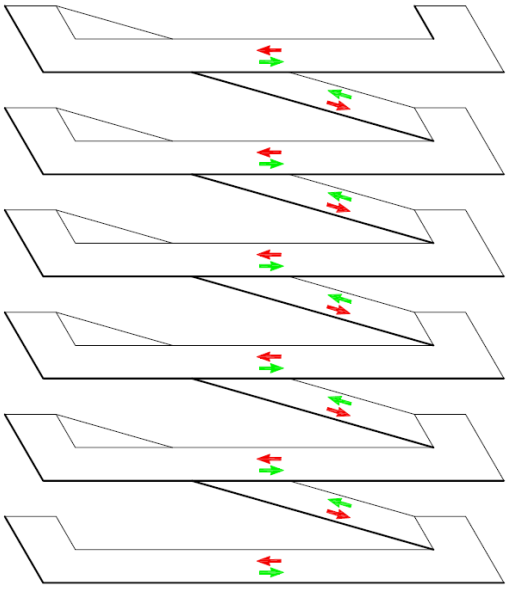


Figure 4 – Single-Threaded Helix with One Level Bay

Double-Threaded Design

A facility with a one-way circulation system and angled parking can be provided in a double-threaded helix with modules ranging from 54 to 58 feet in width, depending upon the angle of parking. The preferred angles of parking for an efficient layout are 60°, 70° and 75°. A double thread, which requires a ten-foot rise along each module, requires 240 feet in length. More efficient layouts can be achieved on longer sites. The isometric right represents a two-bay double-threaded helix with one-way traffic.

A double-threaded helix can work with either one-way or two-way traffic flow, although one-way traffic is more common. A two-way double-threaded design can be configured as two separate structures with no vehicular connection. A double-threaded helix rises two levels with every 360° of revolution, which allows for two intertwined "threads" and the opportunity to circulate to an available parking space without passing all parking spaces as inbound and outbound traffic can be separated. Because of this, double-threaded helices are often recommended for larger facilities with seven or more levels. A two-bay double thread has a functional system capacity for up to approximately 2,000 spaces with angled parking and one-way traffic flow.

PRINCIPAL ADVANTAGES OF A DOUBLE-THREADED HELIX:

- Efficient circulation and more traffic flow capacity
- Pass fewer spaces both inbound and outbound

PRINCIPAL DISADVANTAGES OF A DOUBLE-THREADED HELIX:

- Can be complex and confusing, particularly in finding one's vehicle upon return to the parking facility
- Two-sloped bays and minimal flat-floor parking

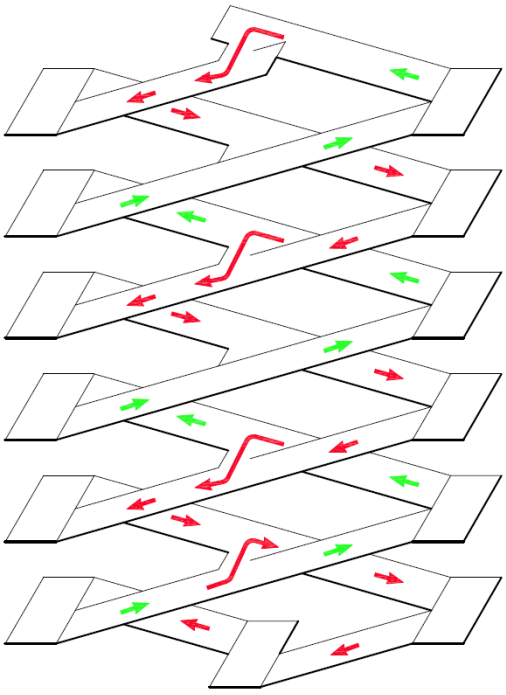


Figure 5 – One Way Double-Threaded Design

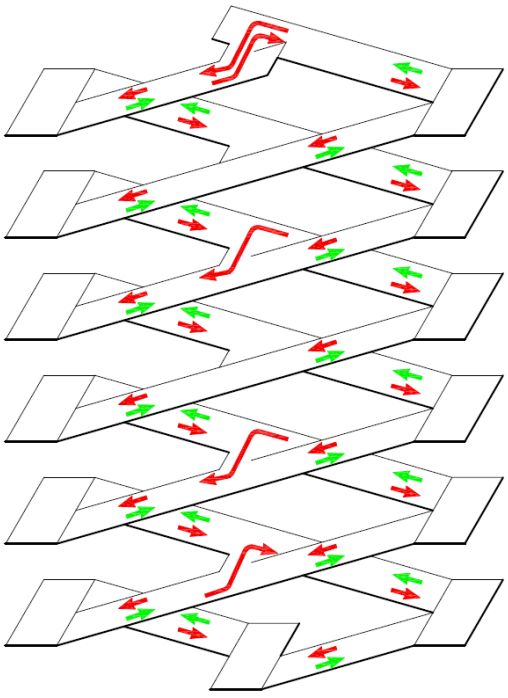


Figure 6 – Two Way Double-Threaded Design

Other Circulation Systems

There are other parking and circulation systems that are often used in parking structures:

Figure 7 –
End to End Helix Both Bays Sloped

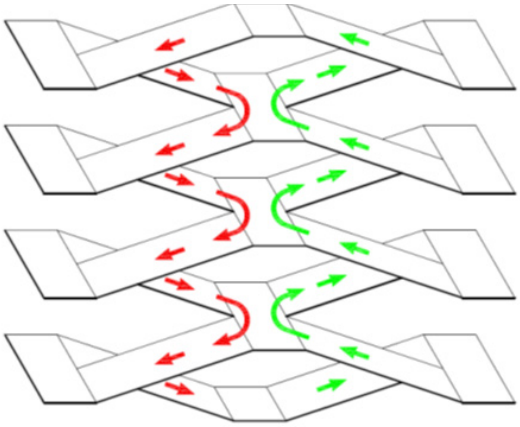


Figure 8 –
End to End Helix One Bay Sloped

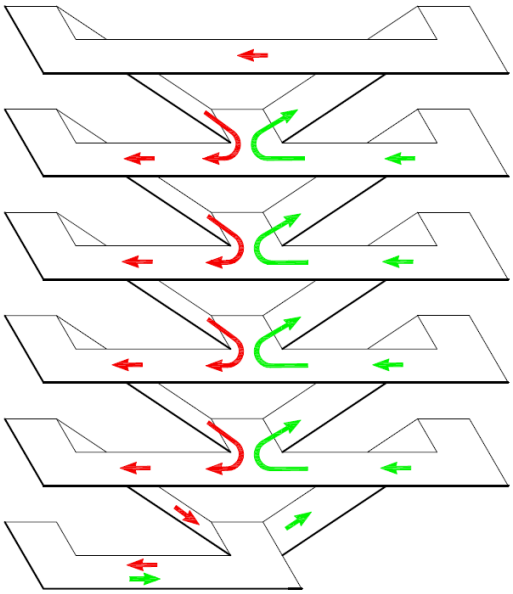


Figure 9 –
Side by Side Helix

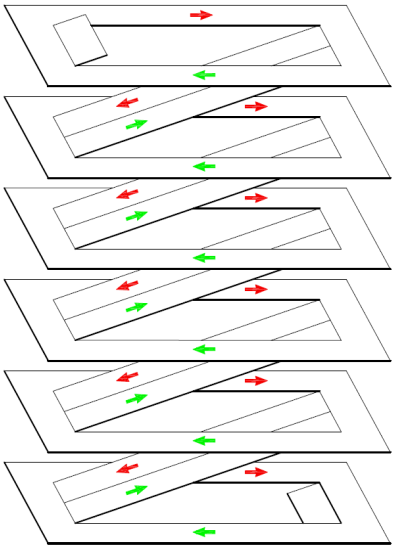


Figure 10 –
Single-Threaded with Flat Bays

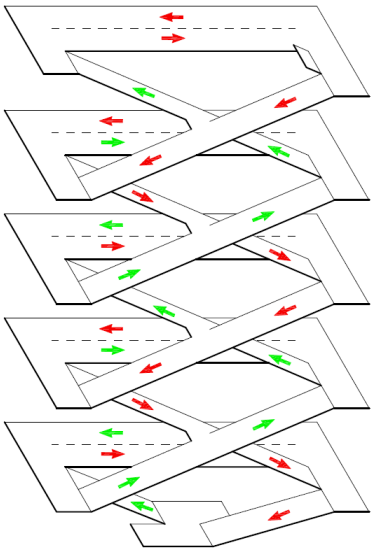
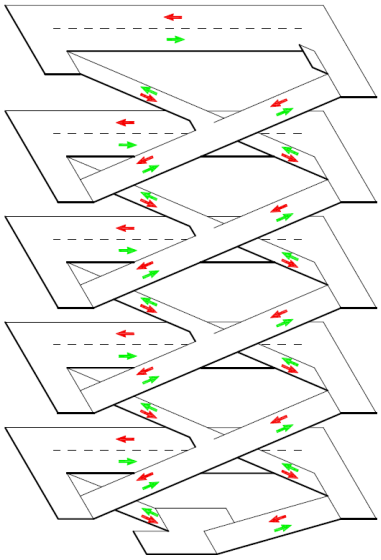


Figure 11 –
Double-Threaded with Flat Bays



Access Design

Vehicle entrances should be visible and easily identifiable. The minimum distance of entrances and exits from corner intersections is at least 75 to 100 feet (preferably 150 feet). Entrances and exits should have clear lines of sight. It is preferable to enter a facility from a one-way street or by turning right from a two-way street and to exit a facility by turning right on a low-volume street. High traffic volumes and left turns can slow exiting and cause traffic backups. Consideration should be given to acceleration and deceleration lanes on busy streets. Gates should be located far enough away from the street to allow at least one vehicle behind the vehicle in the service position (at a ticket dispenser, card/AVI reader or cashier booth) without blocking the sidewalk. Entrance and exit areas that have parking control equipment should have a maximum 3% slope.

It is very important to provide the appropriate number of entrance and exit lanes to meet projected peak traffic volumes. The number of lanes is a function of user groups served, peak-hour traffic volumes, and service rates of the parking control equipment. It is recommended to have a parking professional prepare a lane and queuing analysis to guarantee sufficient entry and exit capacities.

Cross-traffic at entrances and exits should be minimized and preferably eliminated. When placing vehicle entries and exits together on one-way streets it is preferable to avoid "English" traffic conditions where traffic keeps to the left instead of to the right. Pedestrian and vehicular conflicts should be minimized by providing a pedestrian walkway adjacent to entry and exit lanes. Stair and elevator towers should be located so that pedestrians do not have to cross drive aisles on their way to primary demand generators.

Vehicular Entrance and Exit Lanes

The number of entry and exit lanes depends on the expected peak volume of traffic and the rate of flow through the lane. The rate of flow varies depending on the type of access and revenue control equipment. The approach and the departure area from the lanes will also affect the rate of flow into or out of the structure. Tight turns result in a slower throughput. Pedestrian safety at entry and exit portals is paramount. Consider the vision cone of drivers entering or exiting the facility. Check and recheck vehicle turning radii at all entry and exit lanes and adjacent ramps.

Parking Geometrics

Parking geometrics refers to parking stall and drive aisle dimensions. Parking dimensions have been developed to comfortably accommodate the composite design vehicle, which refers to the dimensions of the 85th percentile vehicle in the range of vehicles from smallest (zero percentile) to largest (100th percentile). The composite design vehicle is the size of a Ford F-150 truck (6'-7" x 17'-3").

Table 1 lists parking geometrics by parking angle for standard and compact spaces.

Table 1 – Parking Geometrics

Parking Angle A	Stall Width B	Curb Length Per Car C	Stall Depth D	Driveway Width E
O°	9'- 0"	23'- 0"	9'- 0"	12'- 0"
20°	9'- 0"	26'- 4"	15'- 3"	11'- 0"
30°	9'- 0"	18'- 0"	17'- 8"	11'- 0"
40°	9'- 0"	14'- 0"	19'- 6"	12'- 0"
45°	9'- 0"	12'- 9"	20'- 5"	13'- 0"
50°	9'- 0"	11'- 9"	21'- 0"	14'- 0"
60°	9'- 0"	10'- 5"	21'- 10"	16'- 0"
70°	9'- 0"	9'- 8"	21'- 10"	18'- 0"
80°	9'- 0"	9'- 2"	21'- 4"	20'- 0"
90°	9'- 0"	9'- 0"	20'- 0"	22'- 0"

MINIMUM STANDARDS FOR COMPACT VEHICLES

Parking Angle A	Stall Width B	Curb Length Per Car C	Stall Depth D	Driveway Width E
45°	7'- 6"	10'- 6"	16'- 0"	11'- 0"
60°	7'- 6"	8'- 9"	16'- 9"	14'- 0"
75°	7'- 6"	7'- 10"	16'- 4"	17'- 5"
90°	7'- 6"	7'- 6"	15'- 0"	20'- 0"

Table 2 – Parking Dimensions by User Comfort Factor

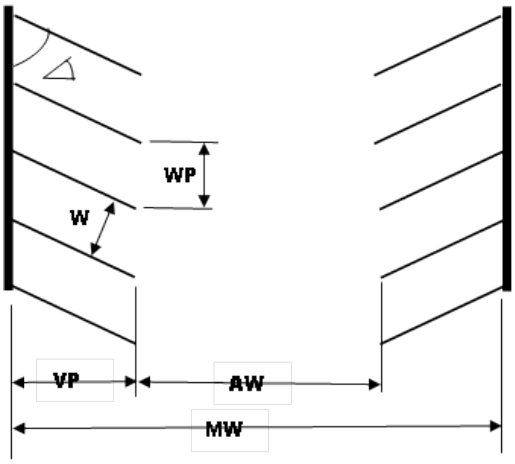
Parking Angle	Stall Width Projection (WP)	Module Width (1) (MW)	Vehicle Projection (VP)	Aisle Width (AW)
User Comfort Factor 4				
	w = 9'-0"			
45	12'-9"	49'-10"	17'-7"	14'-8"
50	11'-9"	51'-7"	18'-2"	15'-3"
55	11'-0"	53'-0"	18'-8"	15'-8"
60	10'-5"	54'-6"	19'-0"	16'-6"
65	9'-11"	55'-9"	19'-2"	17'-5"
70	9'-7"	57'-0"	19'-3"	18'-6"
75	9'-4"	58'-0"	19'-1"	19'-10"
90	9'-0"	62'-0"	18'-0"	26'-0"
User Comfort Factor 3				
	w = 8'-9"			
45	12'-4"	48'-10"	17'-7"	13'-8"
50	11'-5"	50'-7"	18'-2"	14'-3"
55	10'-8"	52'-0"	18'-8"	14'-8"
60	10'-1"	53'-6"	19'-0"	15'-6"
65	9'-8"	54'-9"	19'-2"	16'-5"
70	9'-4"	56'-0"	19'-3"	17'-6"
75	9'-1"	57'-0"	19'-1"	18'-10"
90	8'-9"	61'-0"	18'-0"	25'-0"

Parking Angle	Stall Width Projection (WP)	Module Width (1) (MW)	Vehicle Projection (VP)	Aisle Width (AW)
User Comfort Factor 2				
	w = 8'-6"			
45	12'-0"	47'-10"	17'-7"	12'-8"
50	11'-1"	49'-7"	18'-2"	13'-3"
55	10'-5"	51'-0"	18'-8"	13'-8"
60	9'-10"	52'-6"	19'-0"	14'-6"
65	9'-5"	53'-9"	19'-2"	15'-5"
70	9'-1"	55'-0"	19'-3"	16'-6"
75	8'-10"	56'-0"	19'-1"	17'-10"
90	8'-6"	60'-0"	18'-0"	24'-0"
User Comfort Factor 1				
	w = 8'-3"			
45	11'-8"	46'-10"	17'-7"	11'-8"
50	10'-9"	48'-7"	18'-2"	12'-3"
55	10'-1"	50'-0"	18'-8"	12'-8"
60	9'-6"	51'-6"	19'-0"	13'-6"
65	9'-1"	52'-9"	19'-2"	14'-5"
70	8'-9"	54'-0"	19'-3"	15'-6"
75	8'-6"	55'-0"	19'-1"	16'-10"
90	8'-3"	59'-0"	18'-0"	23'-0"

Note: (1) Wall to wall, double loaded aisle.

Table 2 lists parking geometrics by User Comfort Factor (UCF) which correlates with a Level of Service (LOS) approach. Traffic engineers developed the LOS approach to classify traffic conditions on roadways from A (free flow) to F (gridlock). The UCF/LOS approach has been adopted by many parking consultants to help classify conditions in parking facilities. The UCF categories for parking geometrics are as follows:

UCF 4 = LOS A = Excellent
UCF 3 = LOS B = Good
UCF 2 = LOS C = Acceptable
UCF 1 = LOS D = Poor



LOS criteria should be related to the needs and concerns of users[3]. Generally, users (e.g. hotel patrons, retail patrons, or area visitors) with low familiarity and high turnover should be accorded a higher UCF. If the City's parking standards are not used, we recommend minimum UCF 3 geometrics for moderate- to high-turnover parking (visitor, retail, etc.) and UCF 2 geometrics for low-turnover parking (employee, commuter, resident, etc.).

We recommend using "one-size-fits-all" parking spaces rather than segregating standard and small car spaces. However, if they are used, small car spaces should not exceed 15% to 20% of the total capacity of a facility.

Parking spaces adjacent to walls, columns, elevators, stairs, etc. should be widened, if possible, by one foot so that vehicle doors can be more easily opened.

End-bay drive aisles with two-way traffic should be a minimum of 26 feet wide for improved turning maneuverability. Wider end-bay drive aisles are recommended for high-turnover parking facilities. If possible, it is also suggested for more comfortable turns to hold back the first stall on either side of the turning bay. Small-Car-Only (SCO) spaces are also recommended at the ends of interior parking rows. It is difficult to make a turnaround with only one row of parking. Refer to the graphic to the right.

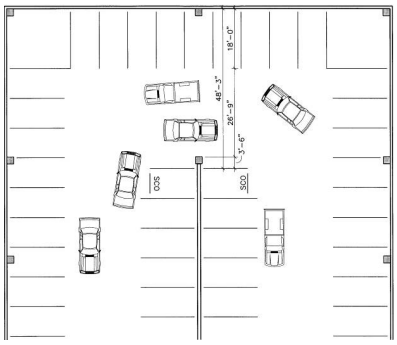
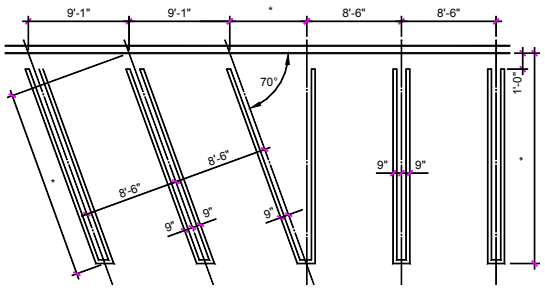


Figure 12 – Vehicle Turning Dimensions

[3] *Refer to the list of user types on page X of this document.*

Double stripes for space striping are recommended as they help parkers center their vehicles between stripes, maximizing the space between vehicles (refer to the graphic below). Also recommended is the use of traffic yellow paint for stall striping as yellow paint is more visible over time than white paint.

Figure 13 – Example Stall Dimensions



Parking Layout Efficiency

Parking efficiency is expressed in square feet of construction per parking space and directly correlates with the construction cost per space. Build less structure per space and the cost per space drops. Non-parking speed ramps, for example, increase the square feet per space.

Parking efficiency should be calculated considering the total parking structure size including the stairs and elevators and non-parking ramps. Any retail space that is incorporated within the structure is also usually included in the calculation.

Typical ranges of parking structure efficiencies are:

- Short-Span[4] Structural System = 330 to 390 square feet per space
- Long-Span Structural System = 300 to 340 square feet per space
- Mixed-Use Developments with retail, residential and parking can be as high as 400+ square feet per space

Pedestrian Requirements

Pedestrian traffic is equally as important in a parking structure as vehicular traffic. A safe, secure, and well signed pedestrian path must be provided. Pedestrian access at the grade level should be separated from vehicular ingress and egress. Pedestrian access is usually adjacent to stair and elevator towers. It is also desirable to place a dedicated pedestrian aisle adjacent to a vehicle entrance and exit because pedestrians are naturally attracted to these openings. Access locations should be restricted to a few locations for security reasons.

A minimum of two stairs are required to meet code-required means of egress for fire exits in parking structures. Stairs should be open or glass enclosed for security reasons. The minimum stair width in parking structures is 44” and wider stairs are required for special events. Travel distance to the nearest exit stair is specified in the IBC and is a maximum of 300 feet without a sprinkler system and 400 feet with a sprinkler system. Additional “Common path of travel limitations apply at dead-end regions of the parking deck. Stairs are usually placed in dead corners so that no parking spaces are lost.

Elevators should be located at termini in the direction of pedestrian travel. Hydraulic elevators can be used for up to five levels or 50 to 60 feet. Traction elevators should be used beyond five levels. The minimum capacity and size is 3,500 lbs. and 5’-0” x 7’-0”. The number of elevators is based on the number of spaces, the number

[4] Short span and long span refer to the length of the beams used in construction of the facility. Short span construction will have a smaller beam length and more internal columns, reducing visibility. Long span construction will have a longer beam length, resulting in less columns and increased visibility and flow.

of levels, user group(s) served, peak-hour flow rates, and the size and capacity of the elevator. A parking consultant can provide a preliminary indication of the number of elevators based on a formula that takes into account the information presented above. Ornate or high maintenance elevator finishes are discouraged. We highly recommend that elevators have glass backs for security reasons. Enclosed lobbies are recommended for protection from the elements on the top level. In buildings where the accessible floor is four or more stories above or below a level of discharge, at least one accessible means of egress must be an elevator. Elevators used as an accessible means of egress have additional requirements which they must meet.

Pedestrian Safe Access

The parking requirements emphasize designs that protect and encourage walking. A safe and direct pedestrian pathway must be provided from the street or sidewalk to the primary building entrance in commercial, institutional, and residential land uses.

This means that if the parking area is located in front of the building relative to the street, a safe pedestrian pathway must be provided through the parking area. These pathways must be ADA compliant, and either be completely separated from vehicular traffic or clearly designated, such as through a raised surface or distinctive paving.

Whenever possible, parking rows should be aligned perpendicular to the main building, as this provides for a safer and more direct pedestrian route. If cross access is provided between two sites, pedestrian safety must be integrated into the design. Pedestrian pathways that cross driveways must be clearly marked. This requirement is not intended to apply to drive aisles within parking areas, but to driveways. Pedestrian pathways between parking areas and buildings must be ADA compliant and the pathway must be widened to account for any bumper overhang.

Americans with Disabilities Act (ADA) Compliance

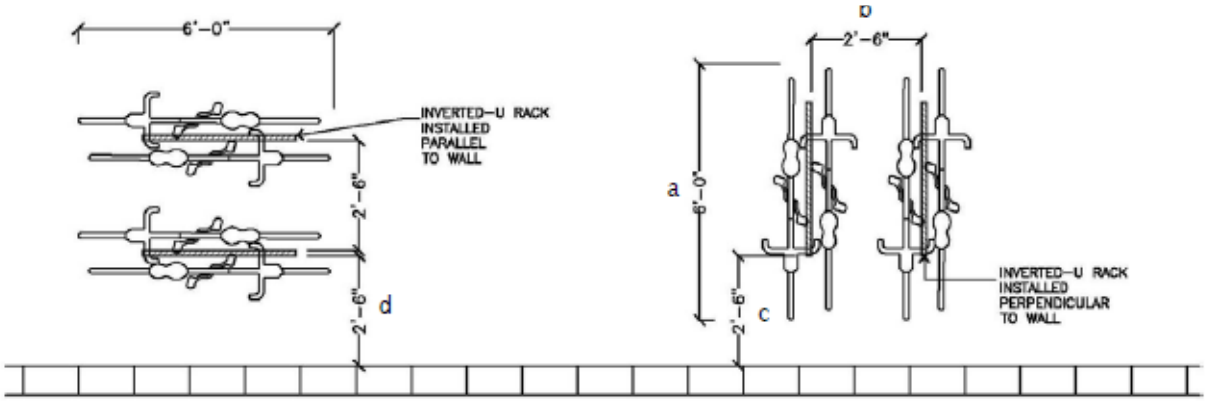
The design guidelines will provide guidance for the City in the implementation and management of ADA spaces in parking facilities owned and/or managed by the City. The regulations for these spaces are evolving for both on-street and off-street spaces and the guidelines will provide guidance for both locating and sizing ADA space inventory to serve the needs of the community.

Bicycle Requirements

Design elements for bicycle parking are presented below.

- Location
  - Goal is to maximize convenience of bicycle parking facilities
  - Curb ramps must be installed where appropriate
  - Short-term parking facilities must be located no more than 100 feet from the main building entrance or no further than the nearest non-disabled parking space from main building
  - If more than one building or a building has more than one entrance, the short-term bicycle parking needs to be distributed to serve all buildings and entrances for easy accessibility
  - Long-term bicycle parking facilities must be located no more than 400 feet from the building entrances

- Outside Pedestrian Pathways
  - Minimum of four feet of unobstructed pedestrian pathway outside the bicycle parking space must be maintained



a. Bicycle parking spaces minimum 6' long.

b. Minimum 2' 6" space between racks.

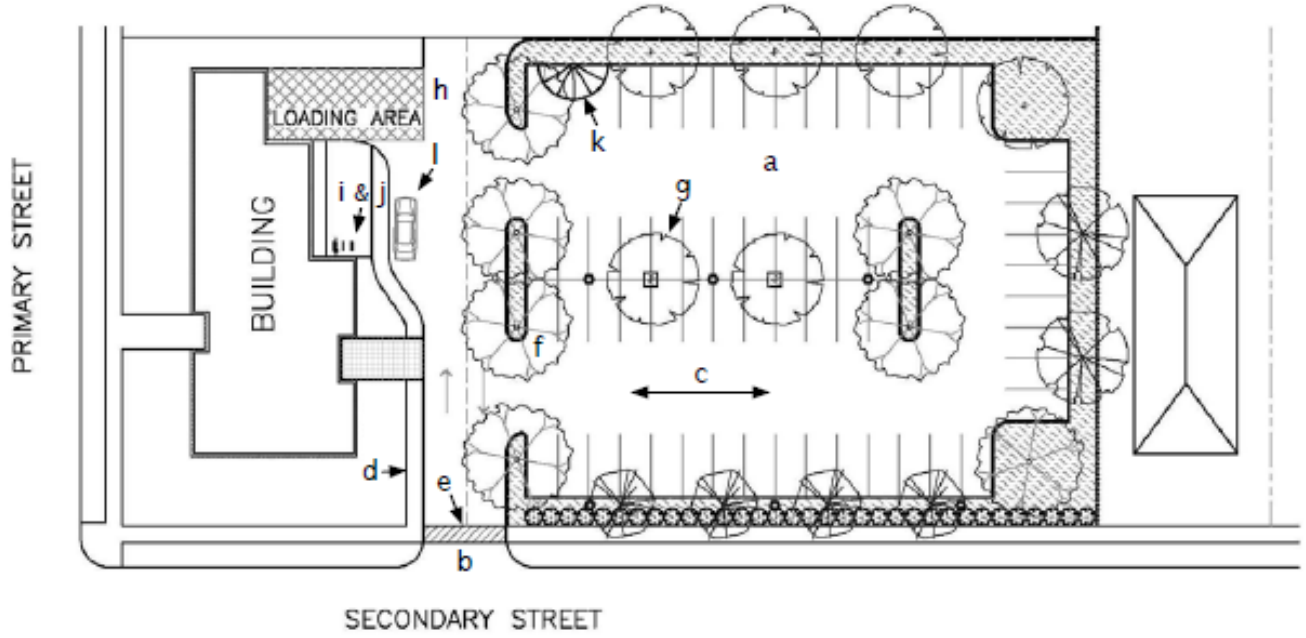
c. Minimum 2' 6" between rack end and perpendicular wall.

d. Minimum 2' 6" between rack and parallel wall.

Figure 14– Bicycle Parking Dimensions

- Facility Delineation and Signage
  - Bicycle facilities must delineated by striping, curbing, fencing, or by other equivalent methods even if the facility consists of one rack for bicycle parking
  - If located near a roadway, parking area, or drive, bicycles must be protected from damage by motor vehicles by the use of bollards, curbs, concrete planters, landscape buffers, or other suitable barriers
  - Signs need to be posted to direct cyclist to the facilities if they are not clearly visible to approaching bicyclists
  - If there are bicycle lockers provided, provide a sign that lists the name or title and the phone number or electronic contact information of the person in charge of facility
- Bicycle Parking Space Dimensions
  - Space length: 6 feet minimum
  - Space between racks: 2 feet and 6 inches minimum
  - Space between adjacent walls/obstruction: 2 feet and 6 inches minimum
- Aisle Width
  - Four-foot wide access aisle from the front or rear of bicycle parking space must be provided beside each row or between two rows
  - Recommended aisle width is 6 feet for high traffic volume areas such as schools or colleges
- Lighting
  - Illumination of ground level shall be provided in both interior and exterior bicycle parking facilities during hours of use

Figure 14– Bicycle Parking Dimensions



a. Preferred: Parking located behind building away from street corner. (Sec. 8108-5.3.1)

b. Parking area access from lowest volume street. (Sec. 8108-5.4.2(c))

c. Preferred: Parking rows perpendicular to the main building entrance to assist safe pedestrian movement toward the building. (Sec. 8108-5.4.2(b))

d. Safe, designated pedestrian pathways from street/sidewalk to main building entrance. (Sec. 8108-5.4.2(e))

e. Pedestrian routes that cross street access driveways clearly marked. (Sec. 8108-5.4.3)

f. Interior intersection landscaping does not obstruct visibility. (Sec. 8108-5.11(b))

g. Min. 1 shade tree per 4 adjacent spaces creates cooler, more attractive pedestrian environment. (Sec. 8108-5.14.5(b))

h. Loading spaces located away from pedestrian pathways. (Sec. 8108-8.2.3)

i. Short-term bicycle parking (bike racks) located within 100' of main entrance and with safe and convenient access to the street. (Sec. 8108-6.3)

j. Bike racks located on sidewalks provide minimum of 4' of unobstructed pedestrian pathway. (Sec. 8108-6.3.2)

k. Long-term bicycle parking for employees located within 400' of the building entrance. (Sec. 8108-6.3.1)

l. Passenger loading turn-out located so that waiting vehicles do not impede bicycle or pedestrian circulation. (Sec. 8108-8.1)

A safe and direct pedestrian pathway must be provided from the street to the primary building entrance. Section 8108-5.4.2

Accessible Parking Requirements

The following table presents the required number of accessible parking spaces based on the total number of spaces provided in any given facility.

The accessible parking requirement is not based on the total parking capacity but rather on the capacities of the individual facilities within a parking system, which always results in the provision of more accessible spaces overall. Accessible spaces for the institution do not have to be provided in each parking area, but can be supplied at a different location provided at least equivalent accessibility in terms of distance, cost, and convenience is provided.

Table 3 – Required Accessible Spaces

Total Spaces in Facility	Minimum 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

Car accessible spaces are eight feet wide with a five-foot access aisle. Van accessible spaces are 11 feet wide with a five foot access aisle, or may be permitted to be 8 feet wide with an eight foot access aisle. An accessible space and access aisle cannot be placed at a location with a running or cross slope greater than 1:50 (2%).

The required ratio for van accessible spaces to total accessible spaces is one to six, and it is required to round up to the nearest whole number when determining the number of van spaces. It is recommended to use the new one to six ratio when determining the number of van spaces. Van accessible spaces require minimum 8'-2" vertical clearance, while car accessible spaces require minimum 7'-0" vertical clearance..

Each accessible space must have a sign showing the international symbol of accessibility mounted at least five feet above the pavement. All van accessible spaces must have an additional "Van Accessible" sign mounted below the symbol of accessibility (mount minimum of five feet above pavement with other sign above).

ADA requires rounding up to the next whole number when calculating the required number of spaces based on a percentage or ratio. For example, a parking facility with 810 spaces will have 17 accessible spaces (810 x .02 = 16.2 = 17 spaces), and three spaces will have to be van accessible (17 ÷ 8 = 2.125 = 3).

Accessible stalls cannot share access aisles when the parking is angled. Access aisles for van spaces must be on the passenger side when the parking is angled because vehicles cannot back into these spaces.

All accessible spaces must have an accessible route to public streets or sidewalks, accessible elevators, or accessible building entrances. An accessible route must have a minimum unobstructed width of three feet. A vehicle way (drive aisle) may be part of an accessible route, although it is preferred to place the accessible route at the front of the stalls. An accessible route can only pass behind other accessible spaces. It is permitted to cross a vehicle way with an accessible route.

The running slope along an accessible route cannot exceed 1:20 (5%) and the cross slope cannot exceed 1:50 (2%).

It is recommended to cross hatch all access aisles and accessible routes.

Signage and Wayfinding

Parking facilities can be very large, complex, and confusing. A well-designed graphics and signage system will effectively communicate necessary information to patrons, reduce confusion, improve safety, and enhance the overall user experience.

Sign messages should be simple and succinct. Messages on signs that are to be read quickly, such as vehicular signs, should be no more than 30 characters and six words in length. The typeface used should be simple and easy to read, and there is a general preference for Helvetica medium in the parking industry. Signs with lower case letters and initial caps are most easily read. The simple block arrow is recommended for parking signs. If a left turn is required, the arrow should be placed on the left side of the sign. The opposite is true for a right turn.

In parking structures, signs with a dark background and white letters are more easily read than signs with a white background and dark letters. The opposite is true in surface lots, where signs with white background and dark letters are better.

Vehicle Signs

Examples of vehicular signs include "Park" and "Exit" directional signs. Vehicular signs are 10 or 12 inches in height with six- or seven-inch letters. Ten-inch signs are recommended for precast structures where sign visibility can be a problem. Vehicular signs should be centered over the drive lane or centered over the drive aisle when signs are mounted back-to-back.

Pedestrian Signs

Examples of pedestrian signs include "Level #," "Remember Level #," "Row #,"and "Stair" and "Elevator" identification and directional signs. Pedestrian signs can be all one color or be color-coded by level. Pedestrian signs should be clearly distinguishable from vehicle signs so as not to interfere with vehicular traffic. Pedestrian signs in parking bays are most effective if located perpendicular to traffic flow, and they should be placed at the rear of parking stalls. Color-coding is often used to help patrons find their vehicles. It is not necessary to provide color-coding in parking facilities that are three levels or less. When color coding, it is recommended to use primary and secondary colors including red, blue, yellow, orange, purple, and green. If there are more than six levels that need to be color-coded, it is recommended to use white, brown, and black. Confusing colors such as turquoise (blue or green?) and taupe (brown, tan, or gray?) should be avoided.

The elevator core area provides an excellent location to utilize super graphics. Super graphics is defined as a graphic that covers a large area and is generally painted on a vertical surface, such as painted walls or elevator doors, with level designation incorporated.

Level Theming

"Level Identification Theming" and other wayfinding aids provides an opportunity to enhance parking interior environment enhancement while also providing a practical tools to assist patrons in remembering where they parked. The level theming can also be coordinated with an area's existing brand or characteristics. An example from Charlotte, NC is provided on the following page. Many communities are simply using colors to define levels, which simplifies the process of finding and remembering your parking space for the patron.


10
9
8
7
6
5
4
3
2

Entry Signs

Emphasizing the entrance to a parking facility is important. Large illuminated signs are often used to emphasize the facility entry and attract patrons. These signs often spell out "Parking" or use the International symbol for parking. Architectural features, such as an arch, canopy, or some different treatment of the façade, are often used to highlight the entry area as well. A height clearance bar is required for all parking structures, including the top (surface) level of below-grade facilities to prohibit over-height vehicles. Generally, the height clearance bar is located at the facility entrance(s). There may be instances when the clear height in a parking structure changes from one level to another (for example, a higher ground level than typical level to accommodate ADA vans), which may require additional height clearance bars within the facility itself. Generally, the height clearance bar is an eight-inch PVC pipe.

Regulatory Signs

Regulatory signs are often used in parking facilities. Examples include "STOP," "YIELD," "ONE WAY," "NO PARKING," "DO NOT ENTER," and accessible parking signs. When used it is imperative that they comply with local and federal requirements. The Manual of Uniform Traffic Control Devices (MUTCD) provides examples of standard highway signs.

Illuminated Signs

Illuminated signs are becoming more common in parking facilities. Technology has advanced significantly in recent years and illuminated signs have become more reliable. Generally, illuminated signs are used for the following parking applications:

- Entry and exit lanes (open in green/closed in red)
- Facility full signs
- Stop (red)/go (green)
- Level space capacity
- Directional control
- Fee display
- Space count systems
- Variable message signs

Pavement Markings

Pavement makings should conform to MUTCD or local standards. MUTCD specifies that white paint be used for markings for traffic flow in the same direction and yellow paint used for traffic flow in opposite directions, which implies a warning.

Pavement markings can be an effective way to direct and control traffic flow in a parking facility. However, pavement markings must be re-applied due to wear and deterioration from vehicular traffic. Pavement arrows may enhance traffic flow. They are often utilized on surface lots or the top level of parking structures where overhead directional signage is not possible. Traffic arrows are also commonly used in facilities with a combination of one-way and two-way traffic flow.

Drainage

Proper floor drainage is essential for all types of parking structures in all climates. While direct rain or snow may not enter all areas of the parking garage, windblown rain and snow and/or vehicles carrying ice, snow, and water will distribute water throughout the facility. Heavy rains will also overload top floor drains and water will run down the ramped floors to lower levels. In addition, the frequent floor wash downs that should be part of a good maintenance program are a source of water throughout the parking facility. If the floor is not adequately sloped, water is allowed to pond and deterioration will accelerate beneath the ponds.

A design slope of 2%, or ¼ inch per foot, is desired, with a minimum design slope of 1-½%. Water should be drained away from exterior columns/walls and pedestrian paths.

Floor drain locations are determined by the circulation system, number of bays, and structural system. The top-level drain system should be designed to accept a 10-year design rainfall or as required by local code. Three- to four-inch piping is generally used on covered levels.

Open or Enclosed Parking Structure

Natural ventilation requires openings in exterior walls of sufficient size distributed in such a way that fresh air will enter the facility to disperse and displace contaminated air. The 2012 IBC states:

"For natural ventilation purposes, the exterior side of the structure shall have uniformly distributed openings on two or more sides. The area of such openings in exterior walls on a tier must be at least 20 percent of the total perimeter wall area of each tier. The aggregate length of the openings considered to be providing natural ventilation shall constitute a minimum of 40 percent of the perimeter of the tier. Interior walls shall be at least 20 percent open with uniformly distributed openings."

"Exception: Openings are not required to be distributed over 40 percent of the building perimeter where the required openings are uniformly distributed over two opposing sides of the building."

Setbacks can affect openness as firewalls are required if certain distance requirements from property lines and other buildings are not maintained. Parking structures are typically classified as enclosed if other uses (retail, office, residential) are located above the parking, but may remain open if parking is above or adjacent other uses. When a parking structure is positioned below grade, area ways (e.g. retaining wall set back from the structure to provide opening to the below grade level) can be used to achieve natural ventilation. The building code addresses the geometry required to permit acceptance of an areaway.

Parking structures classified as "open" do not require mechanical ventilation, fire suppression (sprinklers), and enclosed stairs.

Other Considerations

There are other aspects of parking structure design that will not be specifically addressed but should be considered including:

- Zoning requirements (permitted uses, setbacks, easements, etc.)
- Open and enclosed parking garages are classified as Occupancy Group S2. The Type of Construction (A or B) may create additional area and height limitations.

- Building code compliance
- Subsurface conditions and foundations
- Aesthetics
- Fire rating, fire protection, and life safety
- Mechanical systems
- Storm drainage and water storage
- Parking access and revenue control equipment
- Mixed uses (retail, residential and office)
- Parking office requirements
- Maintenance

OPERATIONS

Once parking facilities have been constructed, it will be imperative that the facilities are efficiently operated, managed, and maintained, which will enable a return of revenues that support the ongoing cost of managing and operating all parking assets.

The City should conduct a financial and operational audit of the facility to ensure that the operating procedures are both efficient and effective. The audit should be centered on the following questions and objectives related to the operation and its financial controls:

- What are the contractual requirements that the operator is obligated to fulfill?
- What additional policies and procedures have been established pertaining to the parking operation, its administration, and financial controls?
- What are the additional policies and procedures that have been established by the operator for its internal operational and administrative controls?
- Are the policies and procedures established the operator effective in maintaining an efficient operation and adequate financial controls?
- Is the operator in compliance with its contractual requirements and those set out in policies, procedures, and directives?
- Is the operator's staff managing the facilities in accordance with its own policies and procedures?
- What opportunities are there for improving operational efficiency, management effectiveness, customer service, and financial controls?

Facility Operation Manual Template

To assist with defining the facility operations and keeping track of them, a facility operations manual should be developed. A manual should include the following elements:

- Routine maintenance
- Preventive maintenance
- Repair procedures
- Condition appraisals
- Rehabilitation and restoration
- Maintenance budget

For each of the above elements, the following system components should be included:

- Structural systems
- Waterproofing systems
- Electrical / Lighting systems
- Mechanical / Plumbing systems
- Fire protection
- Signage
- Life safety items
- Access control systems
- Ventilation
- Landscaping
- Cleaning
- Aesthetics

ASSET MAINTENANCE

The City should also define a maintenance strategy for parking facilities to ensure its proper operation and lifespan. A good maintenance plan, especially for structured parking, can increase the lifespan of a parking facility considerably and lower the overall maintenance costs by a third over a 25-year lifespan.

Few things make a greater impression on first-time visitors than the cleanliness and maintenance of your parking facilities. Beyond first impressions, however, few areas provide a greater potential return on investment than a comprehensive parking system maintenance program.

A few best practices related to parking facility appearance and maintenance are noted below.

- Paint interior surfaces white to enhance the perception of cleanliness and safety and to improve lighting levels.
- Develop a comprehensive preventative maintenance program for all essential systems.
  - Parking Access and Revenue Control System (PARCS)
  - Elevators
  - Lighting and energy management systems
- Organize and track parking facility warranties in a binder. Schedule warranty inspections six months prior to warranty expiration. Document inspections with digital photos (ideally with time/date stamps) and written reports.
- Regularly schedule facility condition appraisals by an experienced parking consultant and develop a prioritized program of facility maintenance repairs.
- Set aside adequate maintenance reserve funds based on a prioritized facility maintenance action plan developed as part of your regular condition appraisal assessment.

The four general categories of parking facility maintenance include:

- **Housekeeping –** This work is typically conducted by in-house staff and consists of basic cleaning, sweeping, slab wash downs, etc. “Housekeeping” includes items such as sweeping, trash collection, cleaning of signs, lights, stairs, etc.
- **System Maintenance –** This includes tasks necessary to ensure proper operations of systems and components. “System Maintenance” includes items such as landscaping, painting, equipment, lighting, electrical, and signage maintenance.
- **Annual General Maintenance and Repairs –** Annual general maintenance would usually be performed

by outside contractors, although in some cases the operator's staff may perform the work. This work is not typically included in a capital cost budget and may be combined with the System Maintenance category. "General Maintenance" would include items such as:

- Concrete Repairs – Isolated concrete slab, beam, joist, double tee, topping slab, etc. repairs. In some cases, periodic concrete repairs (every five years) are included; however, isolated repairs between this interval should be anticipated.
- Masonry Repair – Isolated masonry repair should be anticipated (repointing, damaged masonry unit replacement, resetting cap stone, etc.).
- Sealants/Expansion Joint – Repair/replacement of isolated sealant (floor and façade) or expansion joint failure (not included under five-year warranty). Leaking at slab cracks may also require sealant installation. Leaking joints should be repaired as soon as possible after discovery and evidence of leaking should be removed.
- Deck Coating – Isolated deck coating repairs (not included under the five-year warranty). Wear of the topcoat should be repaired prior to damage to the underlying base membrane.
- Painting – Painting touchup (spot / seasonal painting) should generally be performed as damage is observed. It is anticipated that repainting of exposed steel and concrete surfaces would be performed every 10 to 15 years, and parking stripes reapplied every two to three years.
- Graffiti Removal – Graffiti removal should be completed as soon as possible after the application.
- General Electrical Repairs & Maintenance – Isolated corrosion damage, switchgear maintenance, and panel maintenance.
- Light Fixture Repair / Replacement – Individual light fixture repair or replacement will require immediate attention.
- HVAC – Office, restroom, and elevator HVAC repairs.
- Plumbing – Isolated replacement of drain lines and floor drain grates; isolated cleanout of drains/lines; periodic sump pump repairs.

- Periodic Repairs, Protection, and Improvements (Capital Expenditures) – This work is generally performed by outside contractors under the direction of parking consultants experienced in restoration and will consist of replacing/repairing damage to waterproofing or structural elements.

The following are general maintenance costs by category:

- Housekeeping, Operations & Operator Maintenance – Costs will vary based on specific operations requirements, but will approximate $350 to $450 per space per year.
- Annual General Maintenance and Repairs – Costs will approximate $0.10 to $0.15/square foot per year ($35 to $50 per space per year), depending on condition and type of structural system.
- Periodic Repairs, Protection, and Improvements (Capital Expenditures) – The maintenance reserve fund can likely be lower during the first 10 years of the facility's life and increased to accommodate improvement planning budgets. For a new structure, this item may range from $75 to $100 per space per year for the first 10 years.

CAPITAL PLANNING

Operation and maintenance costs include cleaning, lighting, maintenance, repairs, security, landscaping, snow removal, access control (e.g. entrance gates), fee collection (for priced parking), enforcement, insurance, labor and administration. Parking lot facilities require resurfacing and repaving every five to 10 years, and parking structures require major reconstruction or replacement after 20 to 40 years, with higher maintenance costs in areas with harsh climates, particularly with frequent salt exposure. Private parking facilities must pay taxes and provide profits. The incremental cost of fee collection ranges from less than $50 annually per vehicle for a simple pass system with minimal enforcement, to more than $500 per space for facilities with attendants or automated control systems.

The following are general costs associated with maintaining parking lots and garage facilities. However, it should be noted that these ranges can vary greatly and what is provided below is a representation of typical ranges. There are a number of variables that affect the range of these numbers for both lots and garages. One large variable is staffing. The largest cost for both lots and garages is payroll, which is dependent on the number of employees. Another consideration is the age of the garage. New facilities will require less operations and maintenance costs than older facilities.

Table 5 – Structured Parking General Expenses

Parking Surface Lot

ANNUAL EXPENSES	TYPICAL RANGES			
Salaries & Wages	$ 200.00	to	$ 250.00	per space per year
Benefits	$ 70.00	to	$ 90.00	per space per year
Security	$ 50.00	to	$ 75.00	per space per year
Utilities / Telephone	$ 25.00	to	$ 40.00	per space per year
Supplies & Tickets	$ 10.00	to	$ 20.00	per space per year
Repairs & Maintenance	$ 15.00	to	$ 20.00	per space per year
Uniforms	$ 1.00	to	$ 2.00	per space per year
Equipment Expense	$ 5.00	to	$ 5.00	per space per year
Elevator Maintenance	$ -	to	$ -	per space per year
Professional Services	$ 5.00	to	$ 10.00	per space per year
Advertising / Marketing	$ 3.00	to	$ 5.00	per space per year
Licenses, Fees, etc	$ 3.00	to	$ 5.00	per space per year
Misc	$ 1.00	to	$ 2.00	per space per year
GarageKeepers & General Liability Ins and Claims	$ 10.00	to	$ 15.00	per space per year
Maintenance Reserve	$ 20.00	to	$ 30.00	per space per year
Property Taxes	$ -	to	$ -	per space per year
Management Fee	$ 10.00	to	$ 15.00	per space per year
	$ 428.00	**to**	**$ 584.00**	**per space per year**

Salaries and Wages includes: Payroll, Payroll Taxes, and Workers Comp

Benefits includes: Group Insurance and Retirement

Table 5 – Structured Parking General Expenses

Parking Garages

ANNUAL EXPENSES	TYPICAL RANGES			
Salaries & Wages	$ 225.00	to	$ 300.00	per space per year
Benefits	$ 70.00	to	$ 90.00	per space per year
Security	$ 90.00	to	$ 110.00	per space per year
Utilities / Telephone	$ 50.00	to	$ 70.00	per space per year
Supplies & Tickets	$ 10.00	to	$ 20.00	per space per year
Repairs & Maintenance	$ 35.00	to	$ 50.00	per space per year
Uniforms	$ 1.00	to	$ 2.00	per space per year
Equipment Expense	$ 5.00	to	$ 10.00	per space per year
Elevator Maintenance	$ 15.00	to	$ 25.00	per space per year
Professional Services	$ 10.00	to	$ 15.00	per space per year
Advertising / Marketing	$ 5.00	to	$ 7.00	per space per year
Licenses, Fees, etc	$ 3.00	to	$ 5.00	per space per year
Misc	$ 1.00	to	$ 3.00	per space per year
GarageKeepers & General Liability Ins and Claims	$ 20.00	to	$ 25.00	per space per year
Maintenance Reserve	$ 50.00	to	$ 75.00	per space per year
Property Taxes	$ -	to	$ -	per space per year
Management Fee	$ 10.00	to	$ 15.00	per space per year
	$ 600.00	**to**	**$ 822.00**	**per space per year**

Salaries and Wages includes: Payroll, Payroll Taxes, and Workers Comp

Benefits includes: Group Insurance and Retirement

SAFETY, SECURITY, AND RISK MANAGEMENT

Within the design guidelines, the introduction of Safety and Security elements will be critical to both the perception of the parking facility but also the customer experience within the system. A number of design and operational concepts are used to improve safety and security. A few examples of these practices include:

- **Clear-Span Construction –** The introduction of more open floor plans allows for better sight lines for patrons and security staff, minimizing the areas where crime can occur undetected.
- **External Ramping Systems –** The use of external ramps minimizes vehicle and pedestrian conflicts and also improves sight lines within the interior of the facility. However, from an urban design perspective, the use of external ramps is generally discouraged based on community aesthetics.
- **Glass-Backed Elevators and Stairwells –** Keeping elevator bays and stairwells open and visible removes opportunity for undetected activity and minimizes hiding areas for vagrants or criminals.
- **Security Screening/Limiting Access Points Into the Facility –** By limiting and controlling access points into a facility, garage management can better monitor who is entering a facility and activities occurring within.

- **Security Cameras and Systems –** Introducing cameras that can view areas of the garage that may only be patrolled a few times a day increases the chance that management can monitor and maintain a safe environment within the facility.
- **Security Patrols –** Garage management should provide consistent security patrols within the facilities to ensure that crime and unwanted activity is not taking place.
- **Lighting Design –** Proper lighting can increase visual distances within the facility and can promote a higher sense of safety and security. Advances in LED design can provide operational efficiency while also promoting a safe and secure parking environment. Sensors that can activate and dim lights based on pedestrian presence can increase visibility without major impacts to operating costs. Sensors in lighting can be directly tied to camera systems that help staff manage and monitor facility activity.
- **Landscape Design –** Exterior landscaping can be used to minimize access points and prevent unwanted entrance into the parking facility.

The Parking and Mobility Program should also introduce Crime Prevention Through Environmental Design (CPTED) principles. CPTED principles include natural surveillance, natural access control, natural territorial reinforcement, maintenance, and active support. These principles typically use increased activity, lighting, and openness to discourage crime by increasing the perception of being caught.

Facility Design Standards

Because curbs can be a potential tripping hazard, curbs in all pedestrian areas (at the end of parking rows, around stairs and elevators, dead corners, etc.) are strongly discouraged. The faces and edge of curbs that remain should be painted traffic yellow to enhance visibility.

Glass-backed elevators and glass enclosed and/or open stairways for enhanced security are recommended.

Lighting that enables users to see and be seen is one of the most important security features of a parking structure. A separate discussion on lighting is included in these guidelines.

Other important aspects of security design:

- Short-span construction is not recommended
- Security fencing at the ground level should not be climbable
- Landscaping should not provide hiding places
- Security cameras are a deterrent to criminal activity
- Panic alarms and two-way communication systems are recommended in prominent locations on each level

In general, provide as much openness as possible in the design to improve sight lines, eliminate hiding places, and enhance perceived security.

Any proceeds from the facility sales would be reinvested into new parking development projects.

CPTED Principles

CPTED principles include natural surveillance, natural access control, natural territorial reinforcement, maintenance, and active support. These principles typically use increased activity, lighting, and openness to discourage crime, by increasing cues that increase the perception of being caught.

Lighting

- Key Security Measure
  - Enhances user comfort and perception of safety
  - Business attraction amenity
  - Permit safe movement for pedestrians and vehicles
  - Enhances signage visibility
  - Typically light levels are not code regulated, except emergency lighting at minimum of one footcandle
  - Industry standards, including Illuminating Engineering Society of North America (IESNA)
  - Liability risk for non-compliance with standards

The recommended lighting standards listed in the table below, slightly exceed the IES lighting standards for parking facilities, and are consistent with pedestrian lighting standards defined by the City for the Aurora Light Rail Corridor[5]. Staining the ceilings white to enhance light levels is suggested.

Table 5 – Structured Parking General Expenses

Recommended Parking Structure Lighting Standards

Areas	Minimum Horizontal Illuminance on Floor Footcandles	Minimum Vertical Illuminance at 5 feet Footcandles	Maximum to Minimum Uniformity Ratio
General Parking & Pedestrian	2	1	10:1
Ramps and Corners			
Days	2	1	10:1
Nights	1	0.5	10:1
Entrance Areas			
Days	50	25	10:1
Nights	1	0.5	10:1
Stairways	7 avg.		10:1

- Lighting entry and exit lanes
  - Provide additional lighting (50 fc) for 10'- 60' Zone From Building Edge (transitional lighting)
  - Include daylight infiltration (> 15 fc)
  - Typically 10' X 10' dpacing of 150 W fixtures
  - Turn 2/3 of fixtures off at night

[5] *Aurora Light Rail Corridor Lighting Study, which defines street and pedestrian level lighting requirements. The above table exceeds the pedestrian level lighting standards defined in that study.*

- Light source types
  - High-pressure sodium (HPS)
    - Golden white HPS light color
    - Common parking structure lighting
    - Lamp life = 24,000-28,500 hours
- Metal Halide
  - White light color
  - Perceived greater brightness
  - Lamp life = 15,000 hours
  - Operating cost slightly > HPS
- Light Emitting Diode (LED)
  - Emerging technology
  - Energy efficient
  - Long life
- Fluorescent
  - White light color
  - New technology – use in cold climates
    - Cold weather ballast (If temps < 50º F)
    - Phosphor coating
    - Sealed fixtures
  - Lamp life = 30,000 hours
  - Energy cost effective
- Induction lighting
  - White light – best color rendition
  - Instant ignition long life bulbs = 100,000 hours
  - Energy efficient
  - High initial costs

Lighting Expense Reduction Strategies

We recommend that the exterior bay lighting of "open" parking structures as well as roof top lighting be on separate circuits so that these lights can be turned off during the day to reduce energy consumption/costs.

ENVIRONMENTAL SUSTAINABILITY

Many cities are focused on reducing impacts to the environment by reducing the impact of parking (e.g. large lots that increase runoff and heat island effects) and encouraging the use of more environmentally friendly vehicles. This includes providing incentives for non-single-occupancy vehicle travel or electric vehicle usage and setting policy that encourage less driving and a less drastic impact to the environment from the parking system. In recent years, the Green Parking Council (an affiliate of the International Parking Institute) was formed to promote sustainable practices in parking, including documenting sustainability guidelines.

Greening parking facilities involves reducing stormwater runoff and heat island effects while still providing ample parking. The strategy involves requiring lots to be constructed with an enhanced use of landscaping and vegetation (both for shade and capturing runoff), use of sustainable materials, and permeable pavements to help control runoff and reduce the heat island effect. Parking garage design should consider alternative lighting schemes, vegetation, and xeriscaping to conserve runoff, hazardous waste mitigation, and the use of alternative energy sources. The International Parking Institute launched the Green Garage Certification program that sets standards for parking facilities to ensure that they are sustainable. Standards include facility design, technology used to encourage sustainable practices, operations, and management practices that encourage sustainability.

Practices and Policies

The following outlines a recommended approach to developing and operating an environmentally sensitive parking management program. Several areas are explored that offer opportunities for "green approaches" to parking operations that can be implemented by an institution, owner, or parking operator in the day-to-day management of a parking facility or program.

Facility lighting

- Reevaluate lighting types (consider replacement with LED or fluorescent lights to reduce power usage)
- Develop a fluorescent lamp recycling program
- Stain or paint interior parking garage surfaces to maximize reflectivity and enhance facility lighting without increasing energy costs
- Consider the use of sensors/timers to reduce light levels in certain zones when not in use or during daylight hours
- Evaluate individually powered solar parking lot lights

Use of recyclables

- Replace all light bulbs in the parking department with compact fluorescent bulbs
- Replace concrete parking and traffic products with those made from 100% recycled rubber (e.g., wheel stops, speed humps, sign bases, etc.)

Water management

- Replace plumbing fixtures with water-saving fixtures
- Use water-efficient landscaping (e.g., xeriscaping/native plants to reduce irrigation needs)

Facility cleaning

- Implement on-site wastewater treatment
- Use sustainable cleaning supplies
- Make interior spaces tobacco free
- Add recycling containers for all facilities where they are convenient to patrons and staff

Alternative transportation support programs

- Increase the amount and types of bike parking
- Partner with bike concierge services

Reserved parking areas

- Implement or expand reserved areas for car/vanpools
- Implement or expand reserved areas for hybrid/low-emission vehicles

Discounted parking rates and special offers

- Offer "Clean Air Car Discounts" or "Green Parking Permits" (i.e., reduced parking rates) for car/vanpools
- Offer "Clean Air Car Discounts" or "Green Parking Permits" (i.e., reduced parking rates) for hybrid/low-emission vehicles

Electric vehicle charging stations

- Provide charging station(s) for electric vehicles

Parking guidance

- Evaluate or implement parking guidance systems to improve parking efficiency
- Develop a parking availability/location mobile device application to reduce the circling of vehicles

Shared parking

- Promote shared parking whenever possible to promote the "rightsizing" of parking development, (taking advantage of complementary peak parking accumulation patterns by certain combinations of land-uses when the parking resources can be effectively shared)

Layout

- Assess current parking space layouts and consider options to maximize use of existing spaces

Green garages

- Adopt a standard that all parking construction will seek a LEED®-based equivalency rating of "Bronze" or better when feasible and/or Green Parking Council standards

- Adopt a standard for new garage development that solar arrays that generate up to 50% of the facility's power needs must be integrated

Leveraging Garage Design

The following are strategies for using parking garage design to support and emphasize good mixed-use development projects and urban design principles

- Modern Mixed-Use Design – The new facilities will reflect the latest standards for functional design and will contribute positively to the areas/districts they serve. They will be architecturally compatible, reflect good urban design practices, and will incorporate mixed-use facilities where appropriate.
- LEED Certification – Sustainable design practices will be employed and LEED silver certification will be pursued as a minimum standard. Parking decks may be leveraged to provide LEED credits towards a mixed-use development, but may not obtain a LEED Certification status by themselves.
  - Catalytic Development – The parking development projects will encourage and stimulate additional private-sector development and will include other public use components appropriate for the district it serves.
  - Positive Cash Flow – Each new facility must be capable of establishing positive cash flow by year five. The City will use its net operating revenues to subsidize initial facility start-up and operating costs for years one through four.
  - No Free Parking – Related to the "positive cash flow" criteria above, no free public parking will be made available within 3 blocks of the parking development sites.
  - Project Business Plan - Prior to authorization, each parking development project will submit a project specific business plan for approval.
- Another goal of the parking strategic plan is to begin a long-term process of reducing the number and improving the character of remaining surface parking lots in the core area. One of the primary strategies for achieving a reduction in surface lots is by transitioning the overall core area parking supply to more structured parking and leveraging the enhanced parking supply to stimulate development on adjacent land parcels currently used as surface parking lots.

Parking "Exit Strategy"

As the core area parking market matures, the City may prefer to allow the private sector to play a larger role in off-street parking management.

One potential role for the City long-term may be to continue to plan and develop new parking capacity in cooperation with other core area development agencies, but once the parking facilities reach "positive cash flow status" the parking facilities could be offered for sale to the private sector.

Environmental Stewardship

While it is possible for parking structures to achieve certification, typically only occupied buildings receive certification for their sustainable design through the U.S. Green Building Councils (USGBC) Leadership in Energy and Environmental Design (LEED) accreditation program. However, parking structures that are part of a mixed-use project can help attain LEED points for the entire building project. The fact that stand-alone parking structures are generally not LEED certified should not discourage including sustainable design elements in parking structures. Examples of sustainable design features for parking structures include:

- Solar panel sunshades on the top levels that generate electricity
- Energy efficient light sources such as fluorescent, induction, and LED
- Volatile Organic Compound (VOC) – compliant waterproofing materials
- Bicycle storage lockers
- Recycled materials such as silica fume, fly ash, and steel
- Green-roof waterproofing systems and vegetation materials
- Interior light wells to enhance lighting and reduce energy consumption
- Incorporate water cisterns to capture and collect water through the storm water system

INTEGRATION WITH TOD DESIGN PRINCIPLES

The following are design strategies that relate directly to promoting TOD. These parking design strategies can be used to enhance the community identity of station areas and to make them attractive, safe, and convenient places.

- **Building and Site Design**
  - Design buildings to front on public streets or on open spaces, with windows and doors at street level
  - Locate building entrances to minimize walking distance between the transit station and the buildings
  - Locate surface parking to the rear of the buildings
  - Design parking structures to include active uses on the ground floor street frontage
  - Limit building heights to 120 feet, with the tallest and most intensely developed structures located near the transit station
  - Screen unsightly elements, such as dumpsters, loading docks, service entrances, and outdoor storage
  - Take safety and security concerns into account during design
- **Streetscape**
  - Design the streetscape to encourage pedestrian activity
  - Include elements such as street trees, pedestrian-scale lighting, and benches in streetscape design
  - Place utilities underground whenever possible
- **Open Space**
  - Establish public open spaces around transit stations
  - Design open spaces to be centers of activity
  - Orient surrounding buildings onto the open spaces