وزارة المواصلات
MINISTRY OF TRANSPORT

الخطة الشاملة لمواقف المركبات في دولة قطر
Qatar Parking Master Plan

Qatar Parking Design Manual

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List of Abbreviations

Term	Definition
4WD	4-Wheel Drive Vehicles
AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
ADC	Actual Dynamic Capacity
AIA	American Institute of Architects
AID	Automatic Incident Detection
APF	Automated Parking Facility
API	Application Programming Interface
APS	Automated (Car) Parking System
Ashghal	Qatar Public Works Authority (PWA)
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
AV	Autonomous Vehicles
AVSRS	Automated Vehicle Storage and Retrieval System
BAS	Building Automation Systems
BMS	Building Management Systems
BRAG	Black Red Amber Green
CAD	Computer Aided Design
CAV	Connected Autonomous Vehicles
CBD	Central Business District
CBR	California Bearing Ratio
CCTV	Closed-Circuit Television
CDD	Civil Defense Department
CEO	Civil Enforcement Officer
CIBSE	Chartered Institution of Building Services Engineers
CMF	Crash Modification Factors
CPS	Car Parking Systems (see also IPMS)
CSD	Circular Sloping Deck
DIDO	Drive-In Drive-Out

Term	Definition
DIRO	Drive-In Reverse-Out
DLP	Digital Light Processing
DMM	Design Management Manual
DMS	Dynamic Message Signs (also called VMS)
EQN	Equation
ESAL	Equivalent Standard Axle Load
EV	Electric Vehicle
FD	Flat Deck
FER	Full External Ramp
FSD	Flat and Sloping Deck
FSS	Fire Safety Standards
GORD	Gulf Organization for Research and Development
GPS	Global Positioning System
GPTS	Guidelines and Procedures for Transportation Studies
GSAS	Global Sustainability Assessment System
GUI	Graphic User Interface
HDP	High-Density Polyethylene
HER	Half External Ramp
HMI	Human Machine Interface
HOV	High Occupancy Vehicle
HVAC	Heating, Ventilation and Air Conditioning
IAN	Interim Advise Note
IBP	International Best Practices
IP	Internet Protocol
IPMS	Intelligent Parking Management Systems (see also CPS)
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
kph	Kilometers per hour
KPI	Key Performance Indicators
LAN	Local Area Network
LCD	Liquid Crystal Display
LCS	Lane Control Signs

Term	Definition
LED	Light-Emitting Diode
LPR	License Plate Recognition
LTPD	Land Transport Planning Department
m	meter(s)
MDL	Minimum Dimensions Layout
MEP	Mechanical, Electrical and Plumbing
mins	Minutes
MLCP	Multilevel Car Parking
mm	millimeter(s)
MMAA	Ministry of Municipal Affairs & Agriculture (now MME)
MME	Ministry of Municipality and Environment (previously MMAA/MMUP)
MMUP	Ministry of Municipality and Urban Planning (now MME)
MOISSD	Ministry of Interior – Security Systems Department
MOI	Ministry of Interior
MOTC	Ministry of Transport and Communications
MPS	Mechanized Parking System
MUTCD	Manual of Uniform Traffic Control Devices
NDC	Notional Dynamic Capacity
NFPA	National Fire Protection Association
NMFC	National Motor Freight Classification
NMFTA	National Motor Freight Traffic Association
NTCIP	National Transportation Communications for ITS Protocol
NTP	Network Time Protocol
N.T.S	Not To Scale
OCR	Optical Character Recognition
PC	Personal Computer
PDV	Parking Design Vehicle
PFG	Pedestrian Facility Guideline
PFPM	Parking Facility Pavement Markings
PFS	Parking Facility Signage
PFSW	Parking Facility Structural Works
PIN	Personal Identification Number

Term	Definition
PLC	Programmable Logic Controllers
PMIS	Parking Management Information System
PT	Point of Tangent
PPA	Pavements for the Parking Areas
PSA	Parking Safety Audit
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl chloride
PWA	Public Works Authority (also called Ashghal)
QCDD	Qatar Civil Defense Department
QCS	Qatar Construction Specifications
QHDM	Qatar Highway Design Manual
QITP	Qatar Integrated Transport Plan
QNBMP	Qatar National Bicycle Master Plan
QNDF	Qatar National Development Framework
QNDS	Qatar National Development Strategy
QNMP	Qatar National Master Plan
QNRSS	Qatar National Road Safety Strategy
QNV	Qatar National Vision
QPCMP	Qatar Pedestrian Crossings Master Plan
QPDM	Qatar Parking Design Manual
QPG	Qatar Pedestrian Guidelines
QPMP	Qatar Parking Master Plan
QPRG	Qatar Public Realm Guidelines
QRC	Qatar Railways Company
QSAT	Qatar Standards for Accessible Transport
QSNDS	Qatar Second National Development Strategy 2018-2022
QTCM	Qatar Traffic Control Manual
QTGPRM	Qatar Trip Generation and Parking Rates Manual
R	Radius
RFID	Radio Frequency Identification Device
RGB	Red Green Blue
ROW	Right-of-Way

Term	Definition
RSA	Road Safety Audit
RSAGP	Road Safety Audit Guidelines and Procedures
RTC	Real-time Clock
RTI	Real Time Information
m^2	Square Meter(s)
SD	Sloping Deck
SDK	Software Development Kit
secs	Seconds
SLD	Split Level Deck
SMACNA	Sheet Metal and Air Conditioning Contractors' Association
SR	Speed Ramp
SSD	Stopping Sight Distance
TCP	Transmission Control Protocol
TDM	Transportation Demand Management
TDMS	Traffic Detection and Monitoring Systems
TFT	Thin-Film Transistor
TIS	Traffic (or Transportation) Impact Study
TMPQ	Transportation Master Plan for Qatar
TNC	Transportation Network Companies
TP	Tangent Point
UAE	United Arab Emirates
ULI	Urban Land Institute
UPDA	Urban Planning Development Authority (now MME)
v/c	Volume to Capacity Ratio
VAC	Ventilation and Air-conditioning
VIP	Very Important Person
VMS	Variable Message Signs
vpd	Vehicles per day
vph	Vehicles per hour
VPN	Virtual Private Network
VVIP	Very Very Important Person
WPD	Warped Parking Deck

Section 1

Manual Overview

1: Manual Overview

1.1 About this Manual

The Qatar Parking Design Manual (QPDM) is a comprehensive parking design standard and guidance document for the State of Qatar. It replaces all prior parking design requirements contained in several documents by incorporating them appropriately in this document. All reference documents are listed in **Appendix-A**.

1.2 Purpose and Objectives

The purpose of this Manual is to provide guidance for the design of parking facilities and to ensure the uniformity of parking design in the State of Qatar. The objectives are to:

Develop a uniform parking design guide	Improve safety	Document parking standards and best practices	Provide effective parking operations

1.3 QPDM Principles

The QPDM is a key document to implement the overall vision for the parking facilities in the State of Qatar and to provide comprehensive parking design standards and guidance. The QPDM principles are in line with the vision of the Transport Master Plan for Qatar (TMPQ) and mission of the Qatar Parking Master Plan (QPMP), which are mentioned below:

TMPQ Vision: To develop an Integrated and Sustainable Transportation System that supports the economy and better quality of life while preserving national identity.

QPMP Mission: The Qatar Parking Master Plan provides a sustainable framework for efficiently developing and managing parking supply and demand that leverages technological advancements and prioritizes integrated mobility and safe accessibility.

The QPDM has been developed on three key principles, as mentioned below:

Improve Safety	Promote Multimodal Transportation (less reliance on automobiles)	Optimize Resource Sharing (leverage emerging technologies)
Design guidance in the QPDM incorporates the elements of International Best Practices emphasizing better standards to provide a safe parking environment in the local context.	The parking facilities covered under the QPDM incorporate the needs of multimodal transport users with a goal to develop an equitable and integrated transportation system.	The transportation technologies with an objective to increase the operational efficiency of the parking facilities are included in the QPDM.

1.4 Manual Updates

The QPDM will be updated periodically to incorporate the needs of the transportation system, in any given point in time. The nature of transportation as well as composition of the vehicle fleets are changing rapidly as new technologies and concepts are introduced frequently. This will have a significant impact on the nature of parking facilities designed in the future.

For example, there have been rapid advances in Intelligent Transportation Systems (ITS) and Autonomous Vehicles (AV). New inventions in Internet of the Things (IoT) and ubiquitous computing are influencing both ITS and AV technologies. It is envisaged that new technologies will be leveraged for better parking solutions. This will require an update of the QPDM in the future, to incorporate parking design for autonomous vehicles, such as reduced parking stall dimensions and related aspects like signage.

Although it is too early to develop parking design guidance for autonomous vehicles, future updates on the QPDM will assure that guidance contained within this Manual keeps pace with the changes in transportation. The revisions for respective document will be made in the following format:

Publication Date (DD MMM YYYY)	Version Number (YYYY)	Summary of Changes

1.5 Scope and Target Users

This Manual provides the design guidelines that should be followed for designing the parking facilities. The designer should use sound engineering judgment and obtain explicit approval from the Overseeing Authority.

The QPDM is intended to be used by parking designers, developers, approving agencies, planners, engineers, consultants, contractors, government officials, and other stakeholders. It is to be used as a standard for designing of parking facilities in the State of Qatar.

The QPDM is intended to be used for developing new parking facilities. This can also be used for upgrading existing facilities to standards as outlined in this document. A formal approval from the Overseeing Authority is needed prior to any modifications and/or Departure from Standard.

This manual includes parking design-related standards and guidance for, but not limited to, the following:

1. Site Planning
2. Design Criteria
3. On-Street Parking
4. Off-Street Parking
5. Access Management
6. Parking Structure Design
7. Supporting Infrastructure
8. Automated Parking Systems
9. Accessible Parking
10. Pedestrian Access
11. Bicycle Parking
12. Powered Two-Wheeler Parking
13. Bus Parking
14. Commercial Vehicle Parking
15. Signage and Pavement Markings
16. Intelligent Parking Management Systems
17. Emerging Technologies
18. Construction Elements
19. Parking Safety Audit

A few design aspects, such as construction and landscaping, are covered in other standalone manuals and, hence are only referred to briefly in the QPDM. Users of this Manual should refer to the most recent versions of these reference documents.

1.6 Integration of Existing Guidance Documents

The QPDM carefully follows national-level policy directions, the TMPQ vision, and QPMP mission. This is an important document to implement the overall future vision for the State of Qatar, as outlined in policy and framework documents. **Figure 1-1** presents the policy framework and sets out the context for QPDM.

The Qatar National Vision (QNV) 2030 is at the top of the hierarchy of policy documents. Following that is the Qatar National Master Plan (QNMP) 2030, a special representation of the QNV 2030. The Qatar National Development Framework (QNDF) 2032 establishes the spatial framework to achieve the goals outlined in the QNV 2030, while the Qatar National Development Strategy (QNDS) is an implementation strategy for the projects listed in the QNV 2030. A set of transportation-specific planning and policy documents, following the QNMP 2030, were developed, such as the Qatar National Road Safety Strategy (QNRSS) and the Transportation Master Plan for Qatar (TMPQ) 2050.

These overarching planning documents with legal standings govern the formation of all other guidance documents, such as the QPDM, Qatar Highway Design Manual (QHDM), Qatar Traffic Control Manual (QTCM), and the ITS Master Plan 2012. These documents form the basis for transportation-related design and traffic controls and are referred to appropriately in this Manual. A few other relevant guidance documents, such as Qatar Trip Generation and Parking Rates Manual (QTGPRM), Guidelines and Procedures for Transportation Studies (GPTS), and ITS Deployment Guidelines are also referred to in this Manual. The latest version of all these documents are cited in the QPDM.

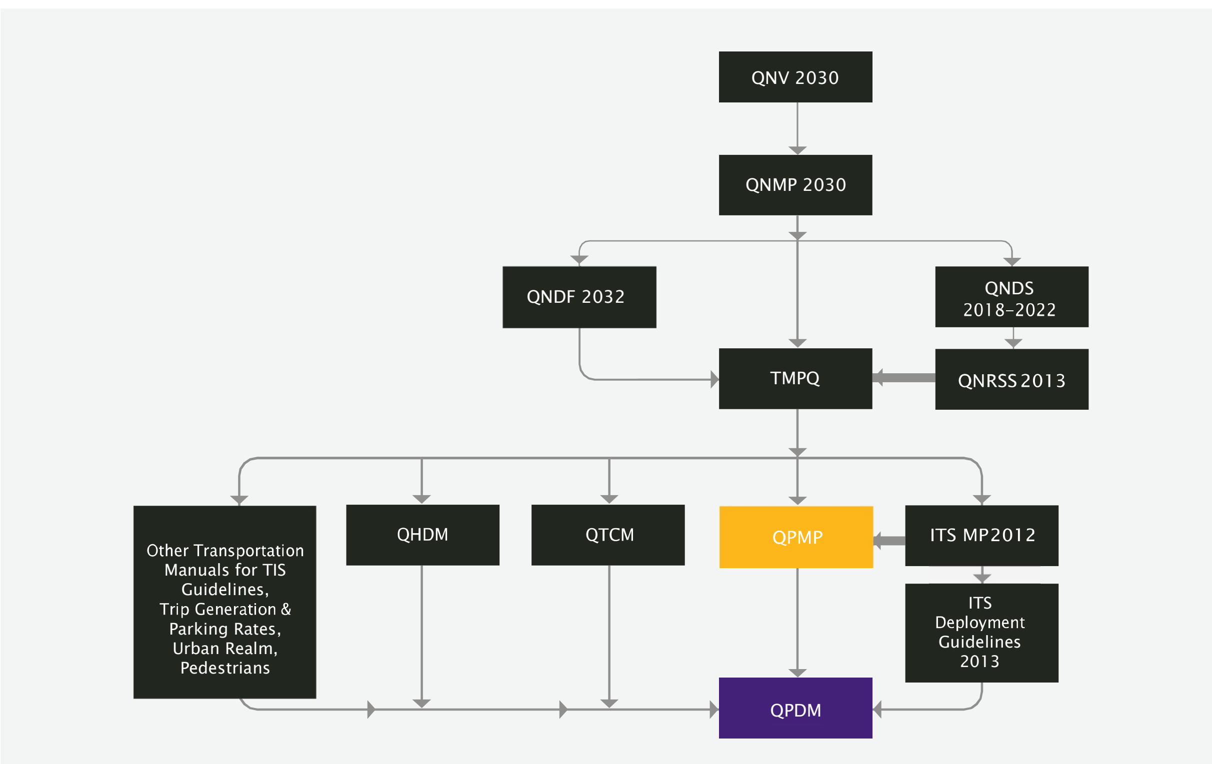


Figure 1-1 Parking Design Manual - Development Process

A comprehensive list of all reference documents used for the development of the QPDM is included below:

1.6.1 Qatar References

Relevant documents for general guidance, with reference to the State of Qatar, are listed in **Section 1.6.1.1**. As with other documents cited in the QPDM, it is important to refer to the most recent version of these documents. It is explicitly assumed that a parking designer will also have access to all relevant documents listed in **Section 1.6.1.2**, prior to designing a parking facility.

1.6.1.1 General Guidance

Qatar National Vision (QNV) 2030

QNV 2030 is the overarching vision document that sets the theme for all other documents. It is a comprehensive urban development plan for Qatar that adopts a sustainable policy for urban expansion and population distribution.

Qatar National Master Plan (QNMP) 2030

QNMP 2030 is the spatial representation of the national vision as described in the QNV 2030.

Qatar National Development Framework (QNDF) 2032

The QNDF 2032 establishes the spatial framework to achieve national, human, social, economic, and environmental goals based on the QNV 2030, and the population and economic projections by the Ministry of Development Planning and Statistics.

Qatar Second National Development Strategy (QSNDS) 2018-2022

QSNDS documents the strategy to implement projects identified in the QNV 2030. The focus of this strategy document is short-term and targeted at projects to be completed for the Qatar 2022 FIFA Football World Cup.

National Road Safety Strategy (NRSS) 2013

Despite significant infrastructure improvements, road safety is a major public concern in the State of Qatar because people have lost their lives as a result of road accidents. The NRSS was developed as part of Qatar's commitment to reduce road traffic accidents and sets the path toward the vision of "a safe road transport system, that protects all road users from death and serious injury." The NRSS guides efforts to improve road safety in the State of Qatar over the next 10 years.

Transportation Master Plan for Qatar (TMPQ 2050)

Transportation Master Plan for Qatar (TMPQ) is a Master Plan to guide the next stage of the country's transportation growth and change through 2050. It supports the future development of Qatar as a leading twenty-first century nation, setting out the multimodal transportation networks and policies to support the development of a global transportation system. TMPQ recommends an integrated set of transportation solutions for residents and visitors that will support the vitality and viability of Qatar's future economy.

Qatar National Bicycle Master Plan (QNBMP) 2008

QNBMP 2008 by the Urban Planning and Development Authority (UPDA) of the Ministry of Municipality and Environment (MME) deals with important features like bicycle needs and analyses, recommended bicycle networks, bikeway designs, and bicycle parking requirements.

Qatar Parking Master Plan (QPMP)

A comprehensive Parking Master Plan for the State of Qatar, consistent with QNV 2030 and MOTC Vision 2050, provides safe, efficient, and managed parking facilities for public and business organizations. The QPMP is a policy framework to mitigate existing deficiencies consistent with internationally accepted best practices. The QPMP sets the parameters for the QPDM.

1.6.1.2 Manuals and Guidelines

Qatar Highway Design Manual (QHDM) 2020

General roadway design standards, including on-street and off-street parking, is included in QHDM.

Qatar Traffic Control Manual (QTCM) 2020

QTCM 2020 is the guide for road signage and pavement markings. There is no specific parking-related section; signage and markings for parking appear in multiple sections.

Qatar Public Realm Guidelines (QPRG) 2014

QPRG 2014 provides guidance for urban design, including soft and hard landscaping.

TMPQ, 1.18 G, Pedestrian Facility Guideline (PFG) 2008 & Qatar Pedestrian Crossings Master Plan (QPCMP) 2018

The PFG provides guidelines to design safe and efficient traffic facilities for pedestrians. The QPCMP provides guidance for pedestrian crossings. The QPDM has additional guidance for certain aspects not covered in the PFG.

Road Safety Audit Guide

The Road Safety Audit Guide is to be used to conduct Road Safety Audits (RSA) at various stages of development and design.

Intelligent Transportation Systems (ITS) Guidance

Ashghal Guidelines for:

1. ITS Strategy
2. ITS Telecommunications Strategy V1.0, December 2014
3. Ashghal ITS Deployment Guidelines V2.2, June 2015
4. Civil and Structural Standards for ITS, January 2017
5. ITS Architecture, November 2012
6. ITS Standards and Specifications, July 2013
7. ITS Concept of Operation
8. ITS Action Plan

Public Transport-Related Guidance

Bus parking guidance is in the QHDM and QTCM. Also see Mowasalat Bus Stop Design Guide (V 0.7), 2014.

Qatar Rail Guidance

1. Station Design Plans (Gannett Fleming, UNStudio)
2. Planned Parking Strategy at Metro Stations

Freight Fleet Specifications

Freight fleet specifications from Manateq that includes specifications for various freight vehicles.

Site Plan Requirements for Proposed Development Projects (SPRPDP) 2017

This document, by MOTC-LTPD, provides information on planning requirements for site access, parking, pedestrian, bicycle, public transit, on-site circulation roadways, parking aisles, and ramps.

Qatar Trip Generation and Parking Rates Manual (QTGPRM) 2020

QTGPRM, by MOTC-LTPD, incudes trip generation and parking rates for different land uses, as well as trip reduction factors where applicable.

Guidelines and Procedures for Transportation Studies (GPTS) 2020

Guidance for conducting transportation studies is covered in the Guidelines and Procedures for Transportation Studies, First Edition, 2020, issued by MOTC-LTPD.

Qatar Construction Specifications (QCS) 2014

QCS 2014 contains the building codes for construction of heating, ventilation, and air conditioning (HVAC) and mechanical, electrical, and plumbing (MEC) aspects of the design.

Pavement

See QHDM Volume 2, Part 12 (Pavement Design), Section 10.7. Also see Ashghal IAN 16 Rev 3.

Drainage

See QHDM Volume 2, Part 10, Section 4.4.2.

Civil Defense, Fire, and Emergency

1. Qatar Civil Defense Fire Safety Handbook, 2015
2. Ministry of Interior, Civil Defense Department (QCDD) Fire Safety Standards 4.1 (FSS 4.1), 2008
3. IAN 020 (Road Tunnel Fire and Safety Systems), September 2013

1.6.2 International References

American Association of State Highway Transportation Officials (AASHTO) Green Book, 7th Edition, 2018

A Policy on the Geometric Design of Highways and Streets, also known as "the Green Book," by AASHTO, for general design guidance, is not covered in QHDM.

Americans with Disability Act (ADA) 2019

Guidance for accessible parking requirements, location, dimensions, signage, pavement markings and circulation are included in ADA 2019.

Civil Defense, Fire, and Emergency

Following guidelines are referred to regarding fire safety

1. NFPA 10, 2018: Standard for Portable Fire Extinguishers
2. NFPA 13, 2019: Standard for the Installation of Sprinkler Systems
3. NFPA 14, 2019: Standard for the Installation of Standpipe and Hose Systems.
4. NFPA 16, 2019: Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems
5. NFPA 30, 2021: Flammable and Combustible Liquids Code

6. NFPA 37, 2021: Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
7. NFPA 72, 2019: National Fire Alarm and Signaling Code
8. NFPA 88A, 2019: Standard for Parking Structures
9. NFPA 90A, 2021: Standard for the Installation of Air-Conditioning and Ventilating Systems
10. NFPA 92, 2021: Standard for Smoke Control Systems
11. NFPA 101, 2021: Life Safety Code
12. NFPA 170, 2021: Standard for Fire Safety and Emergency Symbols
13. NFPA 2001, 2018: Standard on Clean Agent Fire Extinguishing Systems
14. NFPA 5000, 2021: Building Construction and Safety Code

Federal Highway Administration (FHWA) Manual of Uniform Traffic Control Devices (MUTCD) 2009 (with updates through 2019)

This manual contains general guidance for traffic control devices that is not covered in the QTCM

1.7 Adoption of Provisions in Other Documents

The QPDM refers to the provisions made in the most up-to-date versions of the relevant documents available at the time, mentioned in **Section 1.6.1**. This manual has either adopted or improved upon provisions made in those documents. It is advised to refer to the most recent versions of those documents whenever applicable. In the event a user identifies an inconsistency between QPDM and a more recent version of a listed reference, it is recommended that the inconsistency be clearly defined and sent to the Overseeing Authority for clarification. Decision of Overseeing Authority will be considered final.

1.8 Manual Development Process

As explained in **Section 1.6**, QPDM is an important document to implement the overall future vision for the State of Qatar, as outlined in the policy and framework documents, including QPMP. Therefore, a robust and structured approach, including the following key stages, were followed for the manual development process:

1. Existing Documents Review (EDR) to establish current practices related to parking in the State of Qatar, as well as, vision and planning

2. Review of International Best Practices (IBP) for international benchmarking standards and innovations

3. Assessment, Inventory and Surveys of Existing Conditions to establish existing operations, design, administration, driving characteristics, fleet characteristics and dimensions, implementation, and parking enforcement in the State of Qatar

4. Gap Study to establish deficiencies in current practices, in relation to best practices, as well as, identifying opportunities for improvements, that are customized to local needs

5. Development of design guidance, based on all of the above

Section 2

Parking Design Guidance

2: Parking Design Guidance

This section provides guidance on how to use the Qatar Parking Design Manual (QPDM) as a part of the parking design process. Assessment of the parking demand, supply, and design in the State of Qatar is included in the current building permit process, which largely involves the Ministry of Municipality and Environment (MME), Ministry of Transport and Communications (MOTC), and Ashghal, and in some cases, the municipalities. The number of parking spaces required must be estimated based on the applicable standard planning documents and the Qatar Parking Master Plan (QPMP) recommendations on parking requirements for new developments.

2.1 Need for Parking Design

Parking is an important aspect of modern transportation. Parking design addresses aspects of on-street parking and off-street parking, multilevel parking, access, and the incorporation of technology. Proper parking design ensures efficiency and safety of parking facilities. These design principles and standards will be used by multiple agencies, designers, and developers for developing new parking facilities and improving the existing ones as part of the site design, road design, public area improvements, temporary parking provisions, and other growth and development activities.

Parking design is an important element for new developments and should be a part of the building permit process. Once the parking design is approved, as part of the Traffic Impact Study (TIS), the land use type or intensity and parking requirement or parking layout should not be modified. Any changes to either the land use or the approved parking design requires that the developer initiate another building permit process with the Overseeing Authority.

2.2 Parking Design Process

The parking design component of the current Guidelines and Procedures for Transportation Studies (GPTS) is included in this Manual. The type and size of a new development, as well as the intensity of land use(s) must be predetermined. Parking supply requirements and design dimensions are a function of these factors. The developer must incorporate optimum structural arrangements (for parking structures) and adequate construction considerations for designing an off-street parking structure to optimize the number of parking spaces, efficiency of circulation for all users, and safety in design. Reference may be made to **Section 8** and **Section 20** for more details about structural efficiency and construction requirements, respectively. Use of necessary signs and pavement markings related to parking and ancillary needs, as well as wayfinding and Intelligent Transportation Systems (ITS) applications, are mandatory.

All new developments should provide the required parking spaces, including, accessible and visitors' parking, area for parking maneuvering and space to hold expected queues within the development, without encroaching on to the public Right-of-Way (ROW).

The process for determining on-street parking spaces is addressed in the Qatar Parking Master Plan (QPMP). On-street parking should only be designed and provided according to conditions listed in **Section 5.1** of this Manual.

The major steps for off-street parking design for new developments as well as redevelopment projects are stated below:

1. Determine the land use type and intensity using zoning regulations.

2. Estimate parking requirements (alternatively, parking demand):

    - If a representative land use type is available in the applicable standard planning documents, use the parking rates from it or from the QPMP recommendations.

    - Conduct proxy surveys of representative sites and incorporate the QPMP recommendations, if a representative land use type is not available in the QTGPRM.

    - Based on land use, determine the number of parking spaces for other modes and uses, such as bicycles, powered two-wheelers, loading or unloading spaces, and pick-up or drop-off spaces. Also determine garbage pick-up locations that may have to be located adjacent to the parking.

    - Determine the number of accessible parking spaces required, based on the recommendations made in the QPDM **Section 11**.

3. Obtain approval of parking requirements from the Overseeing Authority.

4. Establish the Parking Design Vehicle (PDV) as detailed in **Section 4.1**. The PDV will impact the design of each parking elements, such as parking stalls[1], aisles, circulation area parameters, and dimensions of all entrance and ramps.

5. Determine the basic design envelope for the design vehicles from **Section 4.1.2** to be applied to parking elements, such as parking stalls, circulation areas, entrance, ramps, etc.

6. Determine clearances and tolerances based on the dimensions and swept paths for the respective PDV.

7. Based on all of the above, determine the parking layout, entry and exit points, and circulation.

8. Verify that off-street parking is contained within the development and includes space for all parking maneuvers and expected queues. If the required number of parking space cannot be accommodated on site, the Overseeing Authority recommends that the consultant consider additional Transportation Demand Management (TDM) strategies, following the QPMP recommendations, and seek further approval. Alternatively, consider modifying the land use type and/or intensity until the required number of parking space can be accommodated on site.

9. Develop the parking layout design, including parking for bicycles and powered two-wheelers, as well as pedestrian access and accessible parking location and access. It is advised to coordinate with the Overseeing Authority to discuss potential site-related issues, compliance to standards, potential hazards, and identify the way-forward.

[1] *Parking "stall" or parking "space" refers to parking area for one vehicle. Parking "row" means a series of contiguous parking spaces.*

10. Number each parking space; coordinate with the Overseeing Authority to develop an appropriate numbering system.

11. Provide required ITS elements, such as detection for each parking space and communication of parking availability with the master database.

12. Provide signage and pavement markings.

13. Perform safety audit and address recommendations.

14. Develop mitigation strategies and/or modify site layout and circulation, if required.

15. Obtain approval of the parking design from the Overseeing Authority.

NOTE:
These steps are for passenger car parking, including Sport Utility Vehicle (SUV), small vans, and small pick-up trucks. Parking for vehicles other than passenger cars must follow the same steps but with different design vehicles and associated clearances and swept paths.

The design process is illustrated in the flow chart in **Figure 2-1**.

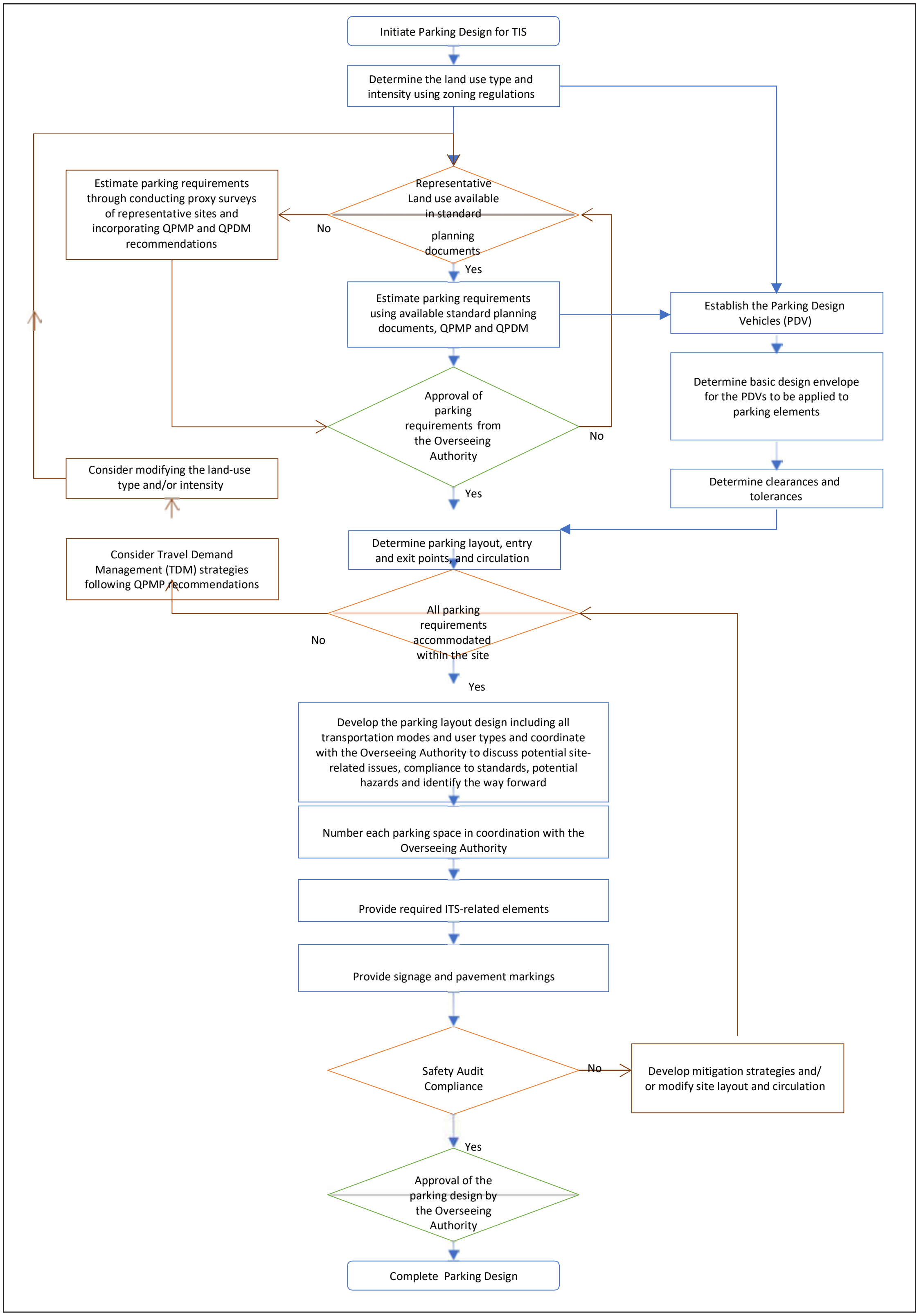


Figure 2-1 Parking Design Process

A design checklist is presented in **Appendix B**. The design checklist includes separate checklists for on-street, off-street, multilevel parking facilities, and it captures all the design elements involved. The summary sheet allows the identification of the parking elements included in a particular facility. This will help the designer and the Overseeing Authority to get an overall glimpse of the elements in the parking facility.

Section 3

Site Planning

3: Site Planning

This section provides an overview of the parking-related consideration for site planning, covering a few common land uses. For guidelines and procedures related to site planning, one may refer to the latest version of Site Planning Requirements for Proposed Development Projects and Guidelines and Procedures for Transportation Studies (GPTS), issued by the Ministry of Transport and Communications (MOTC).

3.1 Long-Term and Short-Term Parking

Office and residential uses typically have longer parking duration and characterized by single occupant vehicles requiring opening of the driver's door. Short-term parking is distinguished by multiple occupants per car and the opening of the driver and passenger doors, typically associated with land uses such as shopping malls. See **Section 4.3** for a description of parking categories.

The consideration of parking category is an important aspect of parking planning and design, because it governs arrival and departure profiles, conflict with pedestrians and safety requirements, zoning within a car parking area and access to vertical transportation, security and parking management needs, lighting and ventilation requirements, etc. Designers are expected to consider parking category appropriately.

3.2 Parking Requirements

The planning guidance emphasizes the need to reduce reliance on automobiles and encourage alternative modes of transportation, such as public transport, cycling, and walking. This will decrease the need to provide more parking spaces in the future.

The parking designer should seek guidance and written approval from the Overseeing Authority for parking space requirements as part of the building permit and Traffic Impact Study (TIS) process. The number of parking spaces required depends on the land use type and intensity. Mixed-use developments may require fewer total parking spaces than the sum of required parking spaces for each land use within the development, if assigned individually. To enable shared parking across various land uses and locations, the following elements are required:

1. Number of parking spaces required for mixed-use should be obtained from MME Zoning Regulations (MSDP or relevant) with the approval of the Overseeing Authority.
2. All parking spaces should be the same dimensions for all land uses.
3. All parking spaces should be clearly marked and numbered, so they can be detected and enforced.
4. Parking space sensors are recommended for all off-street public parking spaces to enable connection to the central database for real-time availability information and efficient parking space management.
5. Appropriate parking design standards should be followed as stated in this Manual.

3.3 Valet and Automated Parking

Valet parking is offered either as a convenience to the users or to mitigate issues related to parking space limitations. Off-street valet parking typically allows for horizontal stacking of parking rows; in self-parking, all spaces must be accessible from a drive aisle. This may allow double (tandem) and triple stacked rows of parking with drive aisle access, only from one side, requiring cars to be moved by the valet staff to gain access to all the parked vehicles. Provision of valet parking should be approved by the Overseeing Authority and strictly controlled.

Automated parking is only provided as an off-street parking facility and allows for both horizontal and vertical stacking. This requires less space than a self-parking facility. An automated parking facility is recommended for the land uses with low turnover and longer parking duration, such as offices and residential uses. Feasibility of automated parking must be carried out by the parking developers/owners and approved by the Overseeing Authority.

3.4 Reserved Parking and Visitor Parking

Reserved parking is an inefficient way of parking management and does not align with the goals of shared parking. It is recommended to consider this item carefully during the parking planning and design stage and seek Overseeing Authority's approval if reserved parking is chosen. Reserved parking may have a significant impact on parking space availability in a mixed-use development where parking is shared among multiple land uses. It is recommended to exclude any reduction factor for a mixed-use development in case adequate provisions are not made for reserved or visitors' parking.

3.5 Parking Features for Specific Land Uses

The specific land uses, like residential, schools, universities, mosques, shopping malls, industrial areas, hospitals, drive-through automated teller machines (ATM), restaurants, and petrol stations have different requirements in terms of functionality, parking layout, accessibility, and driveway arrangements. The basic considerations for each type of specific land uses focused on parking and related requirements are presented in this section.

3.5.1 Schools

Parking within school zones and around schools follows the same design principles as for high pedestrian traffic areas, with provisions for access for mobility impaired. Parking near schools is a special case because it involves vulnerable school-aged children with unpredictable behavior and increased potential for conflicts between pedestrians, cars, and buses. For all new and existing school parking facility redevelopment, the following aspects must be considered as part of the planning process.

Required Parking Spaces

Required parking spaces, for both cars and buses, will be based on the number of students and staff transported by cars and buses. It is recommended that all required parking spaces be provided off-street on school premises to prevent traffic spillover to main roads. Bus parking spaces should be provided on school premises to park school buses and other school transportation vehicles.

On-street curb areas must be strictly controlled and regulated in the school zone, especially during school hours. Use of on-street parking to meet school parking requirements should only be considered under special circumstances, such as access to smaller plot size, access constraints, existing school improvement, etc. Special circumstances must be approved by the Overseeing Authority.

Drop-off and Pick-up Locations and Circulation

Schools must provide dedicated areas for parents and guardians to safely drop off and pick up students. Storage for 95th-percentile queues must be accommodated within school boundaries near the main gates. Similarly, separate bus drop-off and pick-up zones are to be provided with preferably dedicated access arrangements. School bus drop-off/pick-up zones and school bus parking areas and all associated driveways must consider the following:

- Separation of traffic associated with parent/visitor, staff parking areas, service/delivery vehicles, and official school transportation vehicles
- Accessibility of emergency vehicles required at all times
- Accommodation of the required throat length as explained in **Section 7**

Pedestrian Circulation

Canopies should be provided along the school bus drop-off/pick-up zone to protect school bus riders from sun and rain. The height of the canopy must accommodate the tallest anticipated school bus. Canopy support posts adjacent to the drop-off/pick-up zone should be set back at least 1 m from the curb. The location of canopy posts and other frame structures must not restrict the operation of school bus or wheelchair elevators.

As noted in the Qatar Highway Design Manual (QHDM), due to heavy pedestrian activity and the presence of children with unpredictable behavior, pedestrian paths in school zones should be appropriately sized. Fencing along pedestrian paths should enforce formal and safe pedestrian crossings.

Sidewalk access to/from school and pedestrian paths within the school site should be designed so that students do not need to cross school bus traffic or parking areas to access school buildings and facilities. Students must not be permitted to walk between or behind school buses during drop-off or pick-up operations or while school buses are parked.

Access Management and Circulation

All on-site school bus traffic flow must be one-way, with the service door side (right side) of the school bus always on the school side of the drop-off/pick-up zone. School buses must never back up (drive in reverse). School bus parking must be planned carefully to minimize and manage conflicts between cars, buses, and pedestrians. Ideally, buses, cars, and pedestrians should have separate access paths.

A circulation pattern that allows a continuous flow of vehicles as they enter and exit the school area is the preferred design because it avoids the need for any difficult maneuvers and conflicts between vehicles and pedestrians/bicyclists.

Appropriate signs, pavement markings, traffic calming provisions, and traffic channelization should be provided following the outcomes of the Traffic Impact Studies (TIS).

A typical school zone layout is presented in **Figure 3-1**. This layout is for illustrative purposes only and not to be considered as a standard or guidance to influence the design.

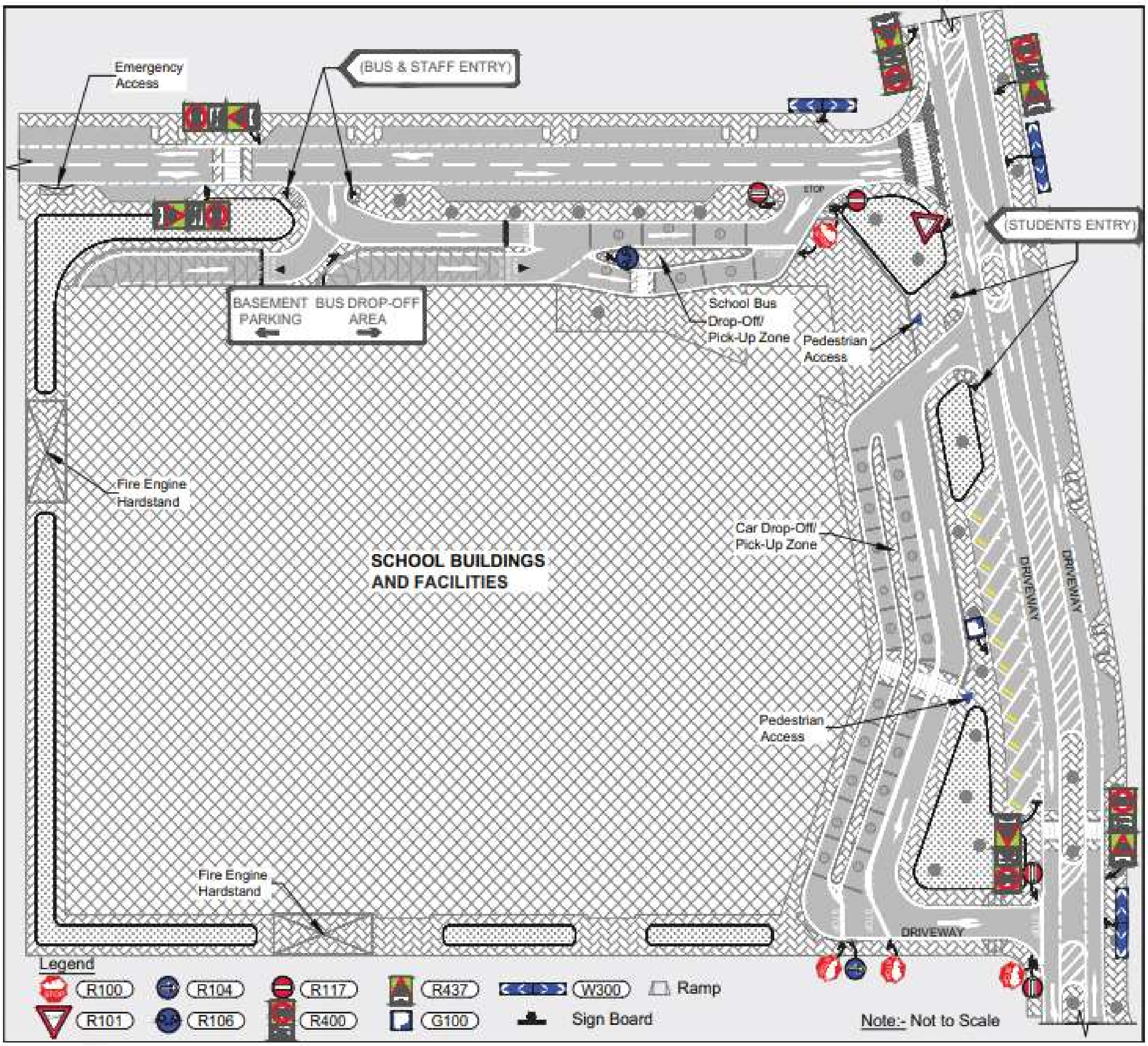


Figure 3-1 Typical School Zone Layout

3.5.2 Mosques

Site planning and parking requirements for new mosques or redeveloping areas around existing mosques depend on the primary function of the mosque. The three broad categories of the mosques and specific requirements are as follows:

1. **Daily Mosque:** Daily prayers are offered in these mosques and they serve a local catchment area, usually within walking distance. Dedicated parking areas with designated spaces are needed for this type of mosque. The dedicated spaces should not be used by any other abutting land use functions. The pedestrian pathways leading to the mosque should be free from any obstruction.

2. **Friday Mosque:** This type of mosque is used for daily and Friday prayers, and it typically serves multiple catchment areas. A complete parking plan for the Friday Mosque is required to address the high peak demand. If a mosque site does not have enough parking spaces within the plot boundary, a parking adequacy assessment should be conducted. This assessment may include public car parking spaces available within walking distance. Passenger drop-off and pick-up facilities should be provided for the disabled and those with mobility limitations.

3. **Eid mosque:** These are the large mosques that perform daily, Friday, and Eid prayers, and they typically serve larger catchment areas. These are generally located adjacent to large open spaces to accommodate a large number of people, as well as parking. It is important to physically separate the open space from the designated parking areas. The parking areas are expected to be used by occasional mosque goers, as well as younger users. Therefore, special provisions for pedestrian safety, as well as speed calming measures should be provided in the parking area.

Appropriate plot size selection and orientation of access depend on the type of mosque. A daily mosque may have access from one side only, while an Eid mosque is best served with access on all four sides. All worshipers are to be accommodated within the mosque, even at peak prayer times. The site should be able to accommodate peak flow within the plot boundary without spillover to the public street. Special parking layout, like a tandem arrangement parking (where two rows of vehicles parked back-to-back), could be considered, but the layout must be dealt with as a design exception, as detailed in **Section 22.3**.

A typical daily mosque layout is presented in **Figure 3-2**. This layout is for illustrative purposes only and not to be considered as a standard or guidance to influence the design.

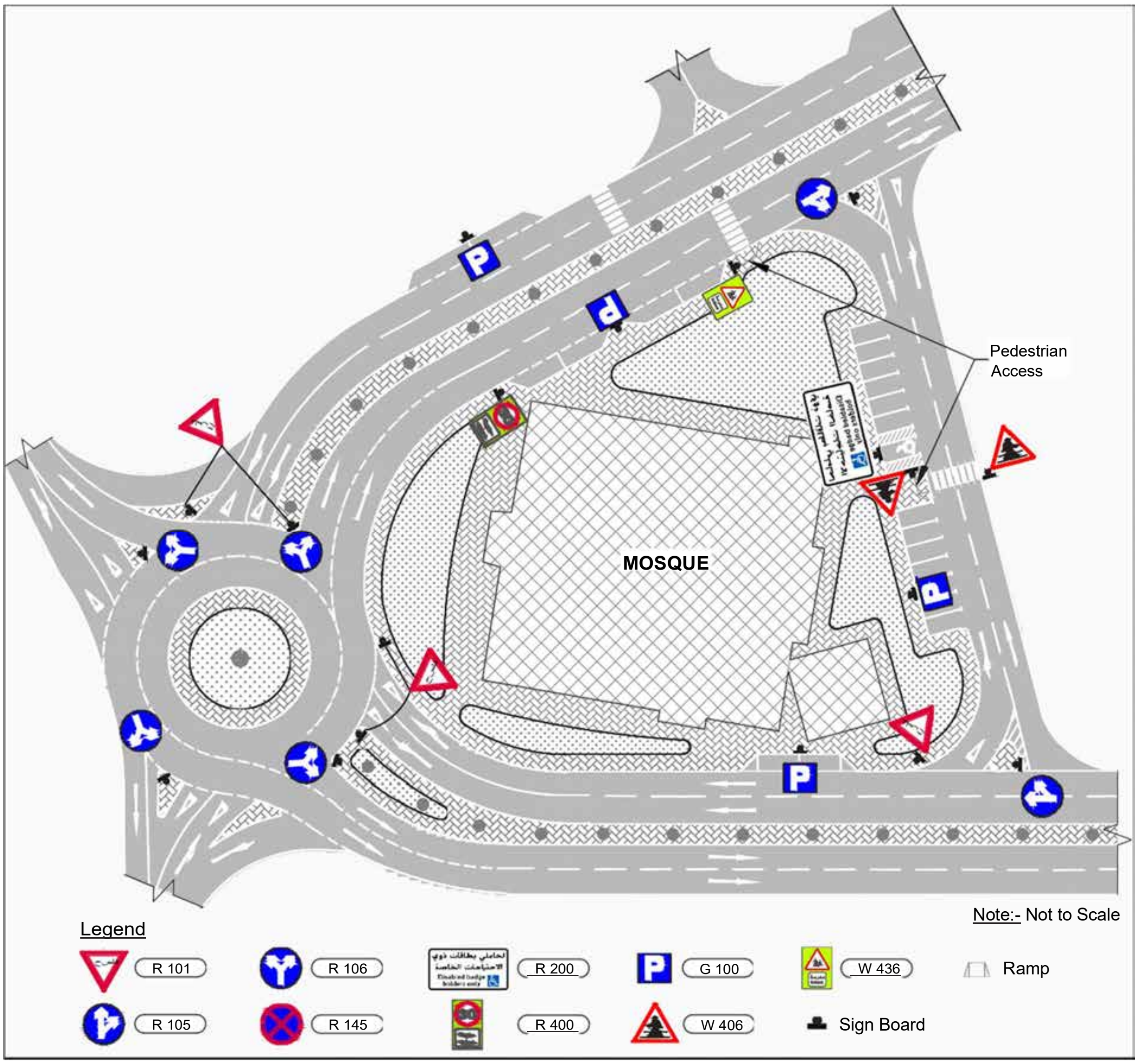


Figure 3-2 Typical Mosque Layout

3.5.3 Shopping Malls and Retail Facilities

Shopping malls and retail facilities typically have high turnover and short-term or mid-term (less than 4 hours) parking. It is recommended that wider parking spaces be considered to allow for frequent door opening of both driver and passenger sides, as well as to allow adequate space to load purchased goods into the vehicle.

Parking Facility Layout

Parking areas for commercial centers should be considered as an integral part of the development design, and commercial center parking areas should include the following elements:

- Safe and convenient vehicle paths that minimize vehicular and pedestrian conflict
- Parking aisles oriented perpendicularly in relation to the building, allowing pedestrians to walk parallel to vehicular movement and not cross rows of vehicle traffic to reach an entrance
- Interconnected network of pedestrian walkways
- Internal vehicular circulation routes with a hierarchy of drive aisles and cross routes for safe and convenient vehicular circulation
- Traffic calming measures to combat speeding and other unsafe behaviors of drivers for long straight aisles of more than 50 m
- Prioritize customer parking by providing long-term vehicle parking for employees at remote location
- Consistent parking layout with respect to dimensions, angles for parking, and aisle width
- Parking canopies to provide shade for vehicles

Employee Parking

A large number of staff working within the shopping malls are likely to use public transport or be dropped off. Some employees and shop owners usually drive and require parking provisions for longer duration. Accordingly, the designated parking for this parking category can be located farther away from customer parking. The employee bus drop-off should be located near to the facility entrance.

Other Modes

In the design of shopping malls and retail facilities, parking layout for all modes of transportation should be considered, including pedestrian and public transportation. The developers should work with the transportation authorities and the Overseeing Authority to coordinate the routing, location, and design of convenient bus stops and metro stations within a convenient walking distance and with efficient pedestrian routes.

The provision of adequate, safe, and convenient two-wheeler parking facilities is an important component of a comprehensive program to encourage the use of bicycles and powered two-wheelers as a viable transportation option. Parking for bicycles and powered two-wheelers should be located close to building entrances, adequately signed, easily identifiable, and separate from pedestrian circulation areas. Covered areas that provide shade are preferred.

Pedestrians

It is the principal objective of a shopping center development to have a quality pedestrian environment that is safe, convenient, and efficient. Pedestrian facility design should consider basic safety concerns, such as adequate pathway widths, sight distance, signage, separation from vehicular traffic, and appropriate design and placement of crosswalks.

Pedestrian facilities should provide an attractive, quality environment with integrated landscaping, shading, lighting, surface treatment, and other amenities. Pedestrian walkways should be functional and direct without unnecessary meandering. The walkways should be well delineated from vehicle driveways.

Crosswalks should be located at intersections of streets and/or drive aisles. If a crosswalk needs to be provided in the middle of a drive aisle, it should have adequate visibility and warning signs for pedestrians and vehicles.

Loading Docks

Loading docks should have separate access point(s) and located away from the main development or retail access points with adequate queuing, turning, and staging spaces. These access points may be used for service vehicles such as those required for maintenance and garbage collection. Loading docks should be screened from public view.

Pick-up and Drop-off

Shopping and retail centers have substantial volumes of passenger pick-up and drop-off. As part of planning, dedicated passenger pick-up and drop-off zones should be provided, preferably closer to an entrance. The space for passenger pick-up and drop-off must be estimated according to the TIS and contained completely within the premises. No spillover on an adjacent public street is permitted, even during peak hours.

Taxi Ranks

Dedicated taxi ranks must be considered based on the size of the development. Adequate queuing area based on a TIS must be provided. Circulation for taxis entering and exiting the premises must be well planned. Taxi ranks must be fully contained on the premises and must not spill onto the public Right-of-Way (ROW).

A typical parking layout for a shopping (retail) facility is presented in **Figure 3-3**. This layout is for illustrative purposes only and not to be considered as a standard or guidance to influence the design.

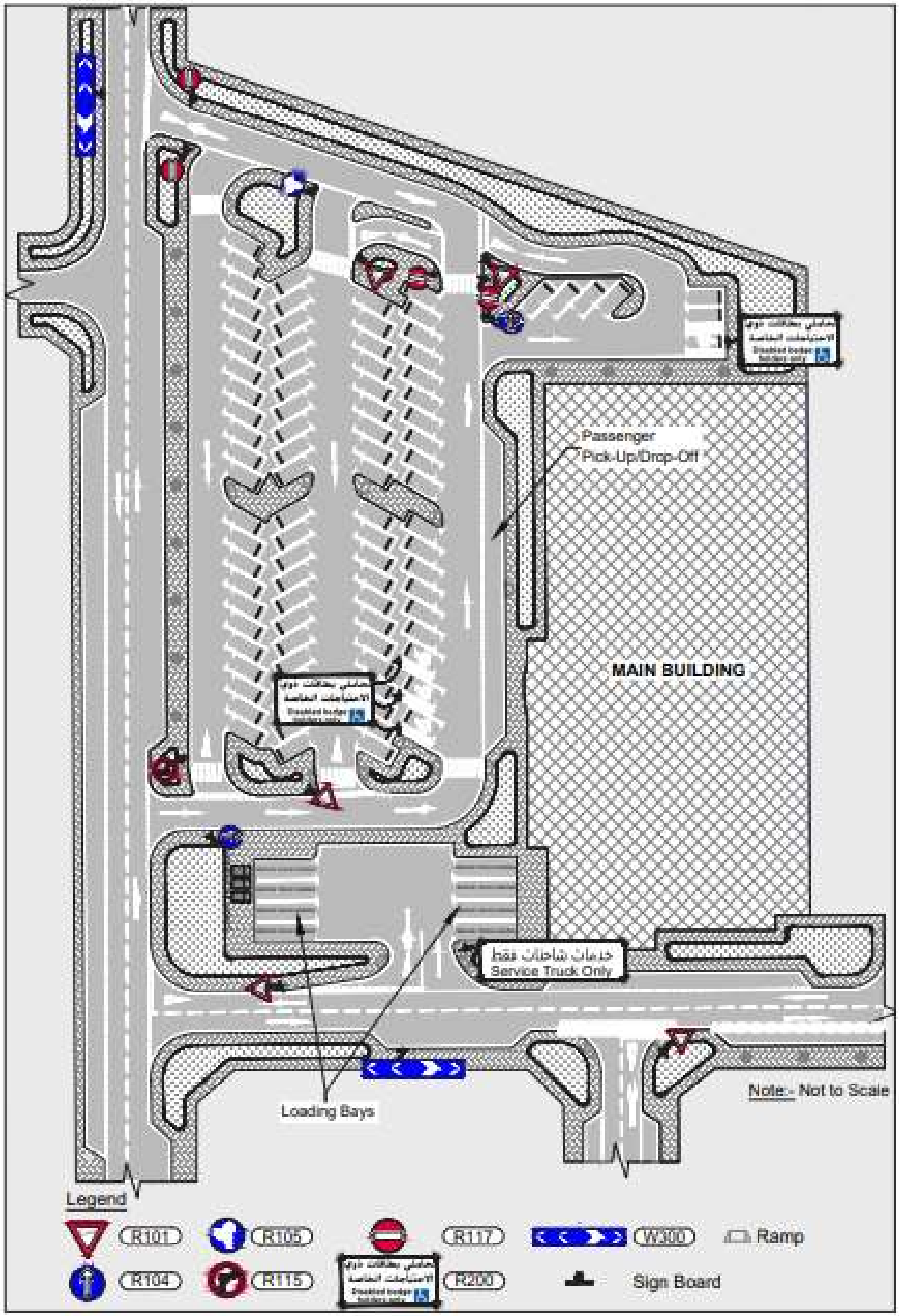


Figure 3-3 Typical Shopping (Retail) Facility Layout

3.5.4 Industrial Areas

Industrial areas typically are characterized by a high frequency of commercial vehicles (**Section 16**) designed to transport goods.

On-street parking inclusive of loading/unloading is not permitted for commercial vehicles and buses. QHDM remains applicable for on-street parking design for non-commercial vehicles in the industrial areas also.

Parking design layout considerations for off-street parking in industrial areas include truck composition, turnaround areas for vehicles' denied access, vehicle breakdown, loading bay locations, and for trucks' backing up. Clearances should allow for safe door openings away from the parked vehicles on the adjacent stalls. Separate pedestrian routes should be planned within the parking lot.

To separate different types of users, visitor and/or staff parking can be provided in front of industrial buildings. Pedestrian access to perimeter buildings can be close to public transport stops to allow easier access by other modes.

A typical industrial facility parking layout is presented in **Figure 3-4.** This layout is for illustrative purposes only and not to be considered as a standard or guidance to influence the design.

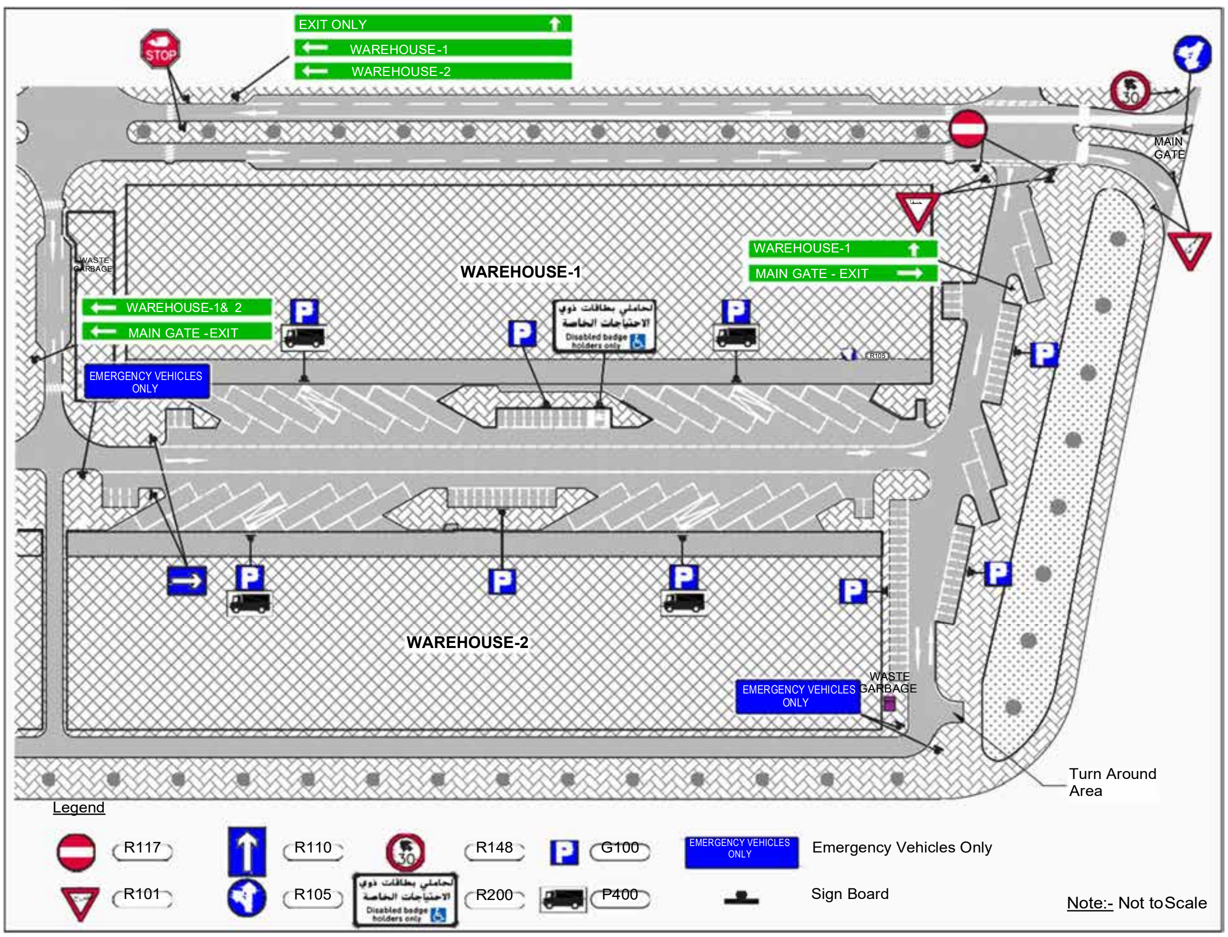


Figure 3-4 Typical Industrial Facility Layout

3.5.5 Hospitals

A hospital is a highly functional building, and transportation requirements vary according to the corresponding functions. Multiple functions create complexity in site planning and parking management. Supporting functions like emergency operation, clinical waste management, garbage collection, medical equipment movement, medicine supply distribution, chemical handling, and enforcement also need separate provisions. Delineating parking zones can effectively address the multiple service and supporting functions. Using parking zones involve allocating a specific area for each function. The zones can be connected to building functions with efficient pedestrian links. Hospitals, generally, have additional disabled access requirements and enhanced safety for pedestrians. Pedestrian paths should be appropriately sized. Separate areas for staff and patient parking need to be designated and clearly marked.

Hospitals serve many groups of users and vehicles, with each group having a different transportation profile and different parking needs. Hospitals also serve a large number of users requiring accessible parking spaces close to building entrances. The Americans with Disabilities Act (ADA) requires that 10% of all parking spaces at hospitals be accessible, an amount greater than the requirement for other facilities. Increased accessible van parking spaces is also a specific requirement. These spaces feature additional width to allow safe wheelchair unloading from the side of the vehicle. The number of parking spaces required for different transportation profiles and accommodating them in the development must be a part of site planning and the required TIS. The designer must get approval for parking space requirements from the Overseeing Authority.

Hospital traffic circulation, both on site and adjacent to a hospital requires planning to meet the unique requirements of all users and separate them where appropriate. For example, emergency traffic should have unimpeded access at all times without mixing with other nonemergency traffic. Allowing access to large trucks through the same areas served by emergency vehicles can pose a safety hazard. To address these hazards, loading bays and emergency vehicles are usually located at opposite sides of the hospital and include turnaround areas. Another example is the visitor parking and long-term parking located farther from entrances than the parking for patients.

Patient/passenger drop-off areas should be near entrances. Less-urgent drop-offs, such as for out-patients with no mobility challenges, can be situated near transit stops. Paid valet parking should be separately located away from patient/passenger drop-off areas. Wherever possible, medical staff should have their own parking areas, which are always available and not combined with patient or visitor parking. It is extremely important to use slip-resistant surfaces for vehicles and pedestrians.

All signs and pavement markings should be clearly legible. Use of speed humps and other means should be considered to ensure slow speeds within the hospital parking facilities. It is important to provide bollards to protect vulnerable buildings and pedestrian spaces from potentially distracted and impaired drivers.

A typical hospital facility parking layout is presented in **Figure 3-5.** This layout is for illustrative purposes only and not to be considered as a standard or guidance to influence the design.

Figure 3-5 Typical Hospital Facility Layout

3.5.6 Petrol Stations

A petrol station is a functional facility with very specific design requirements. This facility deals with highly flammable materials, exposure to weather extremes, pedestrian movements, and several associated facilities like mosque, retail, car servicing and cleaning. Safety and security should guide circulation design and parking design. The following should be considered while designing a petrol station:

- Number of pumps, pump layout, dedicated service lanes, and queuing areas to avoid spillover into access roads
- Dedicated access and parking provisions for retail area
- Location of Automated Teller Machine (ATM) in the primary retail building rather than freestanding or wall-mounted to an exterior wall
- Dedicated car wash area with independent circulation to avoid conflict with the fueling operation
- Dedicated drive-through areas along with the queuing spaces for fueling spot and retail, if necessary
- Orientation and relationship of structures to the street and linkages to pedestrian facilities
- Shared access with adjoining commercial uses, where feasible, to minimize curb cuts and pedestrian and vehicular conflicts
- Minimize cross traffic conflicts within parking areas
- Service areas, storage areas, and refuse enclosures out of public view through screening and orientation on the site
- Minimize solar heat, reflectivity, and glare through building orientation and use of architectural shading devices and covered walkways
- Adequate signs, markings, and site lighting
- Adequate design provisions for large truck fueling

A typical petrol station layout with some retail facilities is presented in **Figure 3-6**. This layout is for illustrative purposes only and not to be considered as a standard or guidance to influence the design.

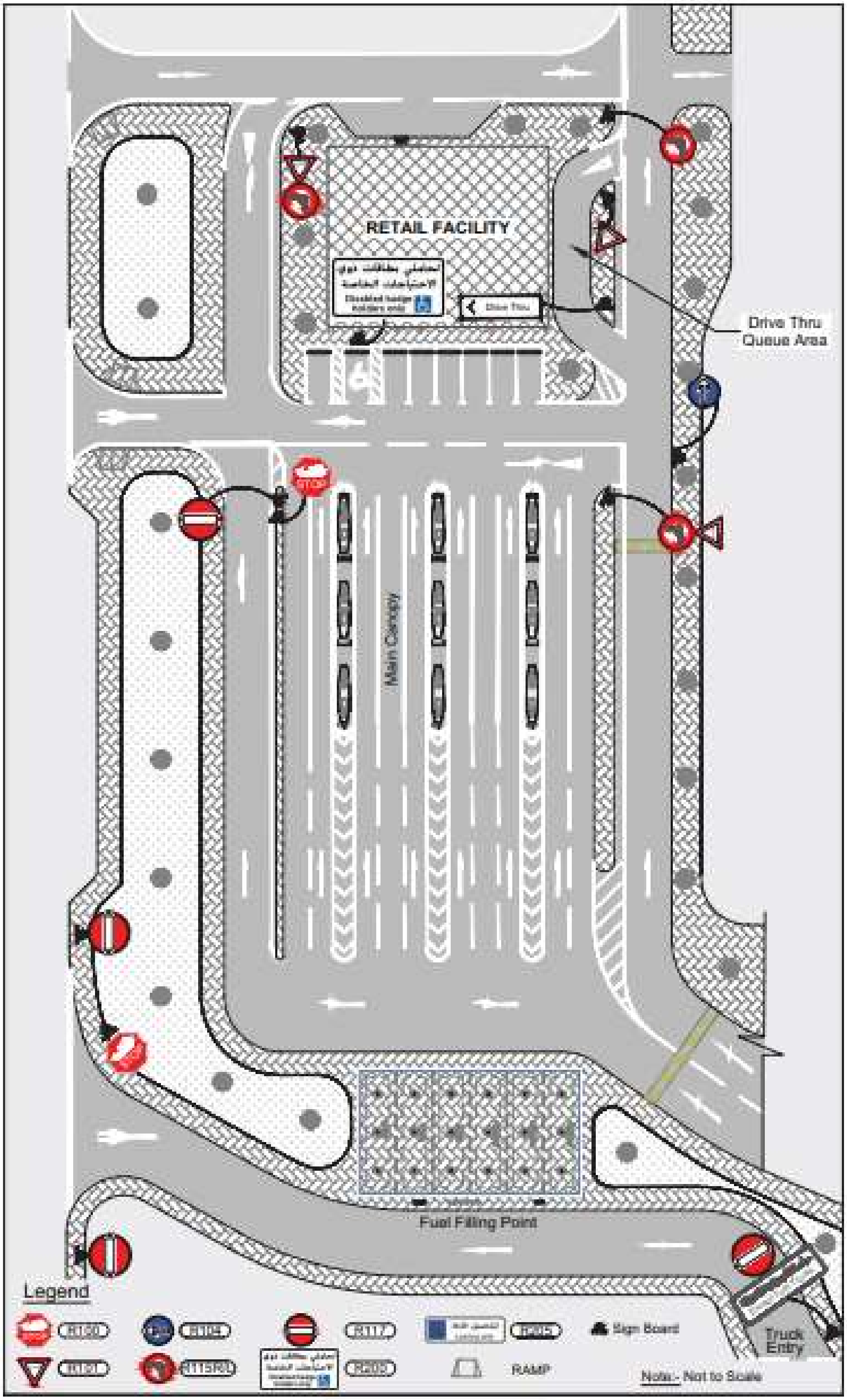


Figure 3-6 Typical Petrol Station with Retail Facilities Layout

3.5.7 Universities

A university generally accommodates several colleges and other ancillary buildings, like the library, administration, hostels, etc. It is used mostly by students and staff. Given the prevalence of inexperienced drivers on university campuses, road safety should be a significant focus. The following key factors are required when designing parking for universities:

- Major off-street parking must be located at peripheral locations. Each building must accommodate a small parking facility for the disabled, short-term visitors, service vehicles, and emergency operations.
- Gender-specific parking lots must be considered.
- Adequate drop-off zones must be provided to accommodate students who are dropped off/picked up on campus.
- Parking stall dimensions, aisles, and circulation elements are generally the same as for other parking facilities. Parking for powered two-wheelers and bicycles must be provided at appropriate locations.
- Site plans for universities should encourage alternative transportation modes to reduce internal traffic and enhance road safety.
- Building layouts and setbacks must be designed with convenient public transport connections and must have convenient walking distances, as well as be conducive to biking on campus.
- Walkways and bikeways must be shaded.

3.5.8 Multifamily Residential

Multifamily residential parking must consider parking for both residents and visitors. The number of parking spaces for residents and visitors should be provided according to standards and as approved by the Overseeing Authority. Adequate parking spaces for the disabled, bicycles, and powered two-wheelers must be considered. Space for moving in or out, loading, and unloading, and drop-offs must be earmarked. The parking spaces must be properly numbered. The circulation path must be defined to avoid interference with pedestrians as much as possible. At pedestrian interaction locations, adequate warning signage and traffic calming devices must be provided. Landscaping must be provided according to standards. Signs and markings as required, must be provided.

A typical multifamily residential parking layout is presented in **Figure 3-7**. This layout is for illustrative purposes only and not to be considered as a standard or guidance to influence the design.

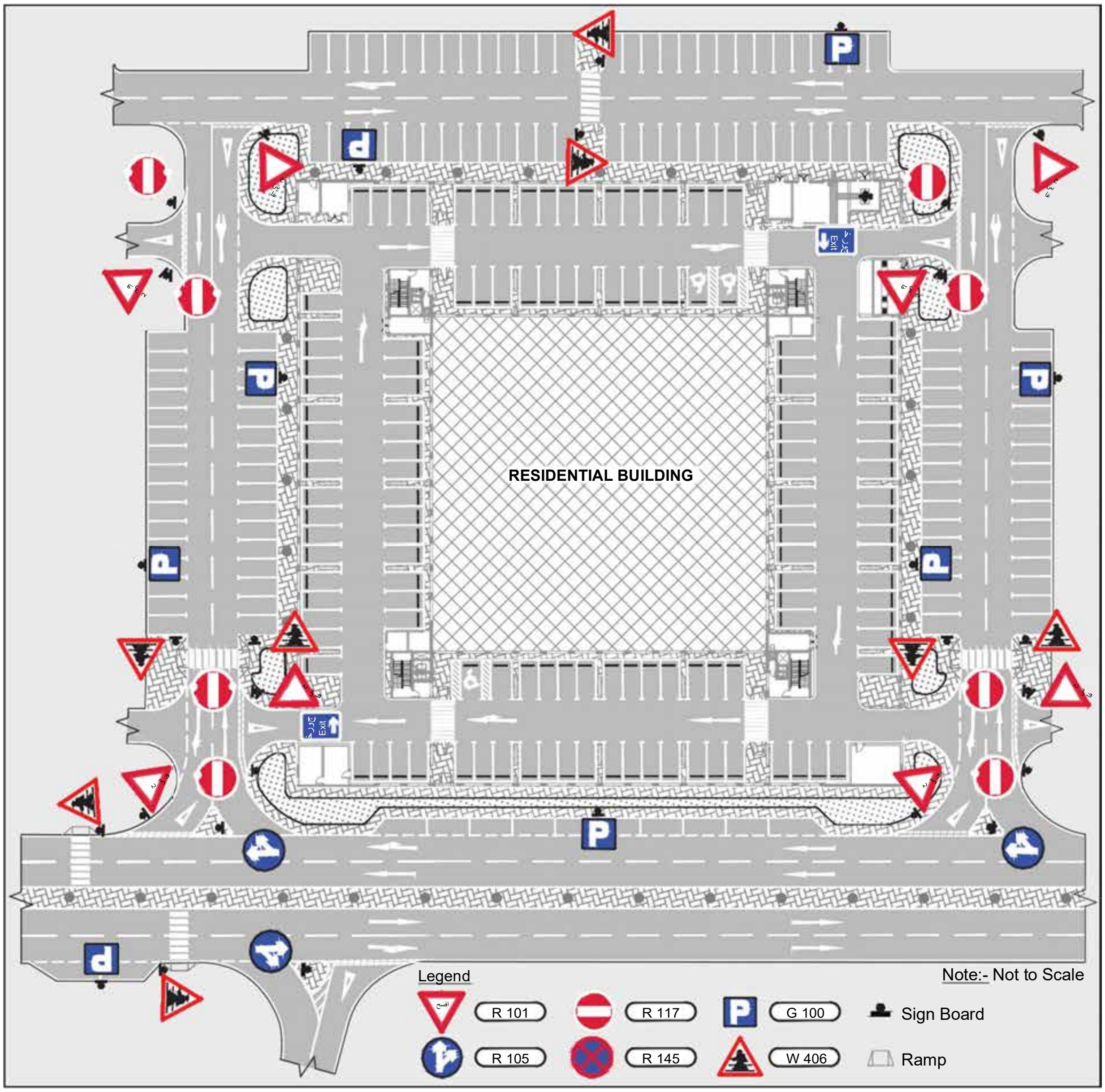


Figure 3-7 Typical Residential Layout

3.5.9 Offices

Office buildings typically have parking garages. If the office facility is occupied by multiple business organizations, parking for each organization must be allocated appropriately. Adequate parking for visitors and the disabled must be provided. Peak hours for office parking occurs in the mornings and evenings with congestion occurring in the parking lots at those times. Between the peak hours, cars stay for a long duration. It is recommended that peak traffic volumes be considered when planning and designing the accesses and internal circulation for office parking.

The pedestrian paths should be planned safely by limiting pedestrian crossings of circulation roadways. Office parking areas should be well lit with adequate safety and security. Parking areas should be provided with all necessary signage and markings.

A typical office parking layout is presented in **Figure 3-8**. This layout is for illustrative purposes only and not to be considered as a standard or guidance to influence the design.

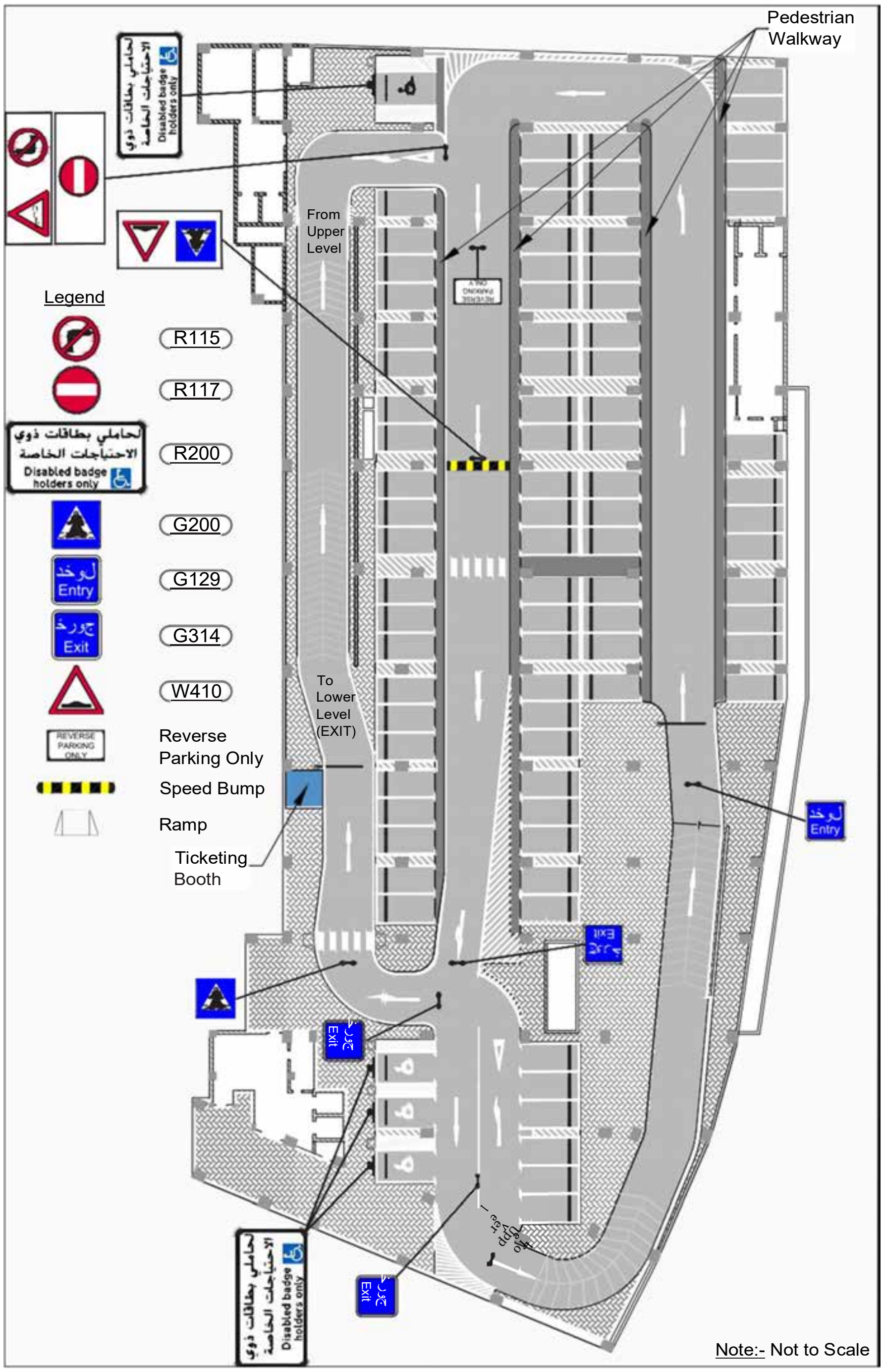


Figure 3-8 Typical Office Parking Layout

3.6 Multilevel Car Parking

Multilevel Car Parking (MLCP) facilities are generally planned to provide parking spaces for the general public. These are normally planed at Central Business Districts (CBD) and close to major event centers, such as stadiums, convention centers, airports, and multimodal transportation hubs, to address high parking demand. The structural design should be efficiently planned to avoid loss of parking spaces due to building columns and to avoid dead ends where vehicles will need to turnaround. The entry/exit ramps and the circulation ways should be planned to avoid any conflicts. MLCPs should be provided with adequate safety and security, as well as adequate signage and markings to allow the user to access the facility, maneuver with ease to park, exit the vehicle and safely move toward elevator/stair or exit and enter the facility to retrieve the vehicle. Lighting within the MLCP must ensure no dark spots.

A typical layout of an MLCP with a ground and one additional level above is shown in **Figure 3-9**. This layout is for illustrative purposes only and not to be considered as a standard or guidance to influence the design.

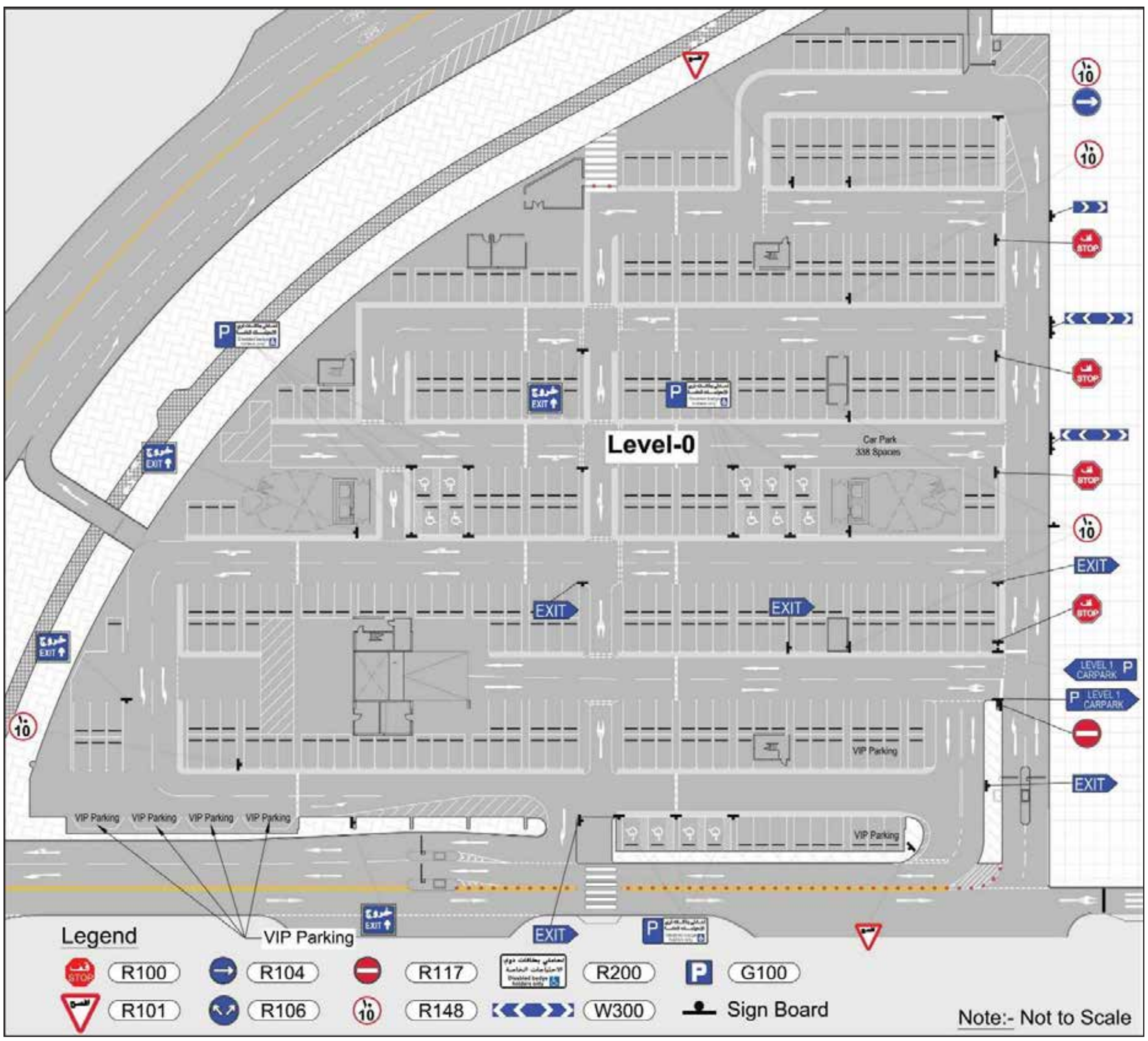


Figure 3-9 Typical Multilevel Car Parking Facility Layout

3.7 Drive-Through Facilities

The most important aspect in the design layout of a drive-through facility is the provision of adequate vehicular stacking or queuing space to avoid waiting vehicles from blocking drive aisles and/or spillover to public roads.

As part of the TIS, drive-through lanes for restaurants, ATMs, and other uses should be integrated with the overall site layout to provide safe, efficient, integrated vehicular and pedestrian circulation. Entry and exit should be placed to ensure smooth traffic movement without creating any conflicts.

Visual impact of drive-through facilities should be minimized by locating or screening them from the public ROW as well as from other users. The facility must provide adequate space for regular parking, including that for the disabled. Pedestrian paths, landscaping, lighting, safety, and security features, as required, must be provided within the facility.

A typical drive-through layout for an ATM is presented in **Figure 3-10**. This layout is for illustrative purposes only and not to be considered as a standard or guidance to influence the design.

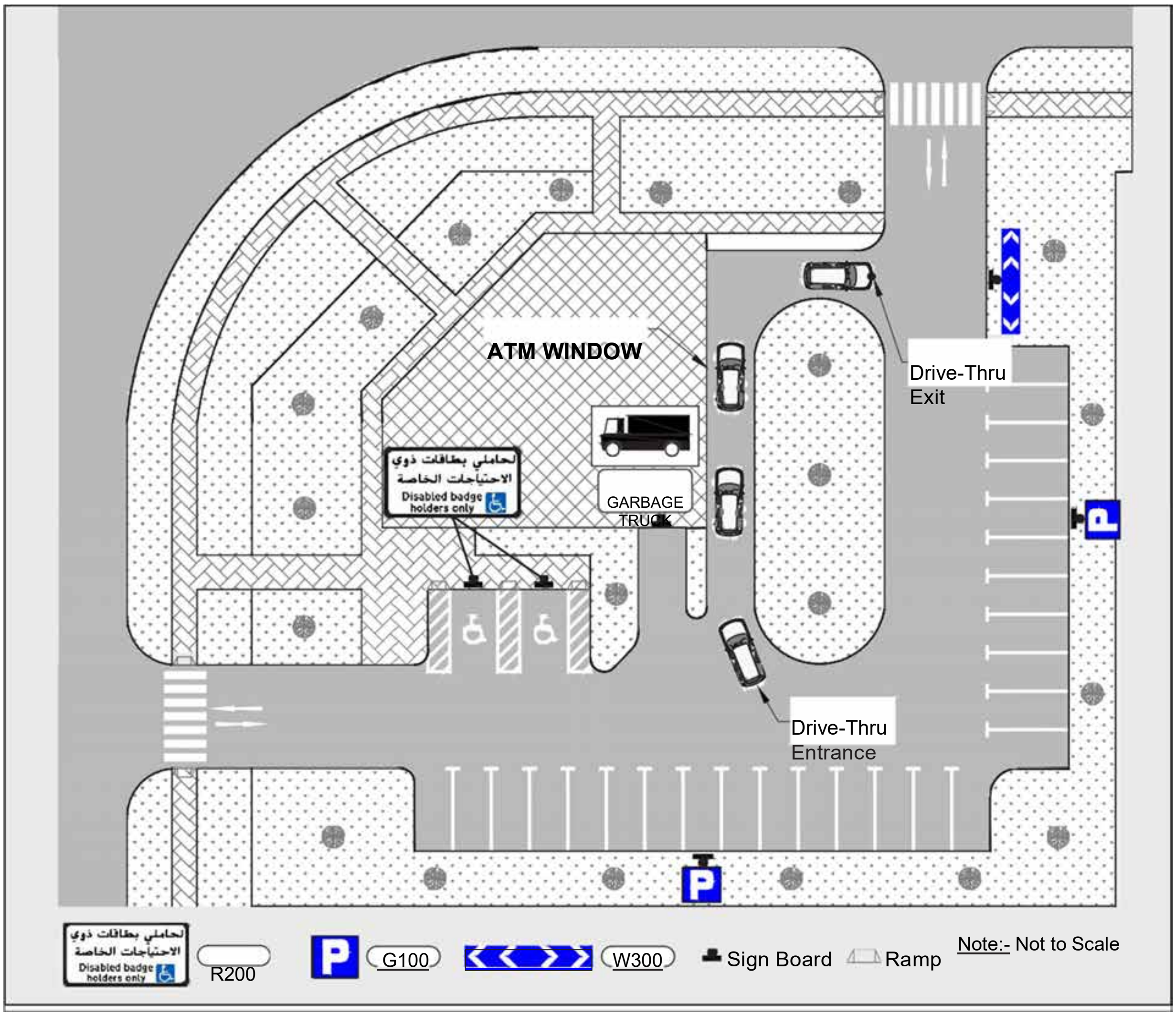


Figure 3-10 Typical Drive-Through ATM Layout

A typical drive-through layout for a restaurant is presented in **Figure 3-11**. This layout is for illustrative purposes only and not to be considered as a standard or guidance to influence the design.

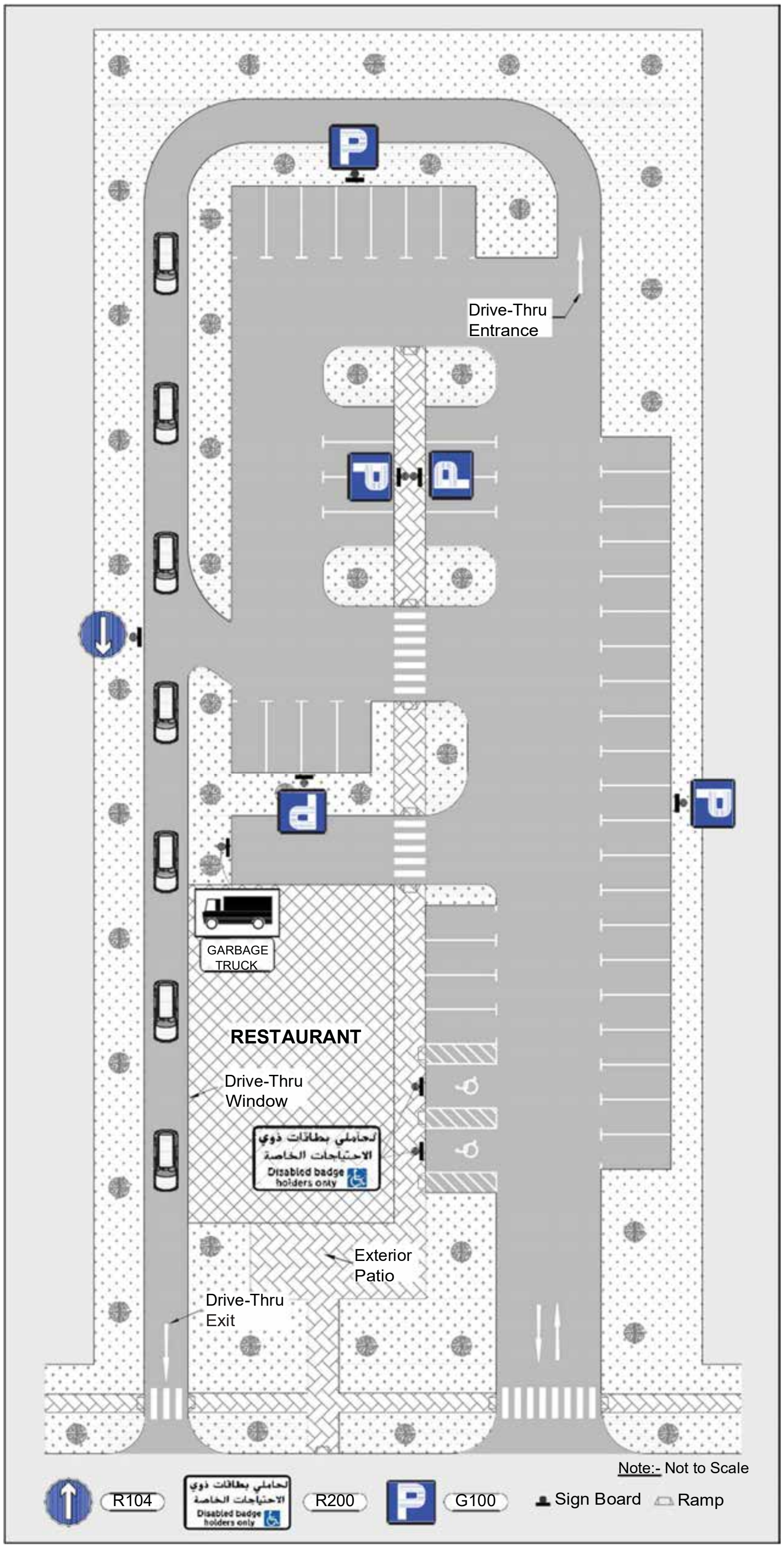


Figure 3-11 Typical Restaurant Drive-Through Layout

3.8 Special-Use Parking

3.8.1 Preferential Parking

To provide enhanced user experience, some parking facilities have special-use parking spaces reserved for specific users. Preferential parking includes Very Very Important Person (VVIP)/ Very Important Person (VIP) parking, elderly parking, family parking, and parking for women. All types of preferential parking should be identified with appropriate signage and marking. Refer to **Section 17** for signs and markings for different preferential parking uses.

VVIP and VIP Parking

VVIP and VIP parking spaces are typically used at facilities like convention centers and stadiums that host large events with large crowds. VVIP/VIP parking spaces are required to ensure easy access and exit for distinguished guests and the elite. The purpose of these parking spaces are priority and safety. The following points must be considered with respect to VIP/VVIP parking spaces:

- Dedicated entry/exit
- Close to entrances
- Away from general parking
- Appropriate wayfinding, signage, and markings
- Validation system with adequate safety and security

Elderly Parking

Exclusive elderly parking spaces are reserved for elderly people. Elderly parking spaces should be provided near the entrance to elevators for ease of access. Appropriate wayfinding, signage, and markings which are clearly and easily visible, must be provided. The access from the parking space to an elevator or building entrance should be well lit and paved with a nonslip surface, which is even and has no conflict with vehicular traffic.

Figure 3-12 shows a good example of parking spaces for the elderly in Souq Waqif.

Figure 3-12 Elderly Parking

Parking for Families, Women, and Expectant Mothers

At locations like shopping malls, exhibition centers, and movie theaters, parking for a few selected users may be provided as a convenience. Dedicated parking spaces for families with children, women, and expectant mothers fall in this category. These special-use parking stalls may not be enforceable, but experience in other countries has shown good compliance. Some countries have introduced women's parking for extra security. These parking spaces should be in well-lit areas, close to buildings, and security booths, and monitored by camera surveillance. **Figure 3-13** provides an example of "Women Only" parking for reference.

SOURCE: scoopempire.com[1]
Figure 3-13 Women's Parking

3.8.2 Carpools

Carpools are used by regular commuters to offices and universities. Successful carpool programs are well organized and include an active ride matching program. The carpool program may be part of an areawide program, or it may be specific to a site. Incentives are an important component of a carpool program. Common incentives for carpool participants include gift cards or parking discounts, preferential parking permits and emergency guaranteed ride home services. In terms of parking planning and design, carpools can be considered in congested areas with very limited parking availability. This should be approved by the Overseeing Authority on a case-by-case-basis, after ensuring appropriate control and enforcement to avoid any misuse.

1 https://scoopempire.com/abu-dhabi-pink-female-mall-parkinglot/

Section 4

Design Concepts

4: Design Concepts

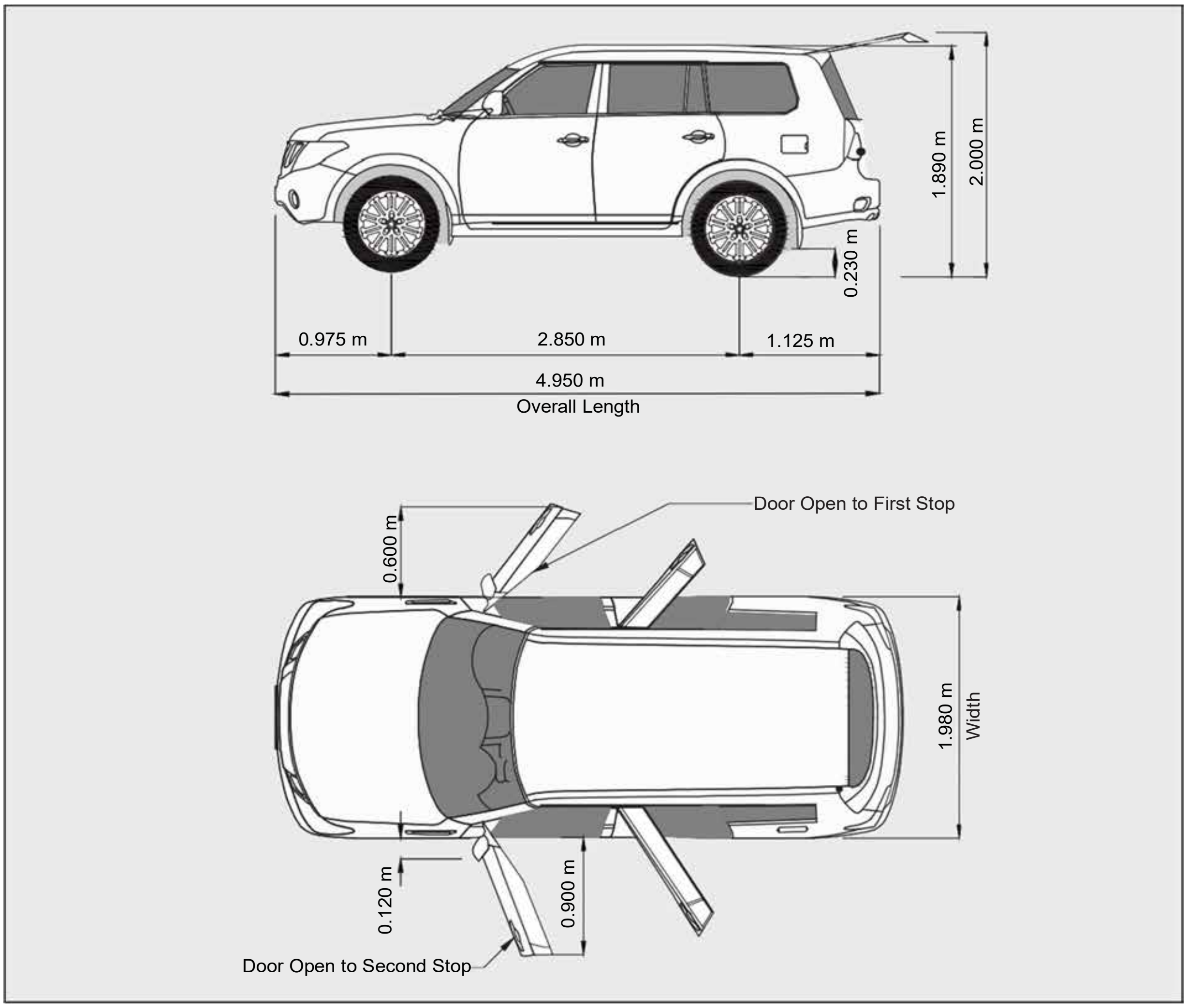
This section presents common parking design elements, including the Parking Design Vehicle (PDV), parking stall dimensions, and safety and surveillance features. Design elements, such as the PDV, have changed over time, leading to changes in parking design characteristics, such as parking stall dimensions. Changes in technology have altered parking facility access and payment methods. These types of changes will continue and require timely updates in the Qatar Parking Design Manual (QPDM).

Simplicity and consistency are the guiding principles of any parking facility design. The design elements must be applied consistently so users know what to expect. In the context of parking, this means clear guidance (design, markings, signage, Intelligent Transportation System [ITS]) to minimize illegibility and unnecessary travel, such as driving around to find a parking space or long queues internally or at the entry/exit points.

4.1 Parking Design Vehicle

The choice of the PDV is the most critical step in parking facility design. The adoption of geometric parking design guidelines is largely driven by the selection of the PDV, which is generally different from the design vehicle used for roadway design. Typically, the PDV is selected based on either a statistical assessment of the 85th-percentile vehicle by size or a qualitative assessment designation of a suitable size of vehicle that is expected to use the parking facility. The 85th-percentile vehicle means that 85% of vehicles that can be expected to park in the facility are smaller than the 85th-percentile vehicle. Vehicle ownership data provided by the Statutory Authority was reviewed to determine the PDV.

Given the prevalence of Toyota Land Cruiser ownership in the State of Qatar, it has been identified as the PDV, and has been used as the basis for designing dimensions of parking stalls, as well as all circulation elements of parking facilities, including entrances, turning radii, and ramps. Dimensions for the selected PDV for the State of Qatar are shown in **Figure 4-1**.



Dimensions from local car dealers and actual measurements recorded on May 2019

Figure 4-1 Parking Design Vehicle (PDV) for Qatar

Many Toyota Land Cruisers have models with spare wheels attached to them or have trims (add-ons) like a towing hitch and/or bumper protectors. These have been considered in the adopted clearances for design of parking stalls. Parking facility design requires the identification of the appropriate PDV to determine design criteria, such as parking stall dimensions, circulation roadway width, and ramp widths. See relevant sections for the design vehicles for trucks (**Section 16**), buses (**Section 15**), powered two-wheelers (**Section 14**), and (**Section 4.2**).

4.1.1 Parking Envelopes and Stalls

Once the PDV is established, the next step is to determine dimensions of the basic parking design envelope, which determines the parking stall dimensions. The parking design envelope is the dimensions along length, width, and height of the vehicle, inclusive of the respective clearances. Safety of all users is the overarching design principle. Adequate clearances for various design parameters, such as parking stall dimensions and circulation roadway widths, should be considered to accommodate the appropriate PDV. For parking facilities designed for more than 500 vehicles, access for towing vehicles must be considered, when calculating entrance and exit dimensions and clearances.

The basic design envelope consists of the PDV dimensions plus minimum clearances on all three axes. The minimum clearances should be 0.8 m for length (0.5 m minimum plus 0.3 m to account for vehicles parking short and allowing for space for spare wheels or towing hitches), 0.5 m for width, and 0.5 m for height. The result is a basic design envelope of 5.8 m in length, 2.5 m in width, and 2.5 m in height, rounded up to the nearest 0.1 m, as shown in **Table 4-1** and **Figure 4-2**.

Table 4-1 Parking Design Vehicle Design Envelope

Specification	PDV Dimensions (m)	Minimum Clearance (m)	Envelope Dimensions (m)
Overall Length	4.95	0.80	**5.8**
Overall Width	1.98	0.50	**2.5**
Overall Height	2.00	0.50	**2.5**

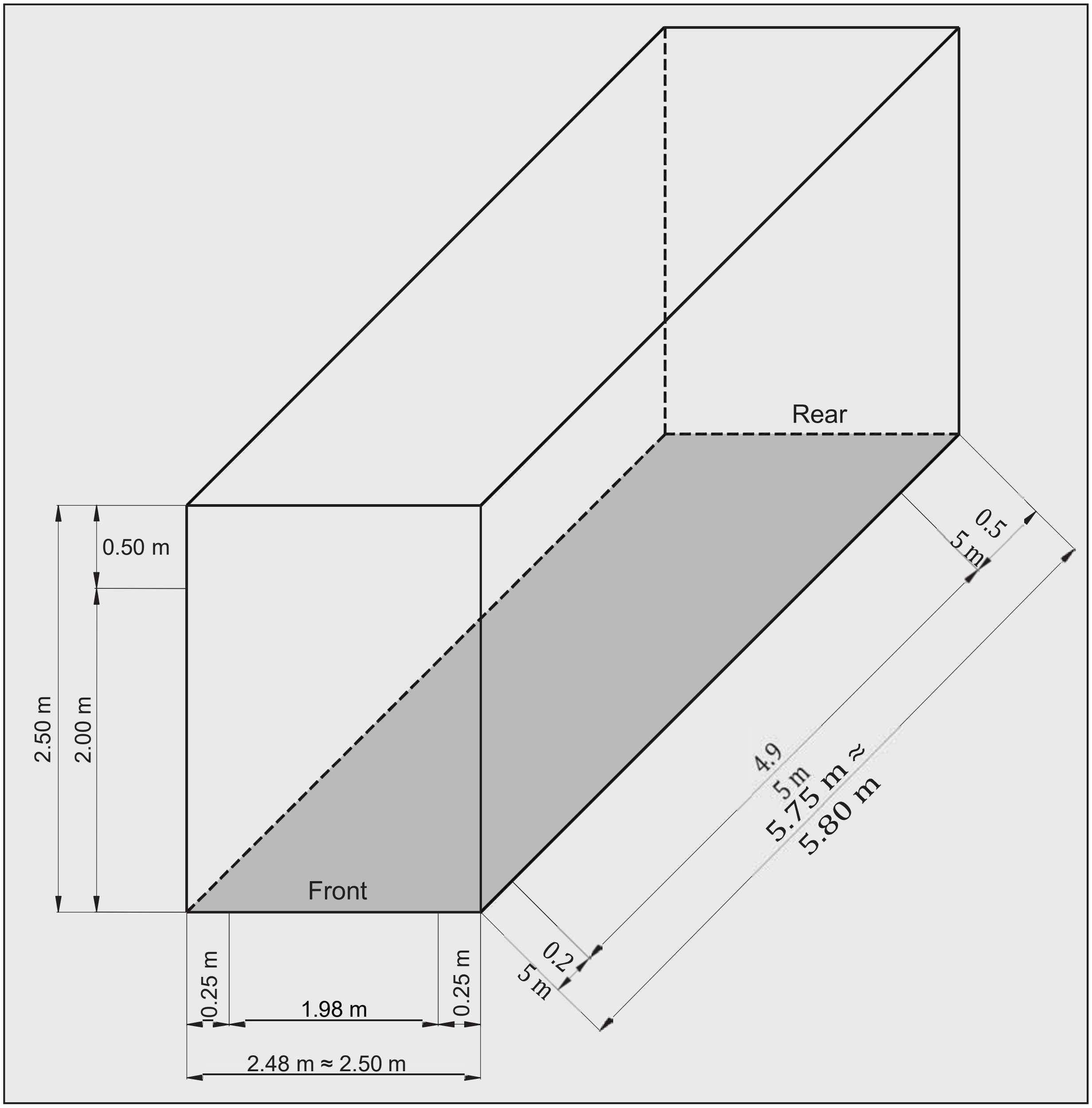


Figure 4-2 Basic Parking Design Envelope for Parking Design Vehicle

4.1.2 Minimum Dimension

All parking stalls, whether parallel or angled, should accommodate the basic design envelope, as shown in **Figure 4-2**. However, to establish the minimum parking stall width, assuming all stalls are occupied with the PDV, the following equation should be used:

Minimum Stall Width = PDV Width (without side mirrors) + 1st Door Opening + Clearance

Table 4-2 provides minimum parking stall widths associated with various comfort levels. Comfort level describes the ease of entering and exiting the vehicle, considering the extent of door opening possible and clearance available. Angled parking stalls allow for some shared space between stalls for door openings, which is 0.6 m for the PDV. The angled parking stall must be a minimum of 2.8 m wide (conditions apply, refer to **Section 6.1**). The minimum width typically applies to long-term low-turnover parking, such as residential and office parking. The minimum width is recommended for land uses that may largely involve opening of the driver-side door only, such as office parking.

Wider, angled parking spaces may be considered where there is routinely short-term and/or high-turnover parking, such as for retail land uses, including shopping malls, which may also need more space for loading/unloading merchandise. **Section 4.3** may be referred for parking categories.

The three comfort levels are:

- A – High level of comfort associated with short-term parking – 0.4 m clearance for door open to 1st stop (half open) and 0.1 m clearance for door open to 2nd stop (fully open)
- B – Medium level of comfort associated with medium-term parking – 0.3 m clearance for door open to 1st stop (half open) and no clearance for door open to 2nd stop (fully open)
- C – Minimum comfort (minimum requirement) associated with long-term parking – 0.2 m clearance for door open to 1st stop (half open) and door open to 2nd stop (fully open) not possible

Additional information on parking categories and associated comfort levels is presented in **Table 4-3**.

Table 4-2 Angled Parking Minimum Stall Widths

PDV Width[1] (m)	Comfort Level	Clearance for Door Stop Position[2] (m)	Minimum Width[3] (m)
1.98	A – High	0.4	3.0
	B – Medium	0.3	2.9
	C - Minimum	0.2	2.8

NOTE:

1 Not including side mirrors
2 Door open to first stop (half open) = 0.6 m wide
3 Rounded to nearest 0.1 m

In special circumstances, as explained in **Section 6.1**, a minimum width of 2.65 m can be adopted for parking stalls with prior approval of the Overseeing Authority.

4.1.3 Minimum Headroom

Normally there should be a minimum clear headroom of 2.5 m for the PDV, which also allows passage of the highest saloon cars and 4-wheel drive (4WD) vehicles in the State of Qatar. It also allows the tallest user to walk unhindered inside the facility. Since the highest 4WD vehicle identified in the Qatar fleet is approximately 2.0 m high, the headroom allows for the presence of a roof rack.

It is not unusual for design to accommodate recreational vehicles (motor homes, campers, etc.), or 4WD vehicles with a roof luggage rack, in the design of multistory facilities. This also conforms to the minimum headroom of 2.5 m for vehicles with "disabled" badge and wheelchair rack on the roof. **Figure 4-3** presents the headroom measurement. Where delivery trucks are expected, the minimum clear headroom must be 4.65 m.

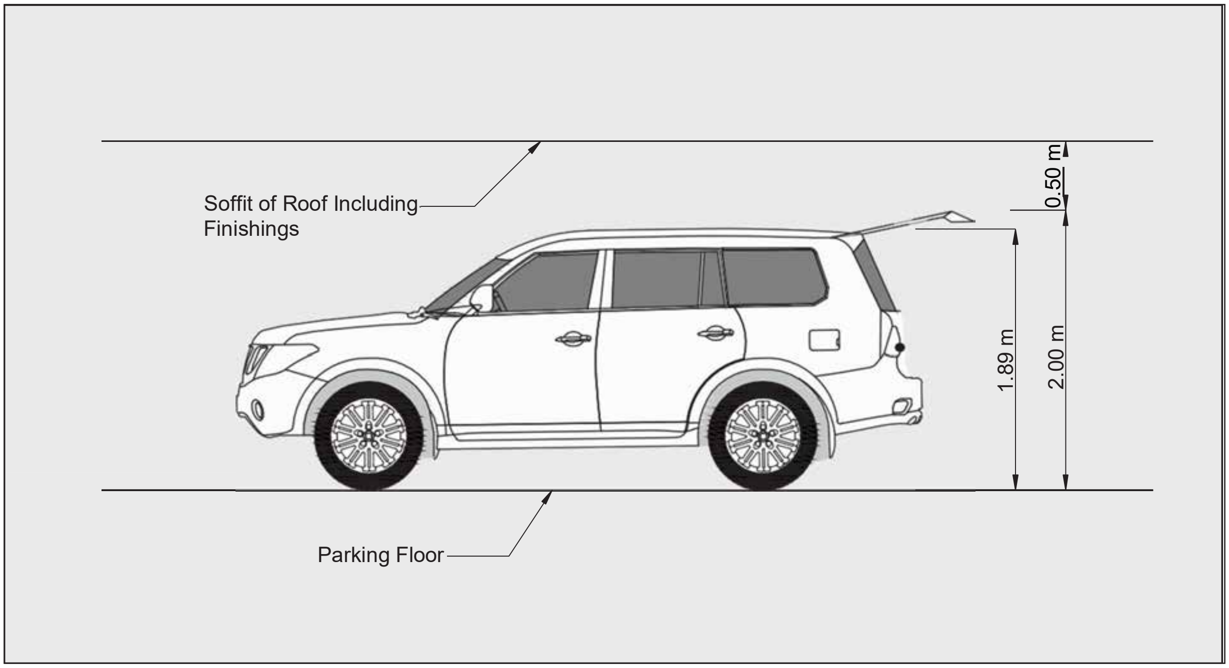


Figure 4-3 Parking Design Vehicle Headroom

4.1.4 Design Tool

Swept path analyses should be used to establish parking stall dimensions, aisle widths, and ramp dimensions. Computer Aided Design (CAD) tests should be conducted to test door opening requirements, wheel stop locations, and transition lengths.

4.2 Designing for Other Vehicles

If a parking facility is expected to be accessed by a vehicle larger than the PDV, as mentioned in **Section 4.1**, respective dimensions of the larger vehicle will be applied for designing the entrances, turning radii, ramps etc., following the same process as outlined in this Manual. The comfort levels and respective clearances mentioned in **Table 4.2** must be appropriately considered as required.

Dimensions of commonly used vehicles as well as the PDV, are shown in **Figure 4.4**.

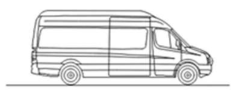
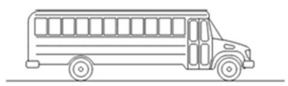
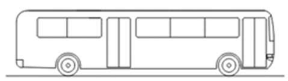
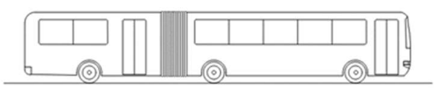
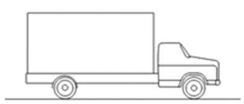
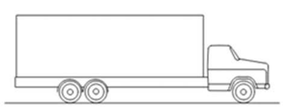
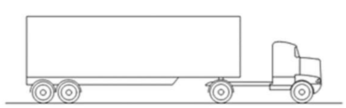
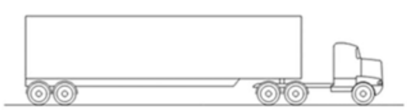
Vehicle Description	Schematic	Length (m)	Width (m)	Height (m)	Radius (m)
Passenger Car (PDV)		4.95	1.98	1.89	6.54
Commercial Van/ Ambulance		6.95	1.80	3.25	5.95
Conventional School Bus (S-BUS 11)		10.91	2.44	3.20	11.75
City Transit Bus (City Bus)		12.19	2.59	3.20	12.80
Articulated Bus (A-Bus)		18.29	2.59	3.35	12.00
Single Unit Truck (SU-9)		9.14	2.44	3.35 to 4.11	12.73
Single Unit Truck (SU-12)		12.04	2.44	3.35 to 4.11	15.60
Intermediate Semitrailer (WB-12)		13.87	2.44	4.11	12.16
Intermediate Semitrailer (WB-15)		16.77	2.60	4.11	13.68
Interstate Semitrailer (WB-20)		22.40	2.59	4.11	13.66

Figure 4-4 Dimensions for Parking Design Vehicle and Other Commonly Used Vehicles

4.2.1 Compact Cars

The PDV is considered to be the standard vehicle for designing parking stalls in the QPDM. However, a maximum of 5% of total parking spaces can be reserved for compact cars smaller than standard PDV for specific land uses, such as offices and schools where parking is expected to be used largely by the same users. Provision of compact cars within a parking lot will be treated as a Departure from Standards and will require approval from the Overseeing Authority. **Section 22** provides guidelines and criteria to be followed where design parameters are required to be exempted or a variation is required outside the design standards given in the QPDM.

A compact car in the QPDM is defined as a vehicle class with a maximum wheelbase length of 2.5 m. The wheelbase is the distance between the center points of front and rear wheels. Minimum parking dimensions are 2.5 m wide and 5.5 m long. A perpendicular parking layout is only permitted for compact cars. The compact car dimensions are not permitted to influence other parking design dimensions, such as aisle width and ramp width.

Compact car parking spaces should be in continuous bays at convenient locations marked with clear signage within a parking facility. The spaces within the compact car area should be preassigned. Pedestrian activities, such as stairways, elevator access, and entries and exits for pedestrians, should be restricted near this area. They must not be intermixed with standard parking stalls. The Overseeing Authority has the right to monitor the use of these spaces.

4.3 Parking Categories and Level of Comfort

Before designing a parking facility, it is important to identify the anticipated parking facility category that correlates to the type of primary usage. This is a major consideration in developing parking stall dimensions, aisle widths, and other associated dimensions based on the recommended level of comfort.

The level of comfort pertains to the width of parking stalls and aisles, and it is indicated with a level of comfort, i.e., from A through C:

A - provides the highest level of comfort
C – provides the least level of comfort

The designer should keep the design as flexible as possible so as to accommodate future land use changes. Three categories of parking and corresponding recommended levels of comfort are summarized in **Table 4-3**.

Table 4-3 Parking Categories and Levels of Comfort

Category	Description	Required Door Openings	Required Aisle Widths	Examples of Categories	Recommended Level of Comfort
1	Short-term parking (less than 2 hours) with moderate to high turnover	Full opening (2nd stop), all doors	Additional allowance above minimum single maneuver width to facilitate entry and exit; minimum pedestrian widths on both sides of the two-sided aisles	Retail outlets, shopping centers, medical visitors, short-term parking at airports, etc.	A - High
2	Medium-term parking (2 hours to less than 8 hours) with low to moderate turnover	Full opening (2nd stop), all doors	Additional allowance above the minimum single maneuver width to facilitate entry and exit; minimum pedestrian widths on both sides of the two-sided aisles	Within CBDs. For example, mixed-use business and town center shopping, low turnover visitor stalls (office - visitor parking, long-term parking at airports, etc.)	B - Medium
3	Long-term parking where the flow is intermittent and mainly light, but continuous. Short periods of intensive vehicle movement can also occur when a large people transporter arrives and passengers disembark	Front door, 1st stop	Minimum for single maneuver entry and exit	Located at major transportation terminals	C - Minimum

4.4 Wheel Stops

Wheel stops are generally provided in the off-street parking stalls, especially those in parking lot periphery, and designed to ensure that parked vehicles do not overhang sidewalks or landscaping nor come in contact with walls or buildings. The designers may also consider providing wheel stops in high turnover parking lots or where it is necessary to protect landscape, structures, or other areas from vehicular encroachment. Wheel stops may also be required at on-street angle parking spaces to prevent the vehicle from overhanging the footpath or walkway. Design must also ensure adequate walkway between the wheel stops. When used, wheel stops should be painted or marked to enhance their visibility and ensure pedestrian safety.

Considering a width of 1,675 mm between PDV wheels on the axle, the wheel stops should be 1,650 mm in length and 100 mm in height. The recommended minimum distance of wheel stops from the curb for the PDV is shown in **Table 4-4**.

The calculations are based on standard PDV overhangs, without rear spare wheel, towing hitch, or any other aftermarket addition. The wheel deduction "d" in **Table 4-4** is the distance from the wheel curvature to the facing edge of the wheel stop. See **Figure 4-5** for wheel stop placement.

Table 4-4 Wheel Stop Distances for 90-Degree Stalls

Mode of Entry	Overhang O (mm)	Wheel Stop Height h (mm)	Wheel Radius[1] r (mm)	Wheel Deflection Under Weight[1] f (mm)	Wheel Curvature Deduction d[2] (mm)	Distance to Low Curb[3] L (O – d) (mm)	Clearance from High Curb or Wall C (mm)	Distance to High Curb or Wall[3] W (L + C) (mm)
Front-in	975	100	229	20	200	775	200	980
Back-in	1,120	100	229	20	200	920	200	1,120

Refer to **Figure 4-5** for notation definitions.

NOTE:

1 *Radius of wheel and wheel deflection under load are both based on wheel size 285/60R18.*

2 *Deduction for wheel curvature "d" can be measured in the field. In the absence of field data, the following formula can be used:*

$$d=\sqrt{r^2-(r-f-h)^2} \qquad \text{EQN. 4-1}$$

3 *Rounded to the next 10 mm.*

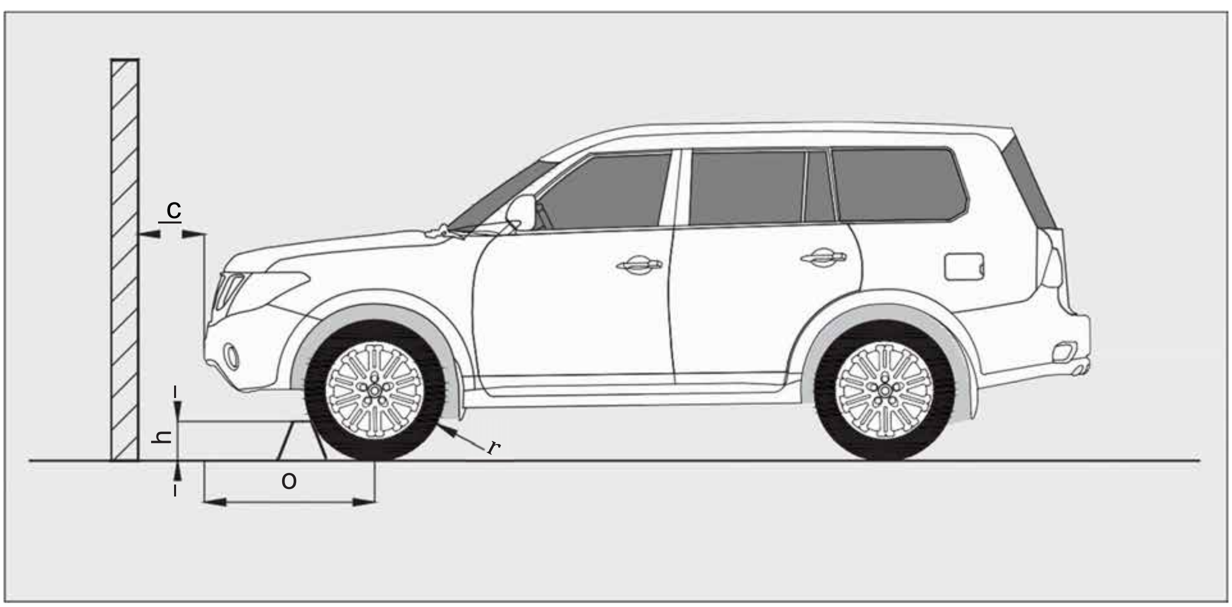
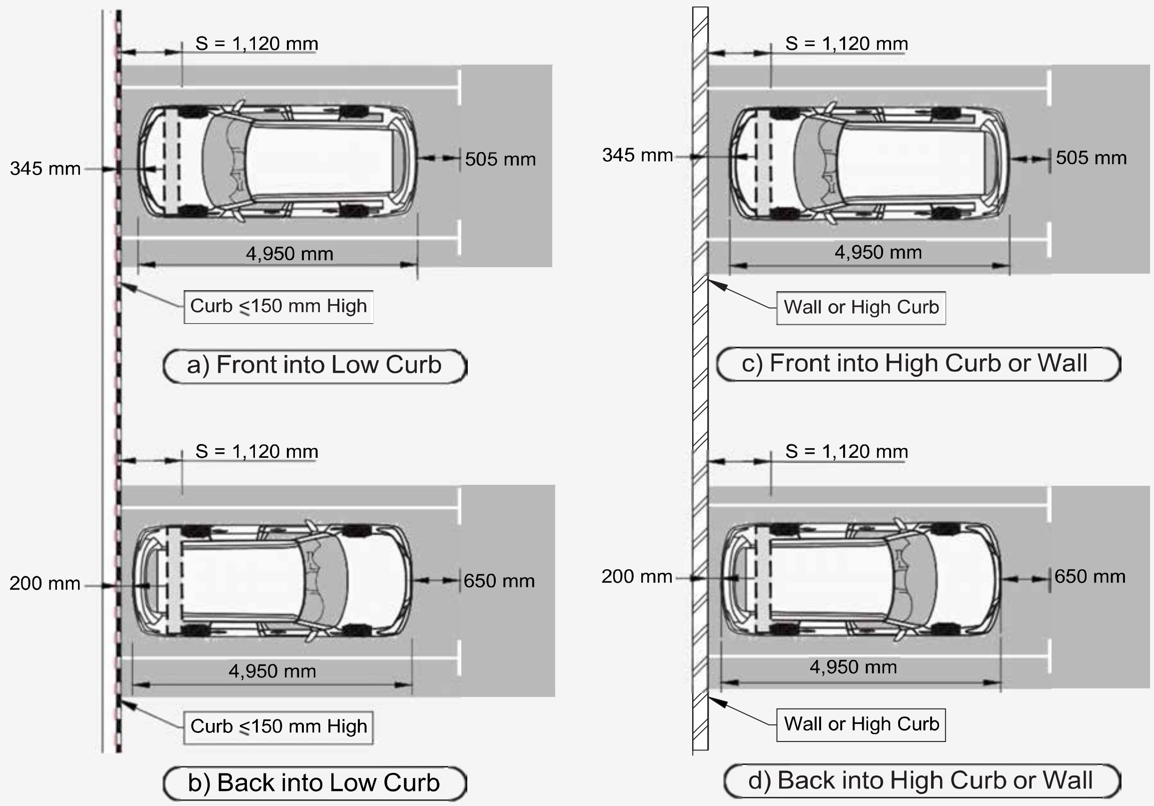


Figure 4-5 Wheel Stop Placement

The proposed dimensions for the wheel stops presented in **Table 4-4** and **Figure 4-6** can be applied for both straight and reverse parking, without encroaching the low curbs.



S = Wheel stop distance in mm (measured to point of contact with vehicle tire)

Notes:

1. Wheel stop distances shown in this figure are for 100 mm high and 1,650 mm wide wheel stops.
2. Wheel stop distances are set for the PDV vehicle. Some curb overlap may occur if either a longer vehicle or an occasional reverse-in vehicle uses the space.
3. Wheel stop distances are set to allow 200 mm clearance when parked in reverse and 345 mm when parked in forward between the PDV and the wall or curb as the case maybe.

SOURCE: Field Measurements in January 2020

Figure 4-6 Wheel Stop Dimensions

4.5 Emergency Vehicle Access and Parking

The requirement for emergency vehicle access has an impact on all aspects of parking facility design. Emergency vehicle access and access routes require early consideration. This section has been developed based on the requirements of Qatar Fire Safety Standards (FSS No. 4.1) of the Civil Defense Department (CDD) of the Ministry of Interior (MOI), unless otherwise mentioned. For on-street and ground-level off-street parking, the access road must have a minimum width of 6.0 m for a fire engine to pass.

For multistory and automated parking, the following are the building and site access requirements:

1. A 6.0 m wide firefighting appliance access/access road to the building should be provided. The grade of approach and departure for any means of access road should not exceed 5% as shown in **Figure 4-7**. The access road should be able to sustain a stationary load of a 24-ton fire appliance.

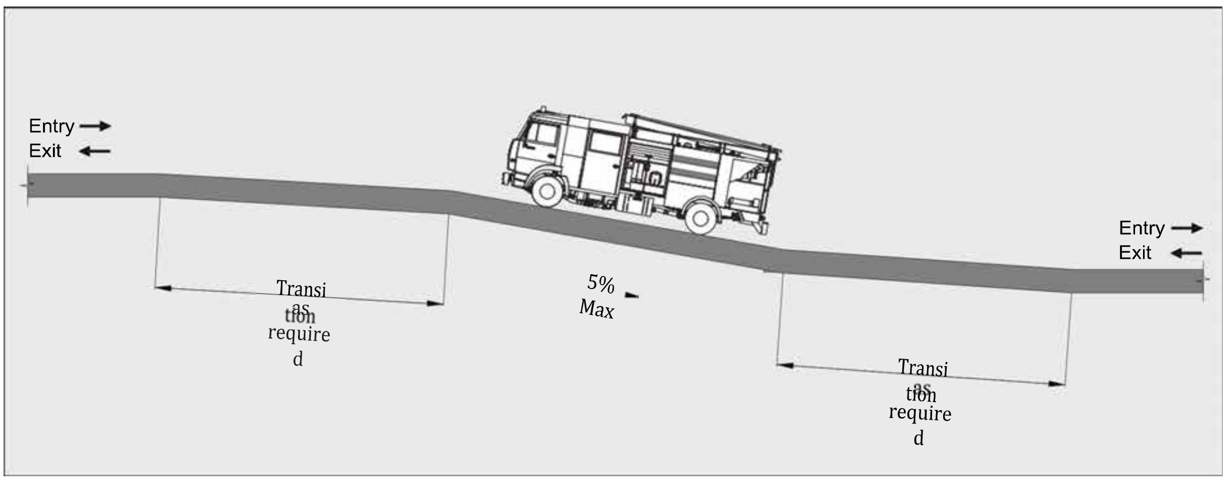
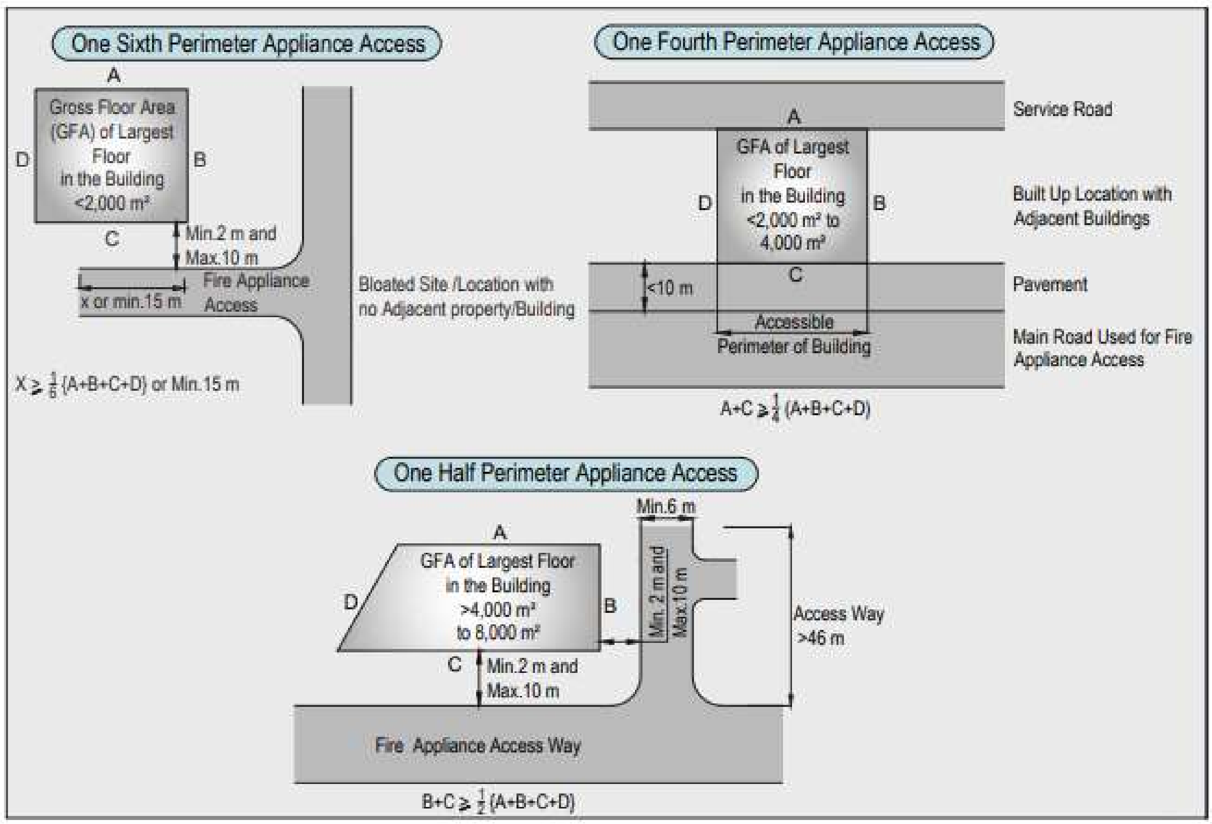


Figure 4-7 Fire Engine Access Approach Grade

2. In addition to the access road, fire engine hard standing, a paved area for parking of heavy vehicles, such as a fire engine of 6 m x 15 m (minimum) with a longer side parallel to the facade of the building should be provided. The hard standing should be able to withstand a stationary load of a 45-ton fire appliance. Access opening should be provided along the external wall of building in front of the fire engine hard standing to provide access to the building for firefighting and rescue operations.
3. The entire multistory parking structure should be designed with sprinklers and fire nozzles on each floor.

Fire engine access is illustrated in **Figure 4-8**.



SOURCE: Civil Defense Department - Ministry of Interior – Qatar fire safety standards minimum requirements – External access to site and building FSS No. 4.1

Figure 4-8 Fire Engine Access

4.5.1 Residential Emergency Vehicle Access Guidance

Fire engine hard standing is not required for residential buildings, such as bungalows, semi-detached, detached, and terraced houses, regardless of the building height, including residential buildings with habitable height less than 10 m. For residential developments including those with shared communal facilities, the following requirements must be met:

- Firefighting appliance access road
- Maximum travel distance of 60 m from the fire engine pump appliance to every point on the project plan area of any building

For residential buildings, exceeding the habitable height of 10 m, the following are required:

- Fire engine hard standing within 18 m of the breeching inlet
- Breeching inlets located on the external wall above ground level nearest to the vertical run of the riser stack

4.5.2 Office, Institutional, Commercial, and Recreational Emergency Vehicle Access Guidance

For institutions, offices, retail, and resorts, the following are required:

- Fire engine access road should be provided within a travel distance of 45 m from every point on projected plan area of any buildings.
- Fire engine hard standing should be provided with a length based on the Gross Floor Area (GFA) (including toilets, stores, and circulation areas) of the largest floor in the buildings with a habitable height exceeding 10 m.

4.5.3 Industrial Emergency Vehicle Access Guidance

Industrial buildings like factories and storage buildings, such as warehouses, must have a hard standing regardless of habitable height. Fire engine hard standing should meet the following criteria:

1. Every part of fire engine hard standing and/or access road should be within an unobstructed distance of 50 m away from a fire hydrant.
2. Fire engine hard standing should be positioned so that the nearest edge is no less than 2 m and no more than 10 m from the center position of the access opening, as measured horizontally.
3. Fire engine hard standing should be laid with a level platform or on an incline with a grade, not exceeding 1:15 (7%).
4. Fire engine hard standing and access roads should have an unobstructed vertical clearance of no less than 4.5 m.
5. Public roads can serve as a fire engine hard standing, provided the location of such public roads comply with the requirements of distance from access openings.

6. Fire engine hard standing and access roads should be kept clear of obstructions and other parts of the building. Plants, trees, or other fixtures should not obstruct the path between fire engine hard standing and the access opening.

7. The inner radius of a turning facility for fire engine hard standing and the access road should be minimum 3.5 m and 7 m, respectively.

4.5.4 Signage and Pavement Markings

See **Section 17.3** for signage and pavement markings for emergency vehicles.

4.6 Speed Limits

The speed limits for any off-street parking facility will depend on the crash history, entry, exit, and layout arrangements. The speed limits for each parking facility should be assessed and must be signed with suitable speed limit, usually in the range of 10 to 20 kph; but, under no circumstance will the speed limit exceed 20 kph. This is consistent with the International Best Practices and other established parking systems. However, a reduction in this speed should be considered for constrained conditions following the safety audit recommendations. This value should be approved by the Overseeing Authority.

4.7 Enforcement

Any design without means of enforcement loses value and function. It is, therefore, essential that enforcement be implemented along with good design practices.

4.7.1 Self-Enforcing Designs

Whenever possible the designer should use self-enforcing designs. For example, raised channelization is preferred to pavement markings alone. Similarly, dead spaces can be made inaccessible by placing physical barriers in conjunction with hatched pavement markings. Bollards can be used to prevent parking on sidewalks. Care must be taken when placing raised curbs or barriers in parking areas, making sure that they are clearly marked and do not pose a hazard to pedestrians. Signage indicating driving directions should be placed to avoid drivers traveling in wrong direction.

4.7.2 Surveillance and Visibility

Surveillance, either through on-site security personnel or Closed-Circuit Television (CCTV) cameras, is a required component of parking design. A parking layout should adhere to the following points to promote surveillance and visibility issues:

- Landscaping and boundary features should not obstruct surveillance or provide opportunities for concealment.
- High levels of illumination throughout the facility should be used, including light fixtures and fittings that incorporate vandal-resistant features with cables and wiring securely enclosed.
- Blind spots and vehicle and pedestrian access routes should be monitored with an effective CCTV system.
- Payment meters should be positioned in busy areas that are out in the open.
- Adequate sight lines should be added to enhance safety at points where traffic movement and flows conflict, such as exit points from ramps and in between floors.
- Good visibility is required at locations where pedestrian access routes cross or intersect with vehicle circulation routes.

4.7.3 Active Enforcement

Active measures to provide security in parking facilities include:

- Availability of staff to effectively monitor cameras
- Public address system to provide a presence and customer information in the facility
- Organized security details with regular patrols

4.7.4 Passive Enforcement

Unattended enforcement requires some sort of detection, such as induction loops or video cameras. Passive measures to provide security in these areas include:

- Locating surveillance cameras in places that provide maximum coverage
- Providing signage that advises users about security measures, such as CCTV cameras, and where to find safety infrastructure, such as intercom systems and emergency call boxes
- Ensuring clear and broad lines of sight from all areas of the parking facility
- Eliminating hidden recesses throughout the parking facility, e.g., on stairs and in corridors
- Avoiding obstructions, such as walls that block passive surveillance from adjoining areas

4.7.5 Control Room and Control Suite

A control room is required to manage the security operations of a parking facility. Discussion with and approval of MOI during the security planning phase is advised. The control room is the hub to monitor and manage normal security measures, CCTV systems, external telephone lines, personal attack alarms, operation of barriers from a kiosk, door locks, and protective screening of cash-handling facilities. The level and method of security must be discussed and agreed upon at an early stage of parking concept development. Control suites are required for a larger facility (more than 1,000 parking spaces). Control suites, in general, consist of the following features/ functions:

1. Central control operations room
2. Central control room for housing workstations and screens
3. Space for a central control room supervisor
4. MOI CCTV room
5. Fan room
6. Transformer room
7. Administrative office
8. Office spaces
9. Parking attendant room
10. Locker room
11. Training/Multipurpose room
12. Storage area
13. Pantry room

Based on the size and function of the facility, a few of the aforementioned features/functions could be combined or excluded.

4.8 Software Programs

Software programs may be used for design, design validation, or simulation of parking facilities in Qatar. The use of design software is encouraged. The designer must obtain the Overseeing Authority’s explicit written approval before using any design software, as well as approval of the recommended settings for the software program.

The software generally follows two fundamental design requirements:

- **The spatial design of the parking facility layout:** Majority of available software uses multiple parking design guidelines (Institute of Transportation Engineers [ITE], American Institute of Architects [AIA], Urban Land Institute [ULI]), as well as allows default standard values customization. The design software programs are compatible with current CAD platforms and allows the estimation of the optimal parking layout for any given area.

- **Vehicle swept path analysis:** Available software allows for the simulation of vehicle forward and reverse maneuvers and turns with interactive drive modes that incorporate speed, superelevation, lateral friction, and turn radius algorithms. This process ensures that parking facilities will safely accommodate vehicles and that designs will meet operational requirements.

As part of the design process, full consideration should be given to the latest version of the Guidelines and Procedures for Transport Studies (GPTS). Additionally, where a development has ingress/egress points that interface with the external public road network, the QHDM Vol. 3 Part 24 and Ashghal's Road Safety Audit Guidelines and Procedures manual should be followed.

There are three types of software that could be used in consultation with the Overseeing Authority:

- Design Software
- Design Validation Software
- Simulation Software

4.8.1 Design Software

Parking design software can carry out high-level estimation of parking capacities. It also automatically generates the optimized parking stall layout within a boundary. Guidelines can be provided as inputs to delineate the parking aisles.

This type of software can be used for larger parking lots, in consultation with the Overseeing Authority. The following parameters must be considered while using parking design software:

1. All Qatar standards are included as inputs, including vehicle dimensions, parking stall size, aisle width, and turning radius.
2. Local site conditions including access locations and grading should be included.
3. Customizing parking stalls, such as valet parking, police, taxi/bus parking, shopping cart pick-up/drop-off, or use of any customized symbol should be in line with Qatar standards.
4. Separate layouts must be prepared for each level of a multilevel parking facility.
5. Design validation software (**Section 4.8.2**) should be used after developing the layouts.

4.8.2 Design Validation Software

This type of software is mandatory for reviewing parking designs. This software validates both horizontal and vertical swept path analyses. The following parameters must be considered when using parking design validation software:

- Create templates for each of the vehicles listed in **Figure 4-4**. Additional dimensions are included in **Table 4-5**.

- Use metric units and a CAD platform only.
- Assume a minimum forward and reverse speed no less than 5 kph.
- Assume a constant turning speed for entering or exiting a parking stall.
- Assume continuous maneuvering without intermediate stops for entering or exiting a parking stall.
- Do not permit encroachment on abutting parking lots for vehicle maneuvering.
- Verify ramp design with three-dimensional (3D) swept path analysis covering both headroom and transition areas.

Table 4-5 Details of Vehicle Dimensions

Design Vehicle Type	Overhang (m)		Wheel Base1 (m)	Wheel Base2 (m)	Inside Turning Radius (m)	Minimum Centerline Turning Radius (m)	Outside Turning Radius (m)	Steering Angle (deg)	Ground Clearance (m)		
	Front	Rear							Front	WB	Rear
Passenger Car (PDV)	0.98	1.13	2.85	—	4.27	5.30	6.54	32.60	0.38	0.23	0.23
Commercial Van/ Ambulance	1.10	2.38	3.47	—	3.20	5.10	5.95	42.90	0.15	0.15	0.15
City Transit Bus (City Bus)	2.13	2.44	7.62	—	7.45	11.52	12.80	41.40	0.25	0.25	0.25
Articulated Bus (A-Bus)	2.62	3.05	6.71	5.91	6.49	10.82	2.00	38.30	0.25	0.25	0.25
Single-Unit Truck (SU-9)	1.22	1.83	6.10	—	8.64	11.58	12.73	31.80	0.61	0.46	0.61
Single-Unit Truck (SU-12)	1.22	3.20	7.62	—	11.09	14.46	15.60	31.80	0.61	0.46	0.61
Inter-mediate Semitrailer (WB-12)	0.91	1.37	3.81	7.77	5.88	10.97	12.16	20.30	0.460	1.21	1.21
Inter-mediate Semitrailer (WB-15)	0.91	1.37	3.81	10.82	2.20	12.53	13.68	17.7	0.460	1.21	1.21
Interstate Semitrailer (WB-20)	1.22	1.37	5.94	13.87	0.59	12.50	13.66	28.40	0.46	1.21	1.21

4.8.3 Simulation Software

Preferably, parking simulation should be performed for large parking lots of 1,000 or more car parking stalls. Typically, parking planned for public uses, such as shopping malls, sports/entertainment facilities, and hospitals, are considered large parking lots.

The purpose of a simulation is to assess the efficiency of the parking lots, unused space, parking search time, pedestrian conflicts, and ITS requirements. Application of parking simulation software must be agreed to by the Overseeing Authority and should include the following parameters:

1. General simulation input parameters used must be approved by the Overseeing Authority.
2. Maximum vehicular speed inside a parking facility is 20 kph.
3. Speeds during parking searching are between 5 and 20 kph.
4. Minimum vehicular speed during parking maneuvers is 5 kph.
5. Pedestrian speed inside a parking lot is 1 kph.
6. Pedestrian composition is defined based on the use of the facility; with children comprising a minimum 15 percent of the pedestrians.
7. Shortest path for pedestrian modeling is to be used unless a structured pedestrian network is planned with enforcement measures.
8. Maximum pedestrian flow is 45 persons per meter per minute in both directions.
9. A constant turning speed is maintained while entering or exiting a parking stall.
10. Continuous maneuvering is maintained without intermediate stops while entering or exiting a parking stall.
11. Parking area should be divided into manageable zones and each zone will be served by a loop road system.
12. Maximum circulation on a single loop is two times for parking search.
13. Maximum parking search time is 15 min.
14. Desirable parking search time is 7 min.
15. Maximum searching angle is 270 degrees.
16. Model must include barriers, attraction points for different user groups, parking fare collection booths, and VMS locations.

Section 5

On-Street Parking

5: On-Street Parking

On-street parking lies within the public Right of Way (ROW); therefore, the Qatar Highway Design Manual (QHDM) remains applicable for on-street parking (roadway features/infrastructure) design. The guidelines provided in this section of the QPDM should be used in conjunction with the QHDM Volume 1, Part 3. This section only bridges the gaps in line with the QHDM. If ambiguity arises over the applicability of the guideline for any particular on-street parking design project, clarity should be sought from the Overseeing Authority.

On-street parking is generally open to the public, but it also can be used as reserved space, such as for taxi, police vehicles, etc. Off-street parking could be open to the general public, but generally it is meant for designated users only, such as tenants, employees, customers, residents, etc. Design requirements for off-street parking are discussed in detail in the following sections of this manual.

This section provides guidance on parking along access roads, near pedestrian crossings, T-intersections, functional areas of intersections, driveways, and bends or on curves. Guidance on curbside management for parking and on-street taxi ranks is also provided.

5.1 Justification for On-Street Parking Provision

On-street parking is generally related to users who need a high level of accessibility, such as short-term car parking, pick-up/drop-off, transit stops, and taxi ranks. The QHDM justifies on-street parking only under the following conditions:

- Posted speed limits of 50 kph or less
- Design peak hour traffic volumes forecast in one direction is less than 1,000 vehicles per hour (vph)
- On local roads, collectors, minor arterials, and service roads

The designers should consider the following items and present to the Overseeing Authority to justify the provisions of on-street parking:

1. Road classification and type meet the QHDM requirements.
2. Surrounding characteristics and frontage activity/land use require additional short-term parking supply.
3. Posted speeds meet the QHDM requirements.
4. Traffic flow characteristics/volume meet the QHDM requirements.
5. Pedestrian requirements and interactions are non-conflicting.
6. Public transportation and bicycle requirements are adequately made.
7. Proposed design does not obstruct traffic and impact nearby junctions.
8. Service vehicle, emergency vehicle and driveway access requirements are met.
9. Overall safety hazard is low.

5.2 Guidelines

The guidelines presented in this section are applicable for both parallel and angled on-street parking. For graphical consistency, diagrams showing parallel parking only have been included.

5.2.1 Parking Along Local Access Roads and Minor Collectors

Parking along local access roads and minor collectors with adequate ROW are allowed. Parking should not be provided at an intersection within 6.0 m from the Point of Tangent (PT) and the end of the parking bay taper as shown in **Figure 5-1**.

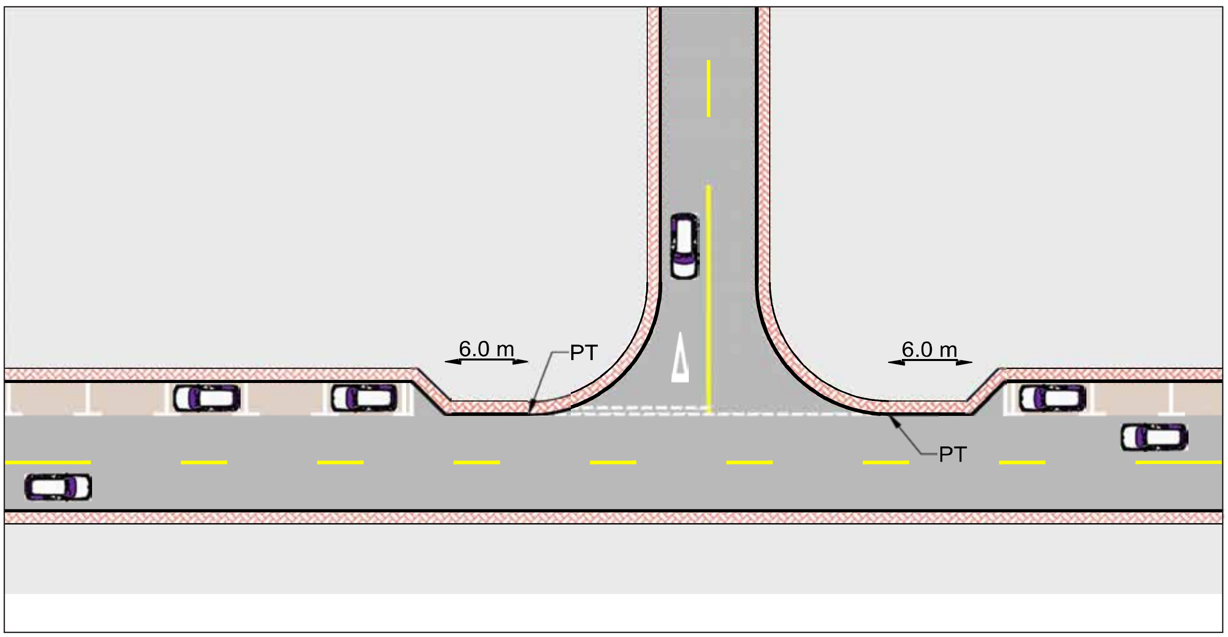


Figure 5-1 Parking Along Local Access Roads and Minor Collectors

5.2.2 Parking Near Pedestrian Crossings

The on-street parking spaces should be positioned at a distance from the marked or unmarked pedestrian crossings. Parking bays must be at least 6.0 m away from the pedestrian crossing as shown in **Figure 5-2**.

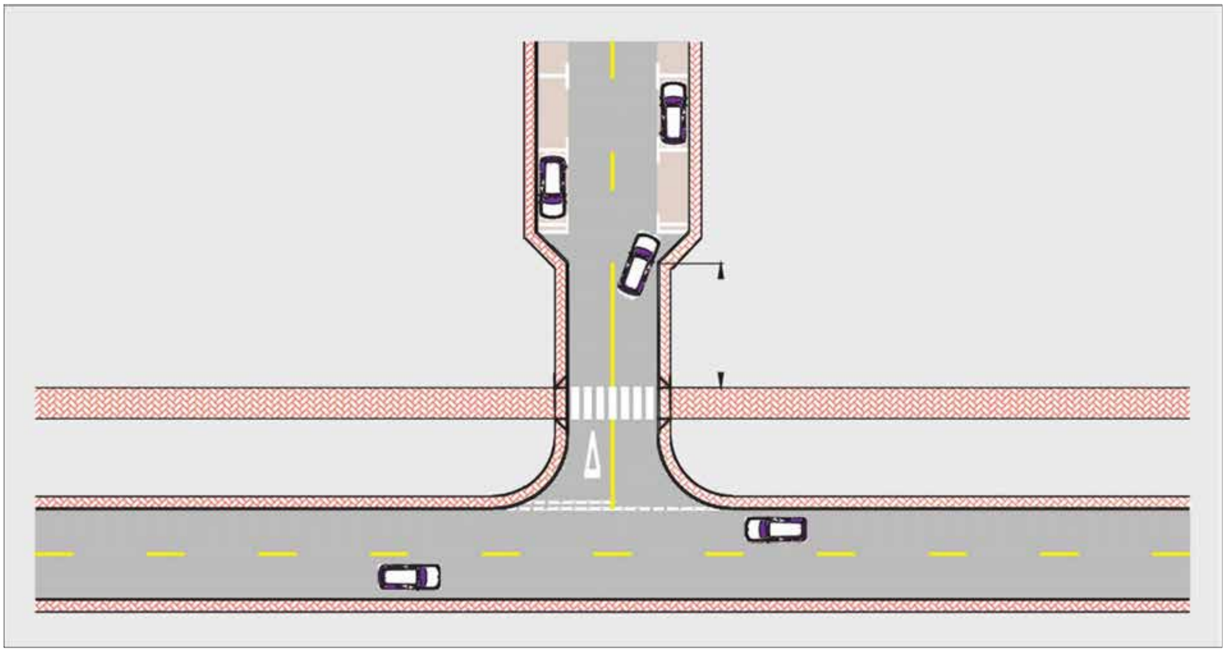


Figure 5-2 Parking Near Pedestrian Crossings

5.2.3 Parking Near T-Intersections

On-street parking is not permitted opposite the minor leg/intersecting road of a T-intersection, unless there is a raised median separating the major traffic flows. Parking is also not permitted at unmarked pedestrian crossing locations. **Figure 5-3** presents this in detail, where a minimum distance of 6.0 m is kept clear between the PT and the beginning of the parking bay taper.

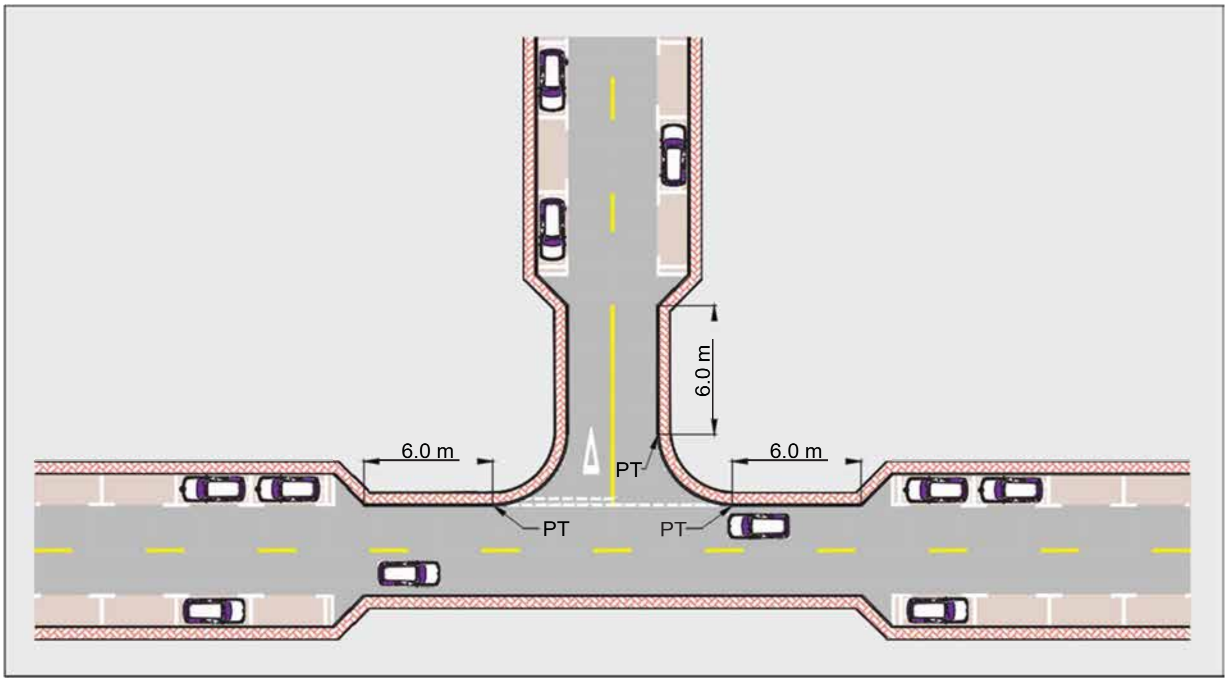


Figure 5-3 Parking Near T-Intersections

5.2.4 Parking Near Driveways

Driveways are access to and egress from a development. On-street parking is not permitted on local roads 6.0 m before the PT for the access driveway. Similarly, on-street parking is only allowed 6.0 m after the PT for the egress driveway, as shown in **Figure 5-4**. Access and egress designs should be based on the needs and location of the access.

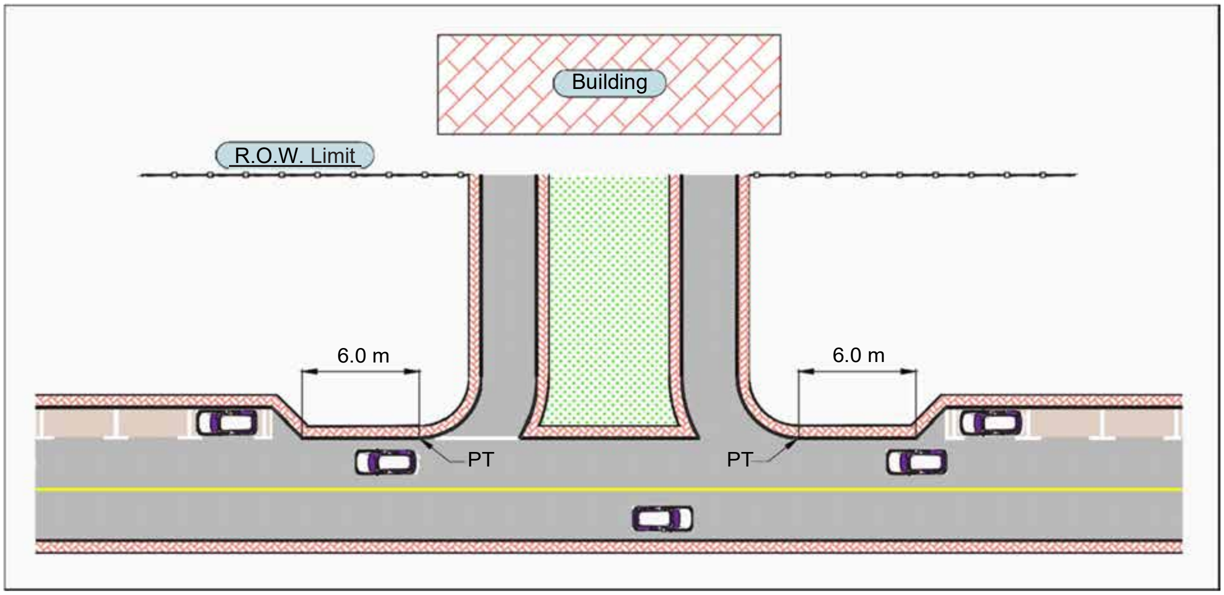


Figure 5-4 Parking Near Driveways

5.2.5 Parking Near Pedestrian Crossings and Access Points

Parking is not permitted within 6.0 m of a marked mid-block pedestrian crossing, as shown in **Figure 5-5**, or opposite vehicle or pedestrian access points to properties, to prevent pedestrians from crossing roads, mid-block.

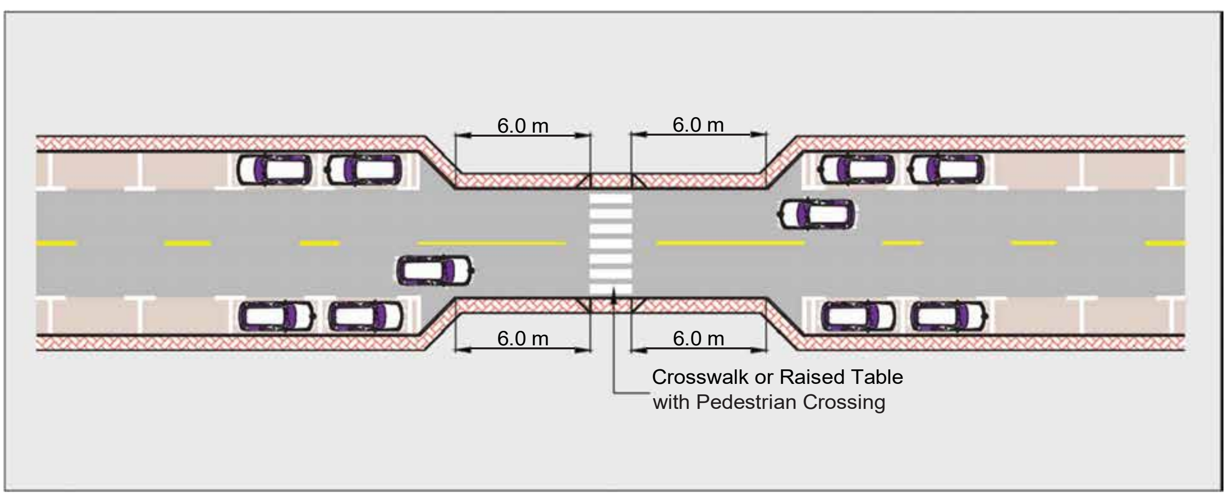


Figure 5-5 Parking Near Pedestrian Crossings and Access Points

5.2.6 Parking Near Fire Hydrant

Parking is not permitted within 5 m on either side of a fire hydrant.

5.2.7 Parking Near Bends and Curves

Parking is prohibited at any location where it may create an unsafe condition, such as the inside of sharp curves or bends, as shown in **Figure 5-6**, adjacent to painted or channelized islands. On-street parking can only be considered if the proposed site is located on a low-speed road with high parking demand and low parking supply. The safety assessment should be carried out for such locations with proper justifications and then provided to the Overseeing Authority for their review and approval.

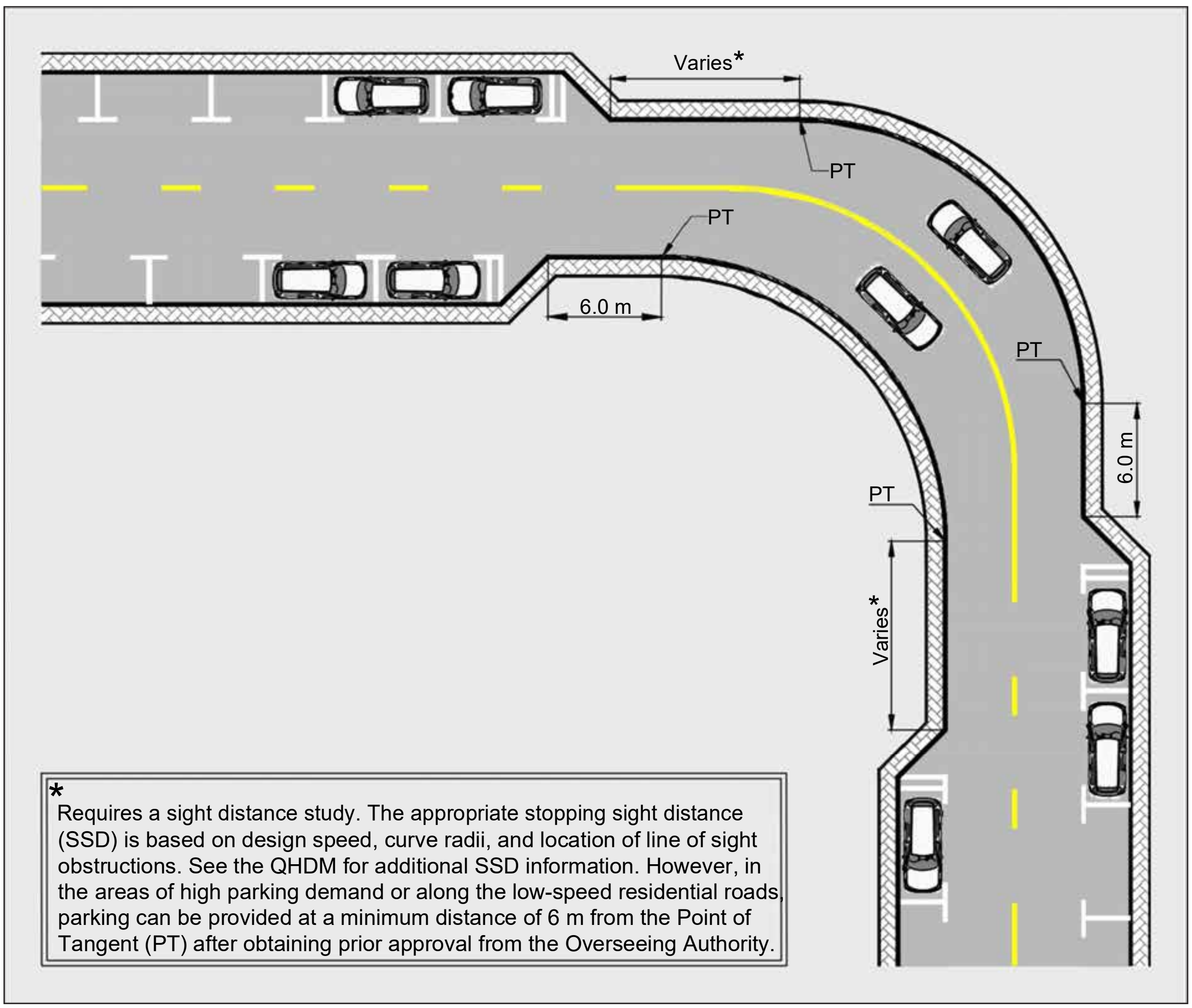


Figure 5-6 Parking Near Bends and Curves

5.2.8 Parking Near the Functional Area of an Intersection

The functional area of an intersection is defined as "the area beyond the physical intersection (including roundabouts) that comprises decision and maneuvering distance and any additional required vehicle storage length". There is not enough research available to define the functional area of a roundabout. Some research suggests that a roundabout generally operates more like an unsignalized intersection. Since roundabouts do not have left turns, it can be assumed that the functional area of a roundabout may be less than that of an unsignalized intersection. A microsimulation study, as part of the Traffic Impact Study (TIS), is recommended to be carried out for better assessment of a functional area, if required by the Overseeing Authority.

For a signalized or unsignalized intersection, the influence area is upstream and downstream of the intersection. The upstream area consists of distance for travel during perception and reaction time, travel for maneuvering and deceleration, and queue storage. The downstream area is equal to the stopping distance and any distance required to reduce conflicts between traffic and vehicles entering and exiting a property.

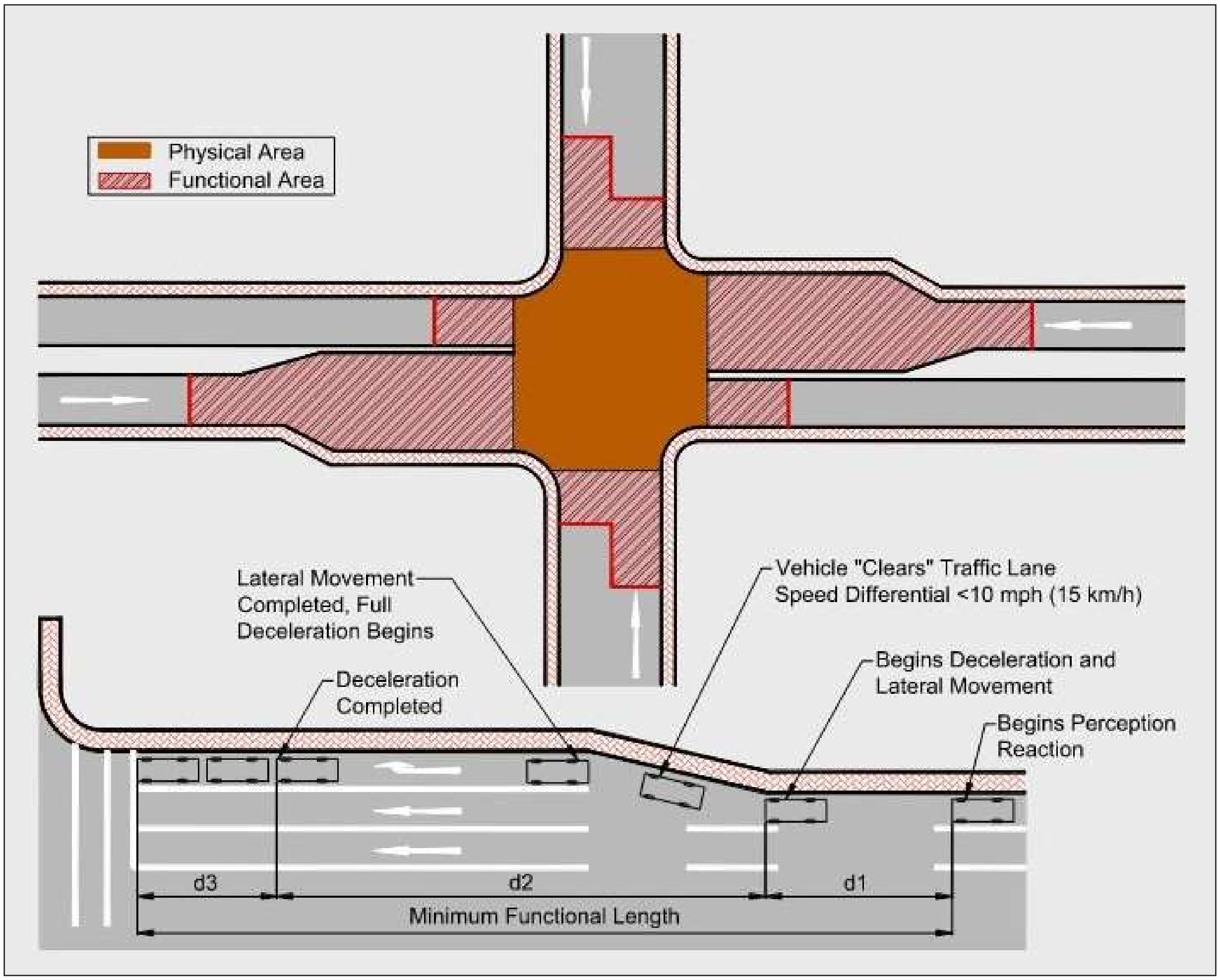
Parking is prohibited within the functional area of an intersection, with the exception of Ministry of Interior's (MOI) enforcement and maintenance vehicles, as needed. Any access or parking within the functional area of a signalized intersection will have an adverse impact on intersection operations and safety.

The methodology to assess the functional area of a signalized intersection and the upstream and downstream influence areas is shown in **Figure 5-7**.

The components of an influence area are:

- d1: Distance traveled during perception-reaction time as a driver approaches the intersection, assuming 2.5 secs for urban and suburban conditions; one is advised to refer to the QHDM for more guidance on perception-reaction time.
- d2: Deceleration distance while the driver maneuvers to a stop upstream of the intersection.
- d3: Queue storage at the intersection based on possible queues.
- Distance immediately downstream (shown in red hatch) of the intersection, so that a driver can completely clear the intersection before reacting to something downstream. Stopping Sight Distance (SSD) is often used for this measure.

The designer will use the same principles to assess the functional areas of other types of intersections, such as roundabouts and unsignalized intersections.



SOURCE: "Signalized Intersection: Informational Guide," Second Edition, U.S. Department of Transportation Federal Highway Administration, Publication No. FHWA-SA-13-027, 2013.

Figure 5-7 Functional Area of an Intersection

5.3 On-Street Parking Dimensions

On-street parking should be integrated with the roadway design. On-street parking can be parallel, or at an angle of 45 degrees, once approved by the Overseeing Authority. For on-street parking dimensions, QHDM, Volume 1, Part 3 will be referred.

5.4 Curb Management for Parking

There are competing uses for urban curb space. The regulation and use of on-street parking is prioritized to support users who need a high level of access, such as accessible parking, passenger pick-up/drop-off, emergency vehicle access, public transport stops, taxi ranks, pedestrians, powered two-wheeler parking, bicycle racks, garbage bins, and service vehicles.

Parking requirements for competing curb uses are discussed in the following sections of this manual:

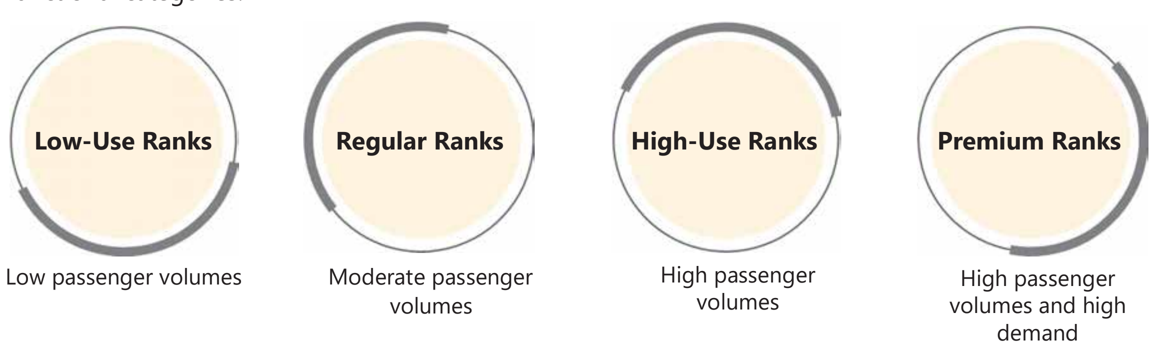
1. Emergency vehicles (**Section 4.5**)
2. Taxi ranks (**Section 5.5**)
3. Garbage bins (**Section 9.6**)
4. Accessible parking (**Section 11**)
5. Pedestrians (**Section 12**)
6. Bicycle parking (**Section 13**)
7. Powered two-wheelers (**Section 14**)
8. Buses (**Section 15**)

Shared use is encouraged between various users to manage the limited curb space more efficiently. This requires adequate signage and pavement markings. A comprehensive study for curbside usage is essential prior to the implementation of a curbside management strategy.

5.5 On-Street Taxi Ranks

A taxi rank (also known as a taxi stand) is a place where taxis wait for the customers. On-street taxi waiting areas should be provided at locations where significant passenger volumes are expected. Placement and number of space slots of taxi rank should be based on required TIS, which is part of the planning process. In general, taxi ranks can be split into a series of levels or hierarchies.

The hierarchy of a taxi rank relates to the land uses, they are intended to serve. The hierarchy can be split into four functional categories:



Low-use and regular ranks are located in areas with a low demand for taxi service and can be served with one or two reserved spaces at the curb. High-use taxi ranks typically include a pull-out area and room for waiting taxis to queue up. Premium taxi ranks are typically located at high-use locations, such as airports where taxis wait in a remote location and are dispatched to the loading area as and when needed.

Some key guidelines and requirements for taxi ranks are:

- Taxi rank should be proportional to the number of taxis expected. Minimum length of the taxi rank is calculated assuming 6.0 m for each taxi with additional length for end tapers. Split taxi ranks are prohibited.

- The minimum effective sidewalk width should be 2 m, to allow passengers to safely get in and out of the taxi. The taxi rank should be suitable for disabled access in at least the first two spaces. The curb height should preferably be raised to allow for step-free access.

Signage and markings required should comply with M125 markings from the QTCM. If the taxi rank accommodates multiple taxis, the on-street parking space markings can be simply in multiples of 6.0 m.

Only the start and end of a taxi rank must be marked. There is no requirement to mark individual parking spaces in a taxi rank. The taxi parking bay must also have an R142 sign. **Section 17** may be referred to for more details on signage and marking.

Section 6

Off-Street Parking Design

6: Off-Street Parking Design

The parking facilities that are located outside the road Right of Way (ROW) are termed off-street parking facilities. Off-street parking accounts for the larger share of parking supply in a city. All private parking, such as those for offices, residences, etc., which are meant for designated users, necessarily falls under off-street parking. Off-street parking could be used for public parking as well, where the parking is not restricted or conditional. The off-street parking can be at-grade or at multilevel garages. This section of the Qatar Parking Design Manual (QPDM) provides the basic design guidelines for off-street parking. **Section 8** of this manual provides guidance on design elements related to multilevel parking garages. References are made to Qatar Highway Design Manual (QHDM), Qatar Traffic Control Manual (QTCM), Guidelines and Procedures for Traffic Studies (GPTS), respectively, for geometric design parameters, signage and pavement markings, access control, and circulation. It is pertinent that guidance in this section be read in conjunction with the latest versions of these standard documents.

6.1 Parking Stall Dimensions

A parking stall is the fundamental element of parking design. The Parking Design Vehicle (PDV) has been used to determine the dimensions for the parking stall and other related design items like entrances/exits, parking aisles, and ramps. **Section 4.1** may be referred to for additional criteria for establishing the PDV. These considerations will impact the physical characteristics of a parking facility and help to determine the facility design requirements.

The following are the minimum dimensions of an angled off-street parking stall:

- 2.8 m wide
- 6.0 m long

A reduced value of 2.65 m wide and 5.7 m long stall dimension is acceptable under special circumstances, in consultation with the Overseeing Authority, as explained subsequently:

- Plot size of the development is considerably smaller (600 m^2) to accommodate the parking requirements.
- Areas have a high floor area ratio (FAR).
- Areas have high-premium land costs.
- Site has access constraints.
- Parking spaces are expected to be utilized for longer stays (long-term low-turnover).

6.2 Parking Aisle Dimensions

A parking aisle is the space required for vehicular movement adjacent to the parking stalls, as well for maneuvering in and out of them. The minimum aisle width depends on the parking angle, direction of aisles (one-way or two-way), and the presence of parking on one or both sides. A parking bay denotes a row of parking stalls.

Parking aisles must be the same for all parking categories (discussed in **Section 4-3**) wherever shared parking is planned between various land uses, irrespective of short-term and long-term parking or high or low turnovers. This will encourage shared use across land uses and align with the QPDM principles, reducing the demand for additional parking supply in the future. Selection of the parking angle will be based on available site width, owner/developer preferences, and traffic circulation considerations. When designing a parking lot, it is most efficient to align the aisles with the longer axis and maximize the number of stalls within the space available.

Minimum required dimensions for off-street parking are shown in **Table 6-1**. This includes pedestrian paths for low to moderate pedestrian activities. Sites with high pedestrian activities should refer to **Section 12**, in consultation with the Overseeing Authority.

Table 6-1 Standard Off-Street Angled Parking Dimensions

Parking Angle (A)	Minimum Requirements (m)				
	B Stall Width	C Stall Depth	D Aisle Width	E Curb Length per Car	F Module Width (C+D+C)[3]
Parallel parking[1]	2.8	2.8	4.0	6.0	9.6
45° with one-way aisle[1]	2.8	5.8	4.0	4.0	15.6
60° with one-way aisle[1]	2.8	6.3	5.0	3.2	17.6
75° with one-way aisle[1]	2.8	6.4	6.0	2.9	18.8
Perpendicular with one-way aisle[2]	2.8	6.0	6.0	2.8	12
Perpendicular with two-way aisle[1]	2.8	6.0	8.0	2.8	20

NOTE:

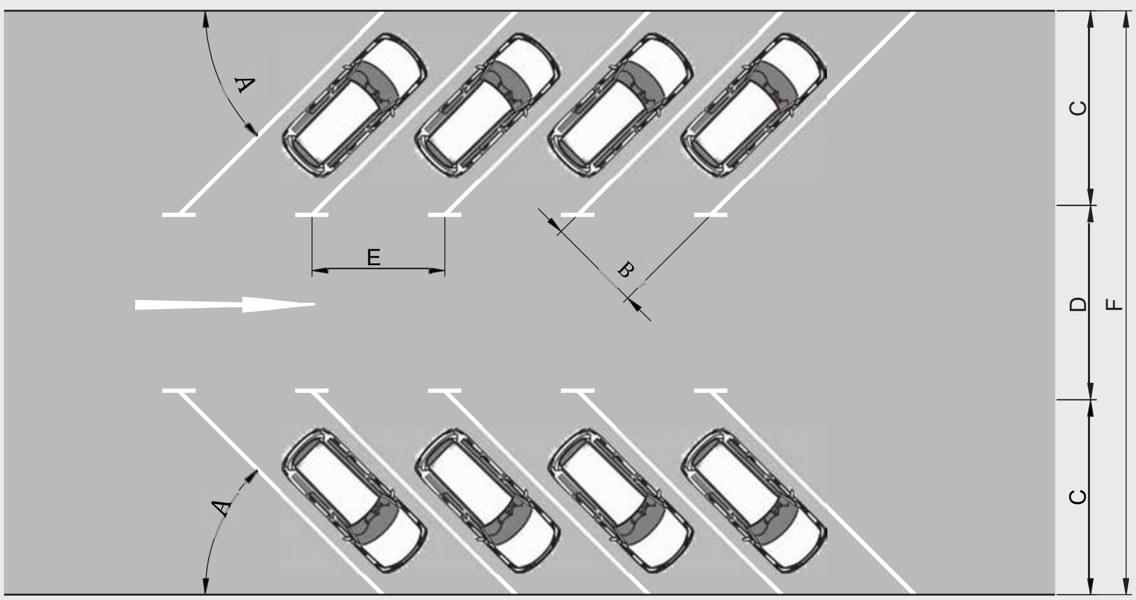
1 *Parking on both sides of the aisle*

2 *Parking on one side of the aisle*

3 *For parking on one side only, F=C+D*

If the Overseeing Authority approves layouts for other parking angles, the dimensions required are to be determined by conducting a swept-path analysis. A clearance of 0.2 m from the curb and 0.3 m from the aisle must be adopted for finalizing the stall dimensions.

The layout of angled parking with a one-way aisle is shown in **Figure 6-1**.

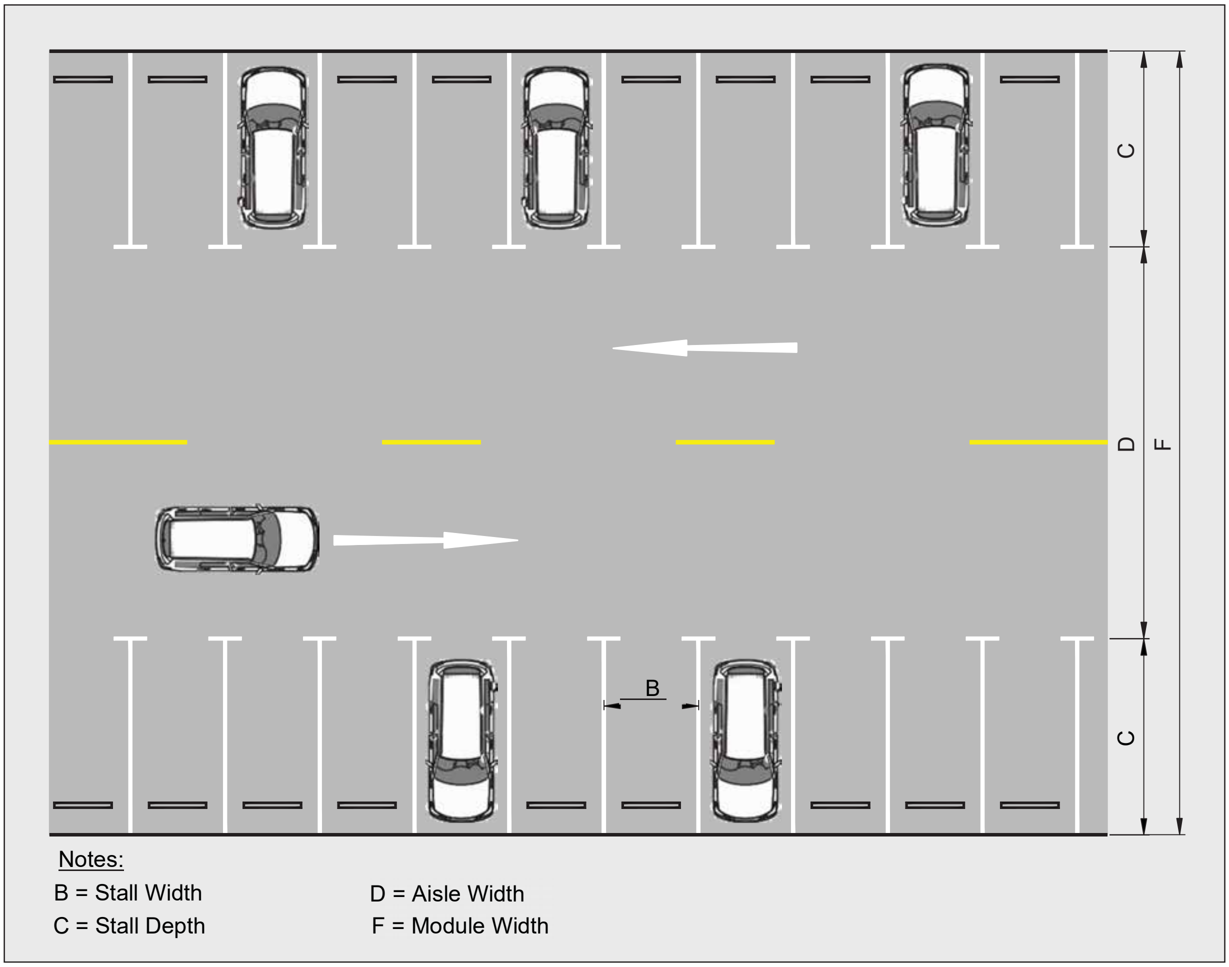


Notes:
A = Parking Angle C = Stall Depth
B = Stall Width D = Aisle Width
E = Curb Length per Car
F = Module Width

Refer to Table 6-1 for dimensions.

Figure 6-1 Angled Off-Street Parking Layout (One-Way)

A layout for perpendicular (90-degree) parking with a two-way aisle is shown in **Figure 6-2**.



Refer to Table 6-1 for dimensions.

Figure 6-2 Perpendicular Off-Street Parking Layout (Two-Way)

6.3 Blind Aisle Design Requirements

A parking aisle closed at one end (dead ends) is known as a "blind aisle". This should be avoided in all parking facilities, where practicable. In case a blind aisle is unavoidable, provisions for vehicles to turn should be provided at the end of all aisles. This is best addressed by providing cross-aisles, which are aisles that intersect at 90-degree (perpendicular) to the parking aisle, to allow a break/crossing, or by providing turnarounds and provisions at the end of blind aisles for vehicles to turnaround. Blind aisles, if provided, must only be allowed with a perpendicular parking layout and with a two-way aisle extended at least 0.5 m beyond the last parking stall. At blind aisles, parking stalls adjacent to a wall or fence should be painted with angled yellow stripes, signifying a "no parking zone" as shown in **Figure 6-3**. This will allow for vehicle turnarounds. The standard is to allow a vehicle to make no more than one reverse movement while backing out of a blind aisle. The user should be cautioned about a blind aisle at the entrance of the parking bay using W209 sign, according to the Qatar Traffic Control Manual (QTCM).

All spaces in the blind aisle should be clearly visible from the main travel path. The maximum length of a blind aisle should be equal to the width of six perpendicular parking stalls, with a 0.5 m additional clearance from the wall or fence at the dead end. Refer to **Figure 6-3** for blind aisle layout.

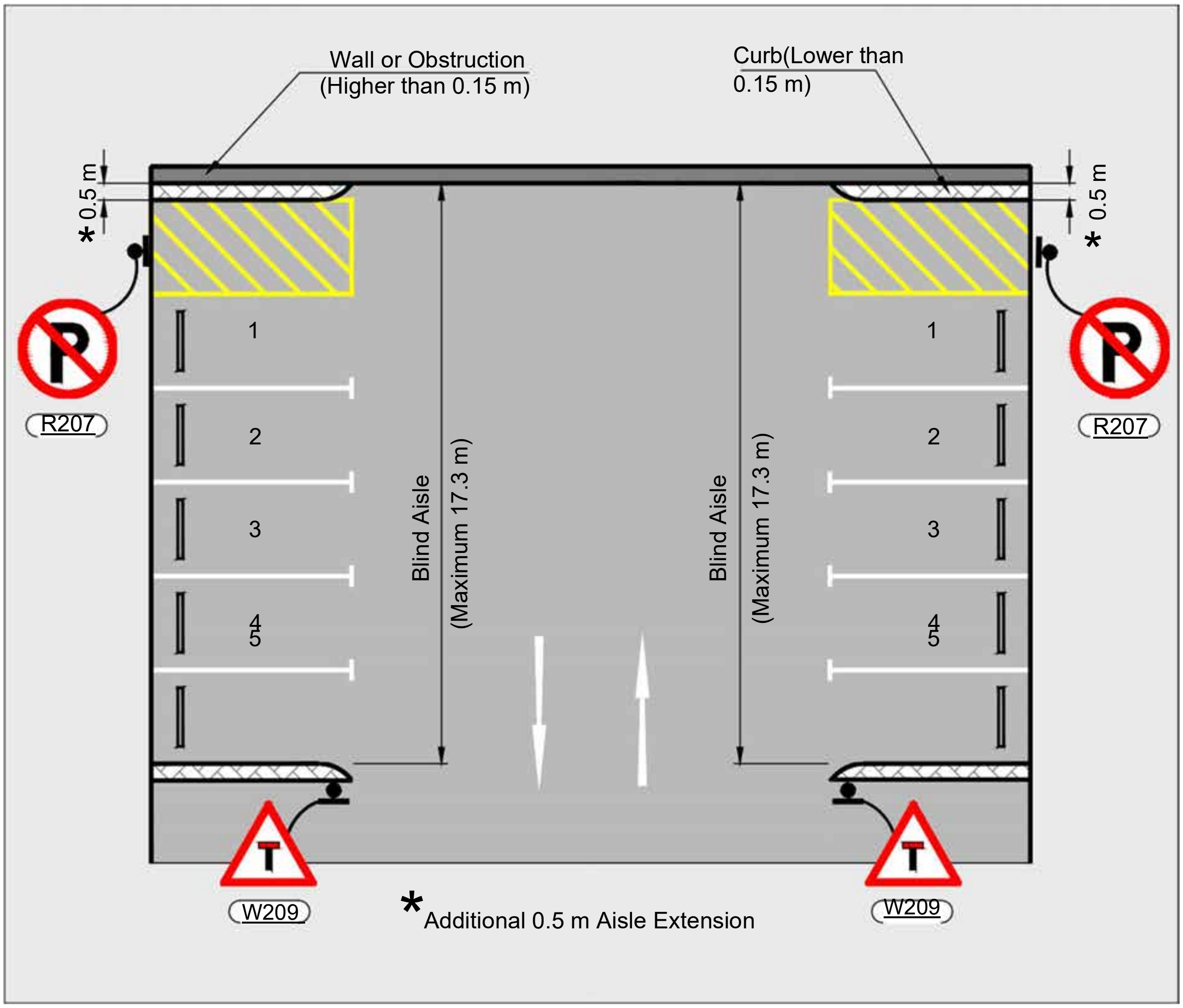


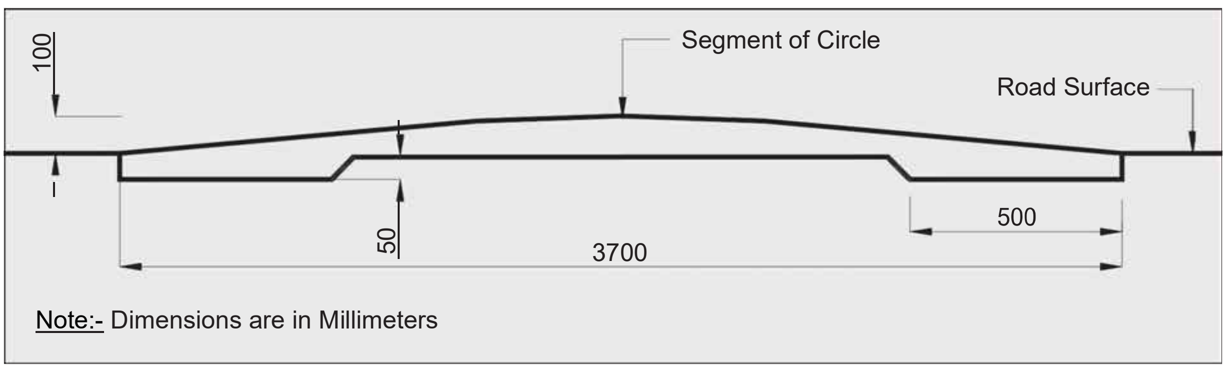
Figure 6-3 Blind Aisle Layout

6.4 Speed-Reducing Features

Speed limit requirements within a parking facility are included in **Section 4.6.** Long parking aisles encourage greater speeds. Parking aisles more than 100 m long (roughly 35 perpendicular parking spaces) should be avoided to discourage high-speed travel through the parking lot. Generally, cross-aisles should be used to provide a break. If the 100 m length is exceeded, or when speeding is an issue, speed control devices such as road humps should be placed at regular intervals in the parking aisle to control vehicles' speed and minimize potential conflict with pedestrians and vehicles. In areas where speed control is necessary within a parking facility, road speed humps should be used as specified below.

Three types of speed management may be used for off-street parking facilities. The type of speed management depends on the location and the level of speed reduction required. The selection of the appropriate speed management type must be agreed on by the Overseeing Authority.

Type 1 - Round-topped speed humps are appropriate for use on long aisles and circulating roadways, such as large outdoor at-grade parking lots. These speed humps generally tend to reduce vehicle speed from more than 30 kph to 25 kph or slower, typically at the midpoint between two consecutive humps. Speed hump markings and spacing should be developed in accordance with the QTCM specifications. Design must be in line with the QHDM. **Figure 6-4** shows the cross section for a Type 1 hump. **Figure 6-5** shows a typical layout for Type 1 speed humps. Speed humps are usually constructed using bituminous concrete and may be unsuitable for installation with Portland cement concrete surfaces.



SOURCE: QHDM, Volume 3 Part 19, Section 4.3.15.3, Speed Humps and Raised Tables

Figure 6-4 Speed Hump Cross Section

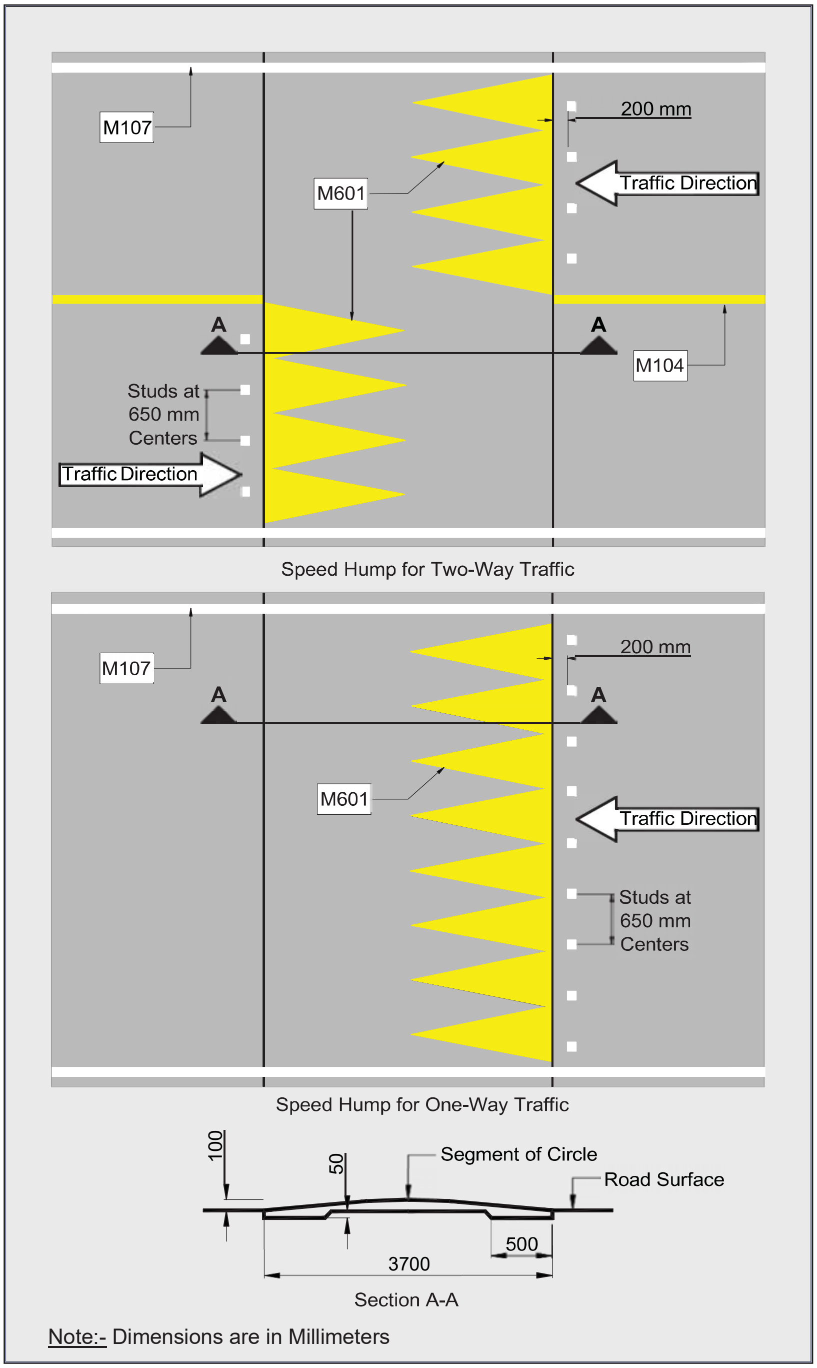


Figure 6-5 Type 1 Speed Hump Layout

Type 2 - Raised-table speed humps are appropriate for use in large, confined areas of covered and multistory parking facilities with high-volume pedestrian movements, such as parking facilities for shopping malls, souqs, mosques, sports facilities, parks, and entertainment facilities. Raised-table speed humps are used to reduce the speed of vehicles traveling at 30 kph or slower. **Figure 6-6** illustrates a typical raised-table speed hump layout for one-and two-way aisles, as well as cross section for Type 2 humps. **Figure 6-7** illustrates Type 2 raised-table speed hump layout with pedestrian crossings.

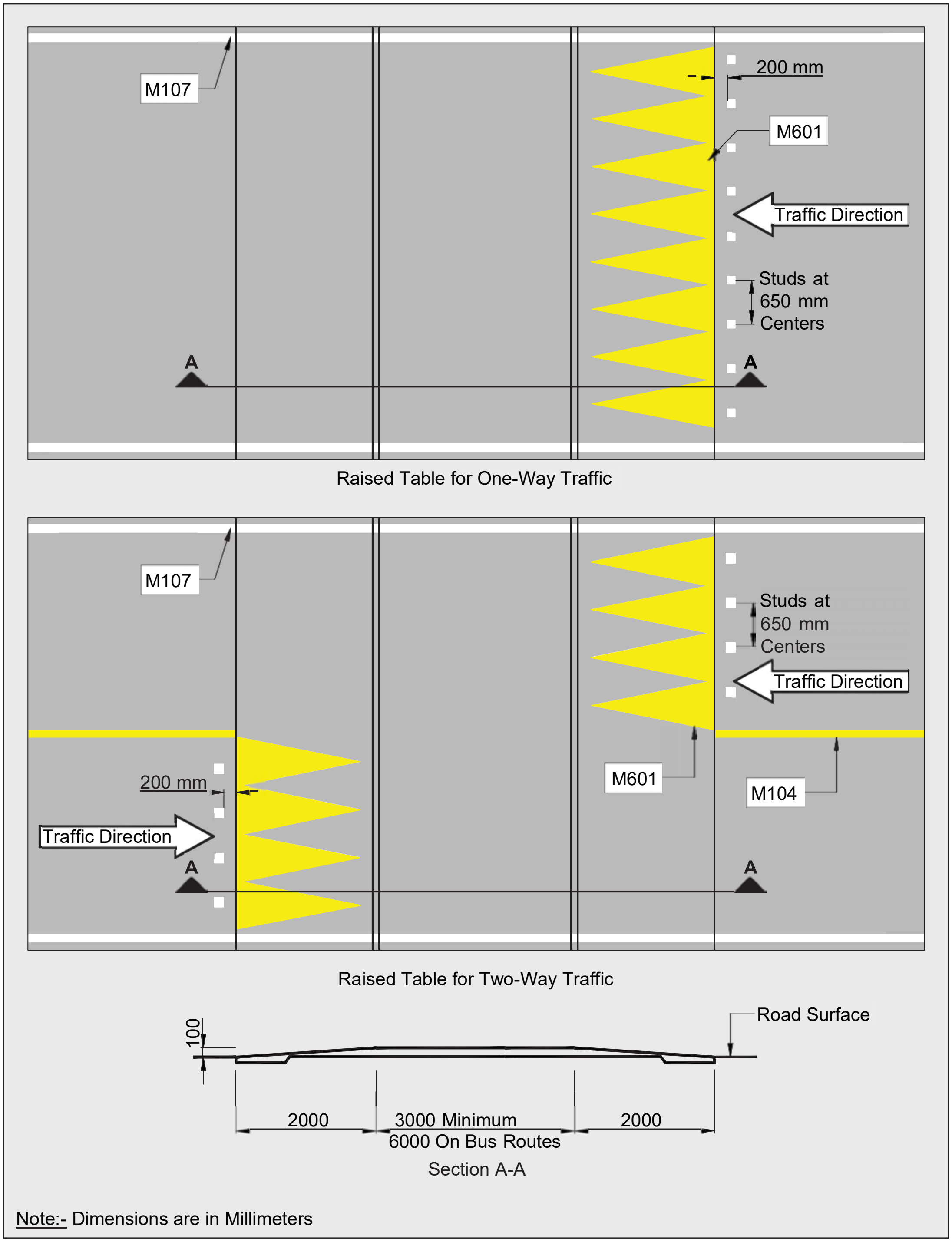
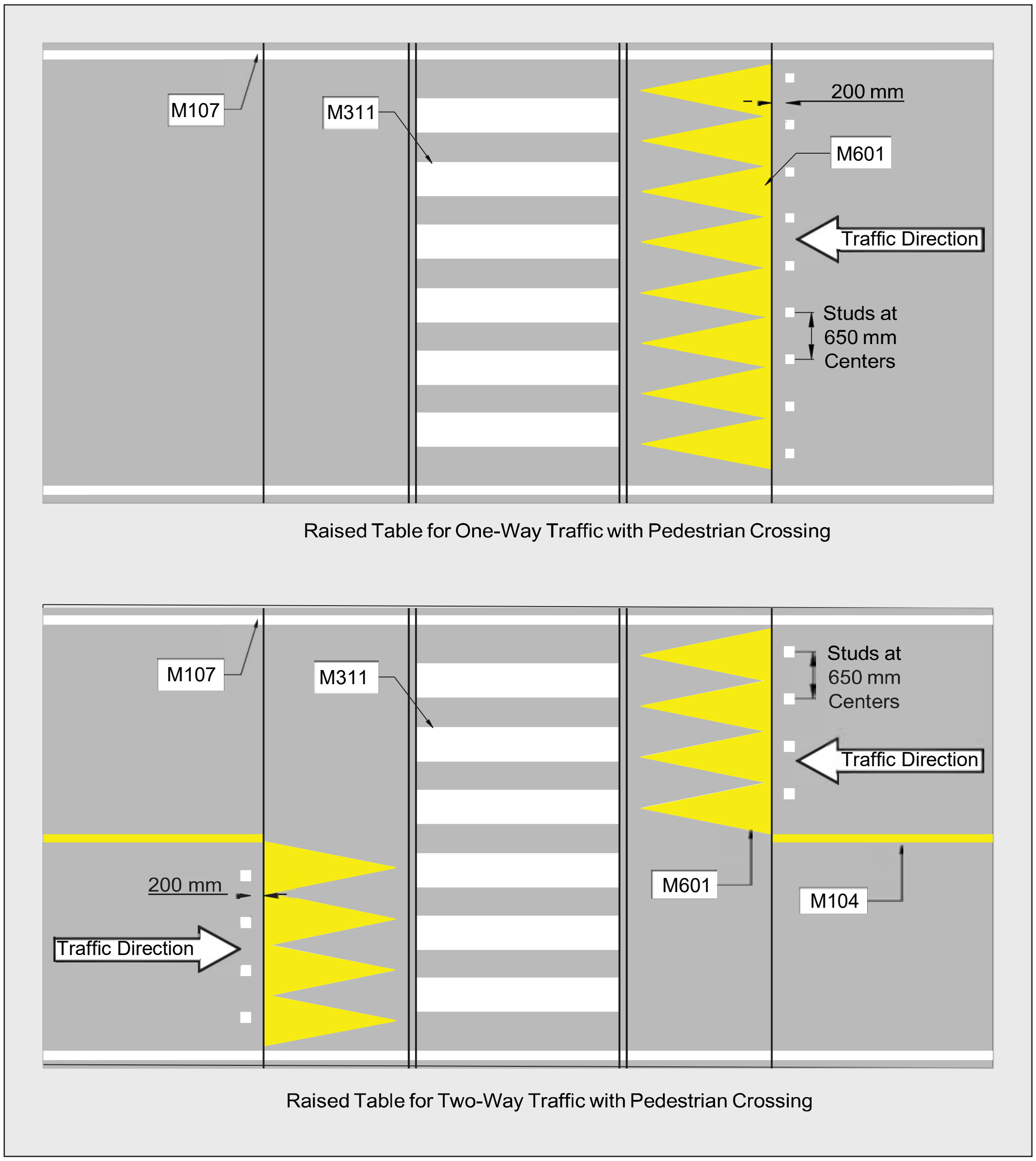


Figure 6-6 Type 2 Raised-Table Speed Hump Layout

Speed humps can be combined with pedestrian crossings in a parking lot, as shown in **Figure 6-7**.



SOURCE: QTCM Volume 2 Part 6, Section 7.2, Speed Humps and Raised Tables.

Figure 6-7 Type 2 Raised-Table Speed Hump Layout with Pedestrian Crossings

Speed humps and their markings and spacing must comply with QTCM specifications. Humps should be clear of intersections and curved roadways. Humps should not impede pedestrian or wheelchair traffic on any accessible travel path provided for people with disabilities.

Type 3 - Speed bumps are made of rubber or plastic with more abrupt (higher/shorter) dimensions than Types 1 and 2 speed humps. These are suitable for smaller, private parking facilities to ensure reasonable and consistent speed. The design for speed bumps should be customized based on site requirements. A speed bump consists of one middle section with two end caps. Key dimensions of a Type 3 speed bump are:

- Height – 50 to 75 mm
- Width – 300 mm
- Length – width of the parking aisle

Speed bumps should be round-topped or parabolic-topped. Flat-topped speed bumps are not recommended due to drivers' discomfort. The middle section includes reflective yellow and black stripes for better visibility. **Figure 6-8** is an illustration of a speed bump.

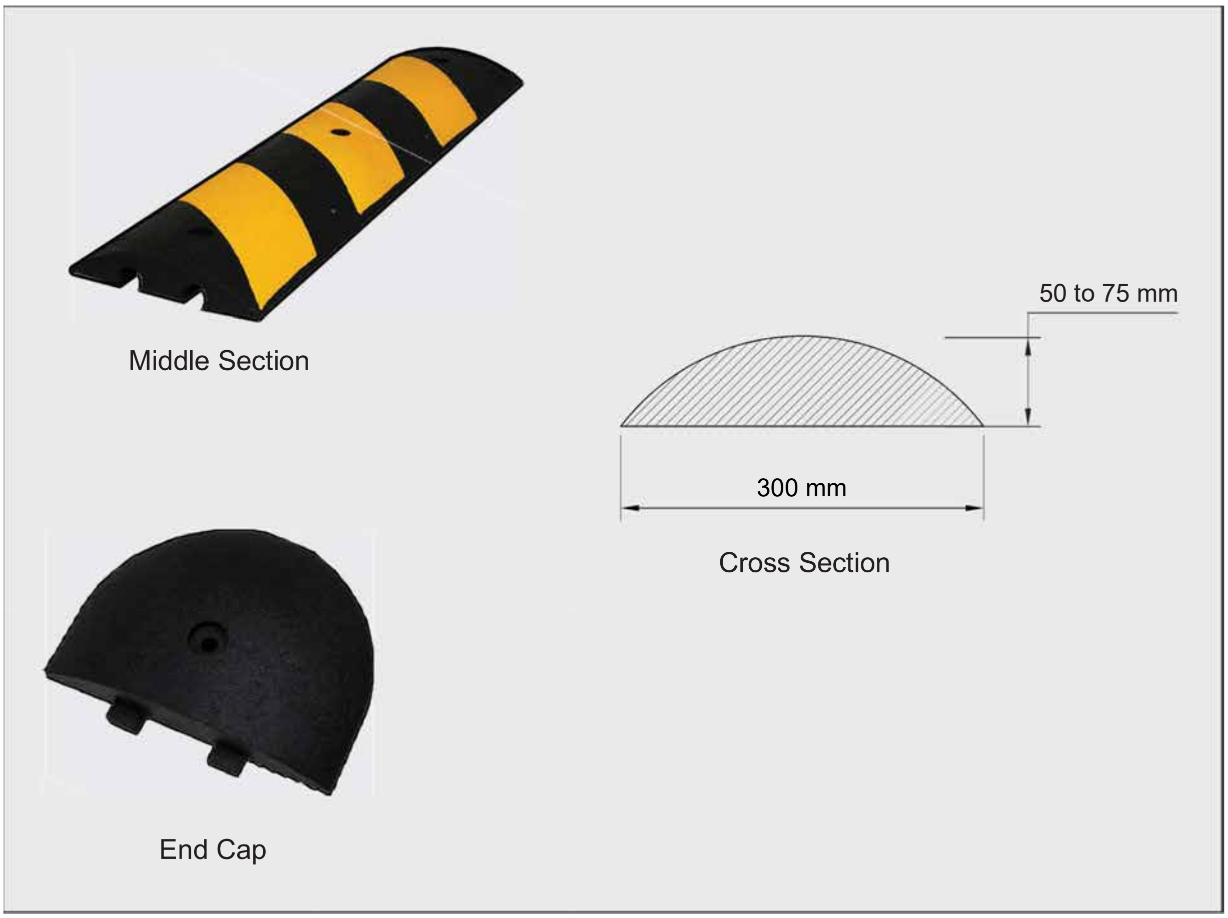


Figure 6-8 Speed Bumps

6.5 Parking Layout and Circulation Roadway

The circulation system inside an off-street parking facility is a closed traffic network. Vehicles enter this system through circulation roadways that have “no parking” on either side. They are then made to proceed either to the circulation aisles that distribute traffic across various parking sections and on to parking aisles, or directly from the circulation roadway to the parking aisles. The widths of the circulation roadways and modules (combined area of aisle and parking bays) that constitute the network are relative to the dimensions of the PDV(s). The aisles should be designed to form a logical hierarchy in order to lead vehicles efficiently from the entrance to the parking spaces and then to the exits. Elements of a typical off-street parking lot are depicted in **Figure 6-9**. This is for illustrative purposes only and the designer must calculate all necessary dimensions, according to requirements.

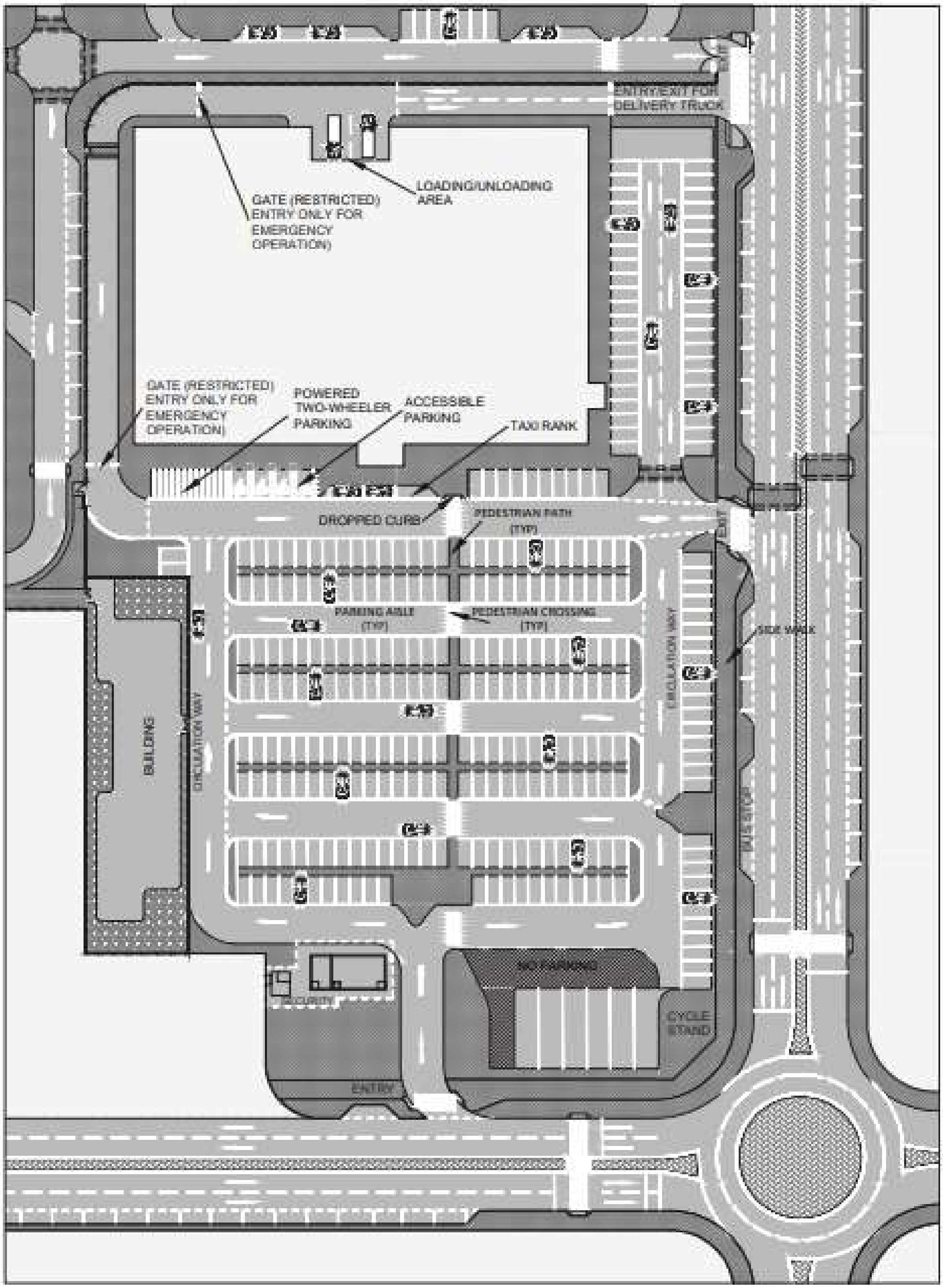


Figure 6-9 Elements of an Off-Street Parking Lot

One-way traffic requires a minimum circulation roadway width of 4.6 m. Two-way traffic requires a minimum circulation roadway width of 6.8 m (3.4 m per lane) and 3.4 m width for each additional lane. These widths should be increased at corners and intersections, allowing safe turning of the PDV through the parking facility. **Table 6-2** provides the minimum circulation roadway widths for straight roadways and ramps without any parking. Reference should be made to **Table 6-1** for parking aisle-related dimensions.

Table 6-2 Straight Circulation Roadway

No.	Minimum Straight Circulation Width (m)	One-Way Traffic	Two-Way Traffic
1	Single Lane	4.6 m	6.8 m (undivided/painted)
2	Two Lanes (or more)	6.8 m (+3.4 m for any additional lane)	Divided 6.8 m (+3.4 m for any additional lane)

See **Section 8.7.3** for details about curved circulation roads.

6.6 Off-Street Parking for Special Uses

6.6.1 Valet Parking

Curbside valet parking is frequently used in many countries, especially in the Central Business District (CBD), where parking spaces are a constraint. At present, on-street valet parking is not allowed on public ROW in Qatar. Valet parking should be located within the boundary of the property.

Valet parking could be used as follows:

- As a business strategy to provide extra convenience to customers/patrons of restaurants, hotels, clubs, retail centers, etc.
- In visitor facilities, such as meeting/convention centers, museums, and sports venues
- In hospitals and medical centers, where walking may be inconvenient for patrons
- Where significant number of disabled patrons visit
- Where walking distances to parking zones may be longer than acceptable
- Where parking a vehicle may be difficult
- Where searching for available space takes too long
- Where limited parking spaces are available and more vehicle stacking is required, such as in tandem parking spaces

Specific considerations for valet parking include:

- Identify the valet parking needs that will be served by the parking facility, as well as the specific drop-off and pick-up locations through a Traffic Impact Study (TIS).
- Develop a suitable and efficient design with an appropriate location in the parking facility for valet drop-off and pick-up locations, number of spaces to meet the demand, staking requirements, etc.
- Use signs and markings to delineate valet parking.

Valet parking improves the parking efficiency by adopting tandem parking or valet-assisted systems. The stall dimensions for both systems should be the same, as that defined in this section. Tandem parking allows retrieval of any vehicle by moving only one vehicle. Valet-assisted parking is adopted in a normal self-parking facility by parking the vehicles in parallel on one side of the aisle. The valet moves the vehicle in case it obstructs another vehicle that needs to be retrieved and uses the newly vacant space to park the blocking vehicle. Where valet parking is considered, specific valet parking requirements need to be determined and included in the design of the parking facility. A typical valet parking/valet assisted parking system compared with self-parking is presented in **Figure 6-10**.

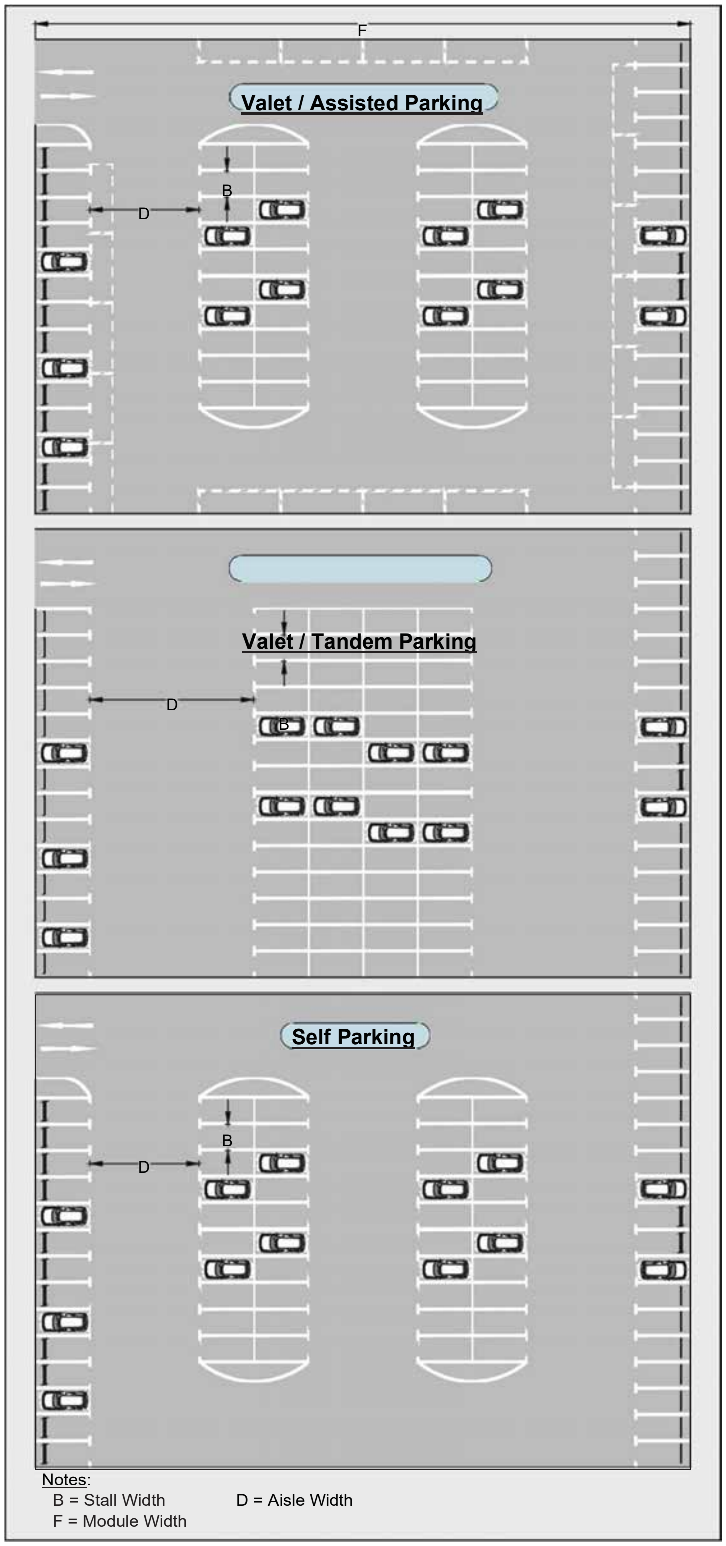


Figure 6-10 Valet and Valet-Assisted Parking Compared to Self-Parking in the Same Facility

The following points should be adhered to when exclusive valet parking is being planned:

1. For valet parking, only markings should be changed, and no separate design will be allowed.
2. Tandem parking indicated in **Figure 6-10** is for reference purposes only.
3. The layout for valet parking should be temporary by nature. Valet parking areas should easily convert to a typical self-parking facility.
4. Developer should provide the justifications and layout for valet parking.
5. For developments contemplating the use of valet parking, space for the valet pick-up should be delineated from the dedicated passing lane for self-parking users.
6. Valet pick-up area should be close to the entrance and can be identified separately from a general pick-up and drop-off area.
7. Valet parking should not interfere with emergency access or vehicular circulation.
8. Valet parking operations must be contained within the site and should not cause queuing across any adjacent roadway.

6.6.2 Taxi Ranks

Taxi ranks in off-street parking are associated with land uses, like malls, hotels, and hospitals, where exclusive taxi parking provisions are made. The following points shall be considered in planning taxi ranks:

1. The pick-up and drop-off location should not interfere with each other.
2. The pick-up location should be close to an entrance point to the development being served.
3. A separate taxi queuing area should be identified so that it does not interfere with parking or circulation of self-parking vehicles.
4. Dedicated space for boarding in a taxi should be maintained.
5. Appropriate signs are needed to direct passengers to taxi ranks.
6. Pedestrian paths including that for wheelchair movement and dropped curbs must be in line with **Section 12**.
7. Signs and pavement markings should be in line with **Section 17**.

6.6.3 Passenger Pick-Up and Drop-Off

Pick-up and drop-off areas for passengers are an important feature for many commercial uses, hotels, theaters, and especially, for hospitals. Drop-off zones should be integrated into the site design as part of the TIS. They should have pavings that visually separate vehicles and pedestrians, and that are conveniently located near building entrances.

Passenger pick-up and drop-off facilities should allow for pick-up and drop-off close to the main entrances, be secured and well lit, and should incorporate facilities for waiting passengers, such as shelters and seating arrangements. They should be designed sufficiently wide to safely allow for good traffic circulation and curb space turnover. It is a good practice to consider the characteristics of the location and extent of the catchment area to estimate the number of people who would likely be picked up or dropped off. Queuing areas should also be carefully designed as part of the site plan to ensure that the vehicle-stopping area for the drop-off zone does not block the traffic in the drive aisle, or spillover on to the public roads.

If the demand for parking exceeds the supply, then more users are likely to adopt drop-off service. A study is recommended to determine the passenger drop-off demand before designing drop-off areas. The drop-off areas should accommodate expected queues within the boundaries of the development, without spilling over on to the public Right-of-Way (ROW).

6.6.4 Commercial Pick-Up and Drop-Off

Concept designs of commercial pick-up/drop-off areas should be given careful consideration in terms of the integration of the different modes of transportation, circulation, accessibility, wayfinding, and pedestrian safety.

The following factors should be considered during the preparation of design options:

1. Parking requirements
2. Pick-up/drop-off area within the property boundary and not in public ROW
3. Traffic circulation within the parking zones
4. Accessibility and connectivity to the main roads
5. Public transport stop/station locations and vehicle layover areas
6. Dedicated bicycle storage areas
7. Safe pedestrian crossing locations
8. Taxi drop-off and pick-up locations and taxi ranks (queuing areas for waiting taxis)
9. Valet parking (within property boundary)

6.7 Other Off-Street Parking Elements

The design guidelines for other off-street parking types and related elements are discussed in detail in separate sections of this manual as referenced below:

1. Access control elements: **Section 7**
2. Parking structures: **Section 8**
3. Parking support infrastructure: **Section 9**
4. Accessible parking: **Section 11**
5. Pedestrian access: **Section 12**
6. Bicycle parking: **Section 13**
7. Powered two-wheeler parking: **Section 14**
8. Bus parking: **Section 15**
9. Commercial vehicle parking: **Section 16**
10. Signs and marking: **Section 17**
11. Construction elements: **Section 20**

Section 7

Access Management

7: Access Management

Access management is the application of roadway design and traffic operations concepts to access land uses from roadways. The purpose of access management is to provide vehicular access to land uses in a manner that promotes safety and efficiency of the transportation system. This section provides a general overview of the access management, pertaining to parking, and offers guidance on access requirements, driveway design, access control components, and access control areas. Guidelines, directions, techniques, and procedures prescribed in Site Planning Requirements for Proposed Developments as well as Guidelines and Procedures for Transportation Studies (GPTS) must be fully adhered to in assessing the access management requirements. It is advised to coordinate with the Overseeing Authority for further clarifications and to seek advice.

Access management techniques are based on established traffic engineering and roadway design principles and includes:

1. Limiting and separating conflict points
2. Reducing vehicle acceleration and deceleration impacts at access points
3. Separating turning vehicles from the through lanes
4. Providing adequate on-site circulation and storage
5. Eliminating queue backing up into adjacent roadways

7.1 Access Requirements

This section covers key elements of planning for access to parking, covering functional classification of roads, site distance considerations, queueing requirements, pedestrian needs, grades, and safety at intersections. All access to off-street parking facilities should be designed and clearly identified as an access driveway or intersection. The entry/exit of off-street parking facilities at an intersection should be designed in compliance with public roadway design standards, with all necessary traffic control devices that follow the intersection geometric design requirements. Key considerations are explained as follows:

Road Functions

1. Direct access is prohibited on freeways, arterials, or expressways.
2. For developments that border multiple functional classes of roads, access should be from a road of the lowest functional class.
3. Access must be designed so that vehicles can exit in the same direction of traffic flow.
4. Parking areas should be close to collector roads and have good accessibility to arterial roads through service roads to minimize traffic intrusions. As an example, for shopping centers located on major arterial roads, access to parking areas may need to be channelized through one-way service roads.

5. The exit roads may be up to three or four lanes wide, depending on peak outflow demand and the type of access control system. Traffic control signals, where warranted, should be enabled in areas where two or more exit lanes are provided, particularly to higher category roads with high traffic flows.

6. All the entrances and exits must be dispersed to take advantage of existing side streets, where possible. Congested roads should be avoided, if possible, for any entrance and exit.

7. For one-way streets, parking entrances and exits must be aligned with the direction of the street. The ideal arrangement is to place the entrance on an inbound route and the exit on an outbound route.

Sight Distance

1. Adequate and safe stopping distance according to QHDM Vol. 1, Part 3, Section 2 should be incorporated into the design of driveway access to minimize vehicle/pedestrian conflict and disruption to through traffic.

2. No obstruction is permitted within the sight triangle (vegetation, poles, boards, signs) and there should be an absence of vegetation or obstruction above driver eye height of 1.08 m.

3. Parking is prohibited within the sight triangles of an intersection with a main roadway within 6.0 m of the Point-of-Tangent (PT) curb radius and the straight curb line on the principal road, as well as at the end of the parking bay taper on the principal road for posted speeds up to 50 kph.

Queuing

1. The entrances and exits of all major parking lots should give way for turning movements away from intersections and provide sufficient queuing space inside the lot to prevent vehicle stacking in the street. A traffic flow and queuing analysis should be conducted as part of the parking lot/structure planning and design process to establish the required entry and exit lanes' capacities and the length of queue storage areas.

2. The impact of increased traffic flow on the performance of surrounding roads should be identified in the Traffic Impact Study (TIS) process as part of the traffic flow and queuing analysis.

Pedestrian Considerations

1. The design of the driveway should convey to the drivers that priority is to be given to the pedestrians and adjacent road traffic.

2. Access driveway curbs and sidewalks should be continuous through the intersection with the frontage road.

3. Identification of adjacent sidewalk, bicycle lane needs, as well as pedestrian and non-motorized user safety measures at the entrance/exit of the parking facility should be done.

4. Pedestrians should not be allowed to walk across an arterial road at-grade to get from a parking facility to their destination. In such areas, grade separation or pedestrian crossings should be considered.

5. Sidewalks should be provided for pedestrians, and the design of access driveways must ensure that they are prioritized. Best practice requires that disabled access should not be compromised, especially near crosswalks. In areas where driveways are provided at-grade, they should be designed to be flush with the sidewalk, without any difference in the level. Curbs across the sidewalk must only be permitted where the driveway is controlled by traffic signals. In instances where more than two adjacent driveways are necessary, a pedestrian refuge at the outside sidewalk crossing should be provided.

6. The pedestrian and vehicular traffic at the entry/exit locations must be separated by effective physical means (e.g., bollards, curbs, railings). These physical means for pedestrian/vehicle separation must be clearly visible to drivers when seated in a normal driving position.

7. The queuing area provided at the entrance between the vehicular access control location and the property boundary must be sufficient to allow a free inflow of traffic. It should not adversely affect traffic or pedestrian flows on the frontage road. This is described further in **Section 7.4**.

Grade

1. Access driveways and ramps must be graded at all the entrances and exits to easily allow vehicles to cross the sidewalk and enter traffic on the frontage road. **Table 8-7** may be referred to for appropriate ramp grades for circulation roadways and ramps. Driveways and access ramps to parking lots should not exceed a 12.5% grade. Refer to **Section 8** for the guidelines related to "Off-Street Parking Structure," including grade requirement within a parking structure.

Driveway Intersection with Roadway

1. Parking access driveways and adjacent road intersections should be designed as priority intersections. Where feasible, left turns to and from the parking driveways on collectors and arterial streets should be restricted. Driveways, including dedicated auxiliary left and/or right turn lanes, storage for the turn lane, and taper, should be designed following the QHDM, Vol 1, Part 6, Design for Priority Intersections.

2. The American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM) 2010 provides crash modification factors (CMF) for installation of left turn lanes on intersection approaches. **Figure 7-1** provides the predicted annual crash frequency at a simple T-intersection, and **Table 7-1** shows the estimated crash reduction associated with adding a left turn lane. It is recommended that the safety auditor should consider these values for assessing the safety hazards and ensure that suitable design recommendations are made. Refer to **Section 21** for safety auditing.

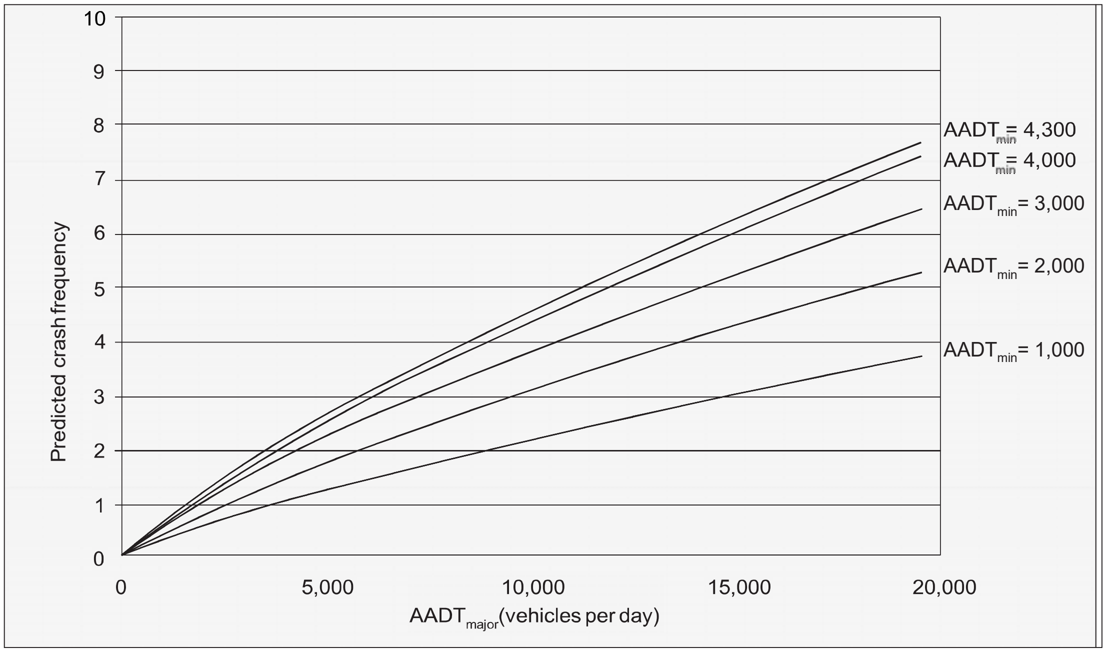


Figure 7-1 T - Intersection - Predicted Annual Crash Frequency

Table 7-1 Added Left Turn Lane Predicted Annual Crash Reduction

		AADT on a Major Road (vpd)									
		500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
AADT on a Minor Road (vpd)	500	0.07	0.11	0.16	0.20	0.23	0.27	0.30	0.34	0.37	0.40
	1,000	0.09	0.16	0.22	0.27	0.33	0.38	0.43	0.48	0.52	0.57
	1,500	0.11	0.19	0.27	0.34	0.40	0.46	0.52	0.58	0.64	0.69
	2,000	0.13	0.22	0.31	0.39	0.46	0.53	0.60	0.67	0.73	0.80
	2,500	0.14	0.25	0.34	0.43	0.51	0.59	0.67	0.74	0.82	0.89
	3,000	0.16	0.27	0.38	0.47	0.56	0.65	0.73	0.81	0.89	0.97

NOTE:

Crash Reduction:

- Less than 1 crash in 5 years
- Up to 1 crash in 4 years
- Up to 1 crash in 3 years
- Up to 1 crash in 2 years
- Up to 1 crash per year

*SOURCE: Based on **Figure 7-1** above and Table 10-13, "Crash Modification Factors (CMF) for installation of Left-turn Lanes on Intersection Approaches," in HSM, Volume 2, Chapter 10 (AASHTO 2010.).*
AADT – Annual Average Daily Traffic
vpd – Vehicles per Day

3. QHDM Clause 2.2.3.1, Volume 1, Part 6 notes that a left turn lane is warranted on a two-lane roadway based on the potential reduction in crashes per year. According to the QHDM, access driveways with dedicated left turn lanes are not warranted if the expected crash reduction is less than one crash in 5 years. Left turns at the driveways on multilane roads are typically prohibited according to the QHDM, Volume 1, Part 6. The Overseeing Authority reserves the right to require a left turn lane at a two-lane road priority intersection on a case-by-case basis.

4. The QHDM, Clause 5.3.1.1, Volume 1, Part 6, notes that diverging/right-turn auxiliary lanes should be provided as appropriate under the following conditions in the design year (also applicable to driveway access):

   I. Volume of right-turning traffic is greater than 600 vehicles AADT (one way).

   II. Percentage of heavy trucks is greater than 20% and the volume of right-turning traffic is greater than 450 vehicles AADT (one way).

   III. Intersection grade on an uphill or downhill is greater than 4 percent, and the volume of right turning traffic is greater than 450 vehicles AADT (one way).

   IV. Traffic flow on the major roads is greater than 7,000 to 8,000 AADT (one way); the figures given in Conditions I through III for turning traffic may be halved.

   V. The Overseeing Authority reserves the right to require a right turn lane on a case-by-case basis.

7.2 Access Driveway Design

7.2.1 Access Driveway Planning

Parking facilities should be designed to limit the number of entrance and exit driveways. A site circulation plan must be designed with efficient access and circulation system that serves the development. It is expected that access arrangements of the abutting plots are duly considered to avoid any negative impact.

Development sites under the same ownership with phased development plans or properties consolidated for development should be considered as one property for the purpose of access management. Where multi use development is planned, separate access for noncompatible use should be considered without creating conflicts and by following the considerations stated in **Section 7.1**.

The number of connections permitted will be the minimum number of connections necessary to provide reasonable access to the site, as illustrated in **Figure 7-2**.

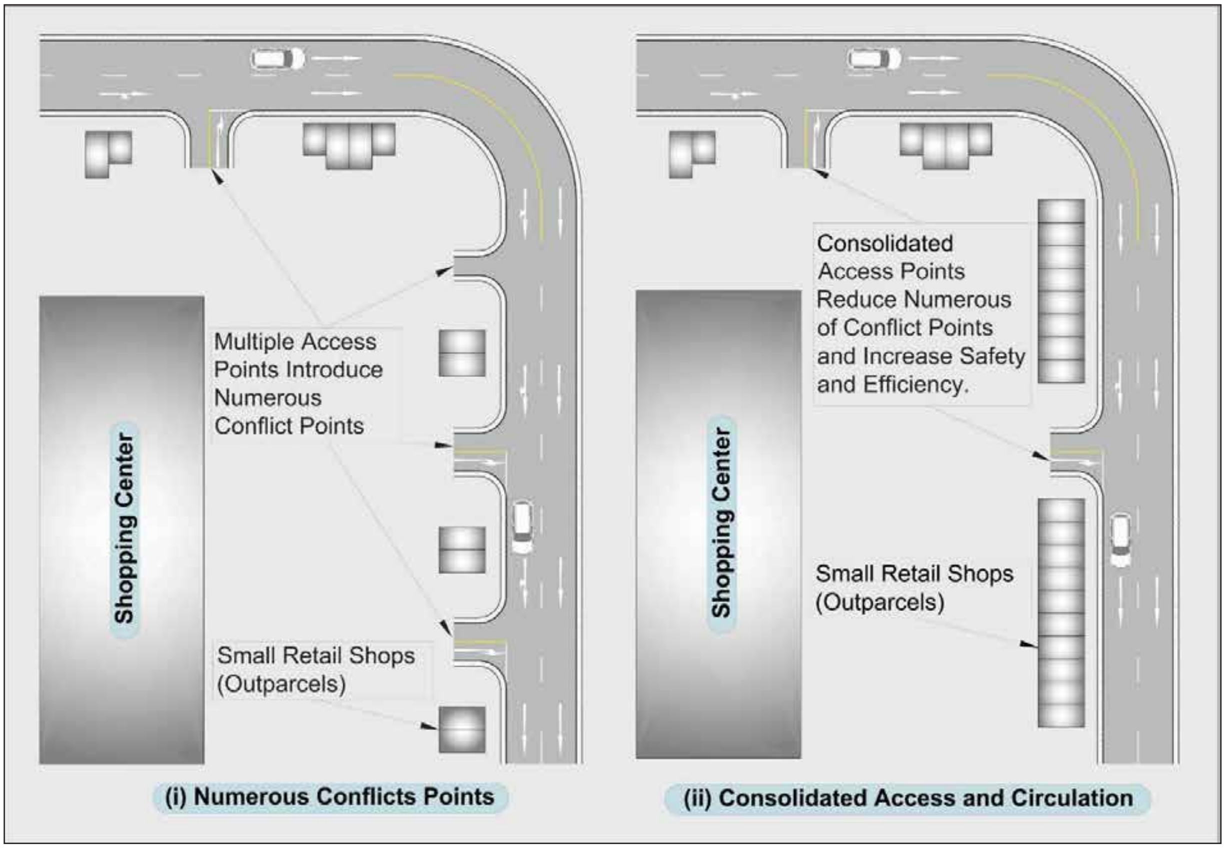


Figure 7-2 Integrated Access Design

Widening at the intersection with a frontage road is recommended to allow turning movements from the curbside lane, without adversely affecting the traffic flows on the frontage roadway. Where the entry and exit driveways are not separately provided, they should be at least 1 m apart.

Larger parking facilities may require multiple access and egress points. The spacing between the driveways must be coordinated with the Overseeing Authority and the following points should be considered:

- Location - Driveways must be located in such a way that they do not affect the traffic operations on the roadway, or impact safety. Driveways must be clearly visible and meet the sight distance requirements of the adjacent roadways. Where access is to be provided for private development or residential driveways from local roads, the designer should use sound engineering judgment to determine and apply the sight distance required, considering traffic volumes and speed on the major roads, traffic volumes of the private access/driveways, and the level of service required.

- Driveways should not be placed within the functional area (refer to **Section 5.2**) of an intersection or roundabout.

- Parking access driveways that are staggered with a driveway on opposite sides of the roadway must be located at least 50 m away from the opposite driveway. In case this distance is not achievable, the Overseeing Authority reserves the right to make the final decision.

- For a development with multiple parking access driveways, the driveways must be spaced so they act independently of each other. Driveway spacing depends on the design speed of the roadway. Guidance related to the minimum spacing between adjacent driveways is presented in **Table 7-2** and is in accordance with QHDM, Clause 1.4.10, Volume 1, Part 5. The spacing between adjacent driveways should not be less than 50 m under any circumstance.

Table 7-2 Minimum Driveway Spacing

Design Speed (kph)	Minimum Spacing (m)
50	60
60	80
70	105

SOURCE: QHDM, Volume 1, Part 5, Section 1.4.10, Driveways

7.2.2 Number of Access Lanes

The number of driveway access lanes depends on the volume of vehicles entering the parking facility. General requirements for the number of access lanes and reservoir areas, are shown in **Table 7-3**. It is a good practice to provide one more lane than the minimum requirement shown in the table below to maintain access in the event of any disruption caused by an access equipment failure or vehicle break down.

Table 7-3 Required Driveway Access Lanes

Type of Lanes/Area	Required Number of Lanes
Entrance Lanes	Short-term parking: 1 lane per 300-600 spaces
	Long-term parking: 1 lane per 300-500 spaces
Exit Lanes	Short-term parking: 1 lane per 250 spaces
	Long-term parking: 1 lane per 200 spaces
Inbound Reservoir Area	Free flow entry: 1 space per entry lane
	Ticket dispenser entry: 2 spaces per entry lane
	Entrance cashier: 8 spaces per entry lane
	Attendant parking: 10% of parking capacity served by each entry lane

7.2.3 Throat Length

Throat length is defined as "the distance between the edge of the crosswalk or that of the main roadway, whichever is closest to the nearest parking circulation roadway within the parking facility perpendicular to the access driveway." Throat length should be calculated on a case-by-case basis as part of the site planning, allowing for adequate clearances from parcel lines and the ROW. Inadequate throat length of a driveway connected to a parking area produces a complex pattern of closely spaced conflicts, as represented in **Figure 7-3**. In case the parking layout is such that the vehicle(s) vacating the parking space blocks the driveway, it may result in high collision potential and low capacity, and it may prevent other vehicles from entering the facility. Adequate throat length should be provided for all parking facilities.

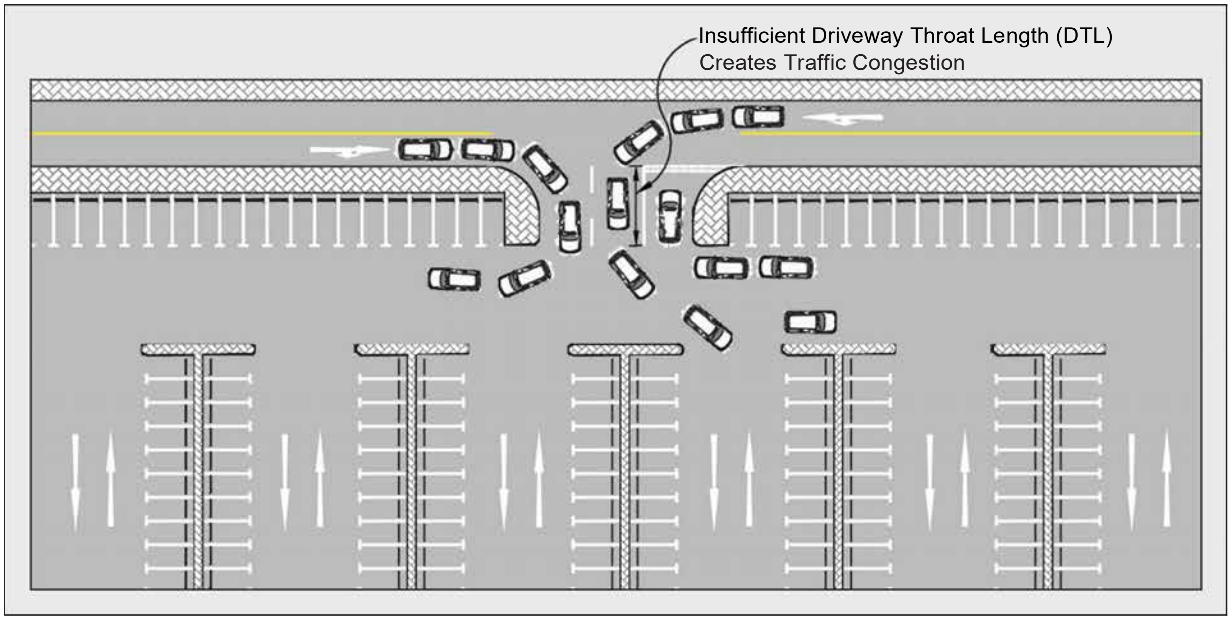


Figure 7-3 Inadequate Entry Throat Length

Driveway throat length should be sufficient for an incoming vehicle to clear the sidewalk, before it stops and waits for a parking vehicle, using the first space to clear the driveway throat (**Figure 7-4**). The figure also shows that if adequate driveway throat length is provided, it allows a left-turning vehicle to clear the opposing traffic lane. The driveway should have sufficient throat length to minimize conflicts between vehicles turning into the driveway or maneuvering in or out of parking spaces off the driveways.

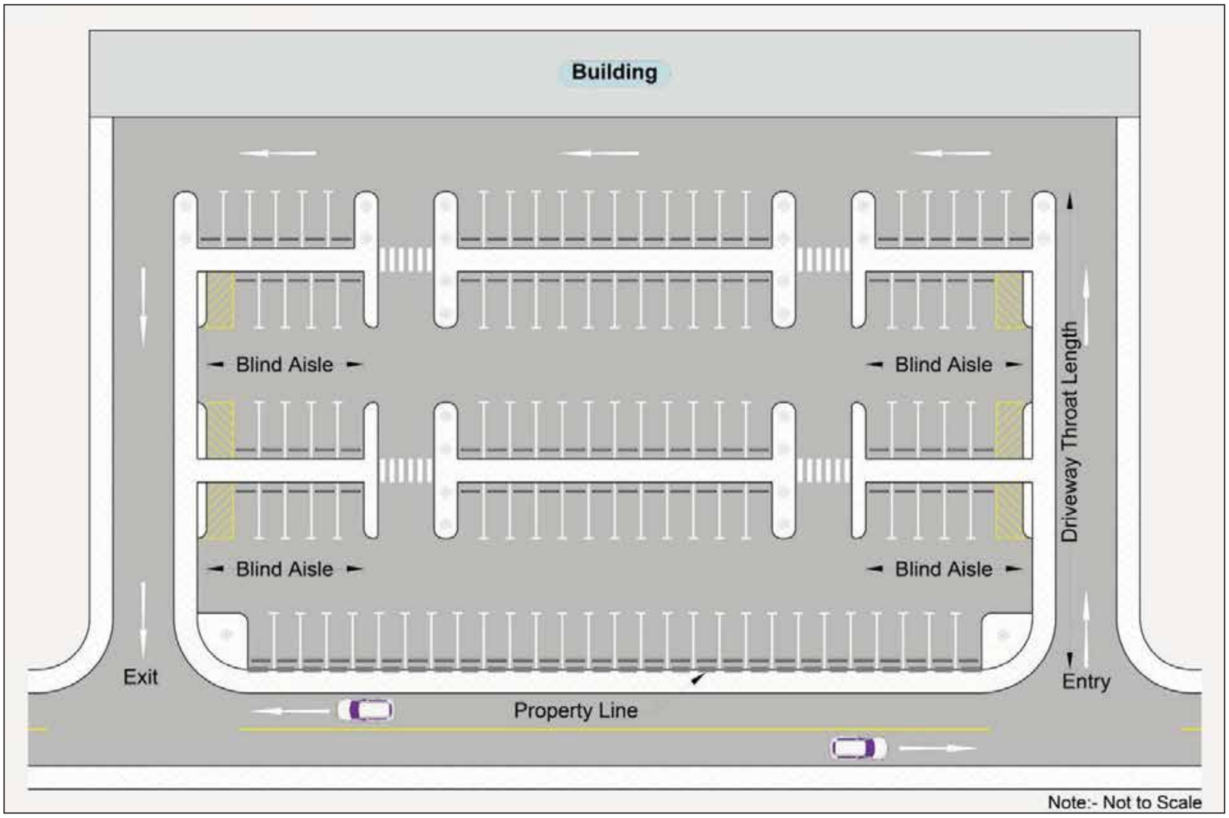


Figure 7-4 Driveway Throat Length

Throat length depends on parameters such as nature of operations, area of development, number of parking spaces provided, and surrounding developments, and it is estimated as part of the Traffic Impact Study (TIS). Values given in **Table 7-4** provide generally adequate throat lengths for specific development types. Actual throat lengths are to be assessed by the designer based on the TIS. Any proposal for a throat length less than 15 m may be considered as a departure from standard and should be approached as described in **Section 22**.

Table 7-4 Typical Throat Lengths for Selected Development Types

Development Type	Minimum Throat Lengths (meters)
Regional Shopping Centers (malls)	75
Urban mall, local shopping center, hypermarket	40
Petrol Stations	50
Schools	55
Parking garages	40

7.2.4 Driveway Geometric Elements

Driveway geometric parameters depend on the type of driveway. QHDM, Volume 1, Part 5, identifies types of driveways, such as residential, commercial, and industrial. The volume of traffic entering the parking facility is also a factor in driveway geometrics. The selection of the design vehicle for driveway access design is determined by the driveway type. The design vehicle establishes the minimum width of the driveway and turning radius. **Table 7-5** lists the recommended dimensions from QHDM, Clause 1.4.10, Volume 1, Part 5.

Table 7-5 Driveway Geometric Requirements

Type of Driveway	Design Vehicle	Width of Driveway (m)		Radius of Driveway[1] (m)	Longitudinal Driveway Grade[2] (Percent)
		One-Way	Two-Way		
Residential	PDV	3.65	7.30	4.50	6.67
Commercial	SU-12	5.00	8.00	7.50	6.67
Industrial	WB-12	5.00	8.00	10.50	5.00

[1] Driveway Radius return treatments are preferred. A flared treatment is acceptable for residential drives.

[2] Absolute maximum grade should be 12.5% (1:8).

SOURCE: Adapted from QHDM, Volume 1, Part 5, Section 1.4.10, Driveways

Where the driveway crosses a pedestrian path or bicycle lane, the crossfall on the pedestrian path or bicycle lane should be maintained (typically 2%), except for curb ramp areas.

7.3 Access Control Components

Adequate number of access lanes should be provided for a parking facility to accommodate normal peak traffic volumes, which conforms with the recommendations made in **Section 7.2.2**.

The following guidelines should be applied:

1. Access approach to ticket machines and barrier arms should be 6.0 m in length, straight, and preferably, level.
2. Width between curb and barrier arms or payment machines should not exceed 2.5 m, so as to allow width of the PDV as well as some applicable clearance (refer to **Figure 4-2**).
3. There should be adequate space for a lay-by in advance of the exit to allow drivers who do not have correct cash amounts for the machine, or have lost their ticket, or (on a “pay-on-foot” system) have forgotten to validate their ticket at the pay station.
4. Reservoir space should be provided between the exit barrier and the road so that the exiting vehicles can pull forward and not impede upon the exit barrier operation.
5. Queuing space should be provided at the entry to prevent vehicles waiting at the entrance barrier from queuing back on to the road.

6. There should be sufficient dynamic barrier capacity at all the entrances and exits, for anticipated traffic flow. It is advisable to provide one barrier more than the minimum number required to allow for parking equipment failure or vehicle breakdown.

7. The ticket equipment should be located within the reach of the driver. A location directly above the curb face is generally suitable for a straight approach. The height of the transaction console should be 1.1 m.

8. Ticket machines or pay kiosks should be located at least 3.0 m in advance of a barrier arm.

9. Storage to accommodate queuing at the entry points should be considered in the design of the parking facility access. Assumed capacities of the various access and egress controls are shown in **Table 7-6**. Refer to **Section 7.4** and **Table 7-7** for additional information on queue length and capacity calculation for a parking facility.

10. Queue storage length of 6.0 m per vehicle should be considered to accommodate the expected queue.

Table 7-6 Access Control Capacity

Type of Entry	Average Flow (Sec/Vehicle)	Capacity (Vehicles/Hour/Lane)
Free-flow access to internal distributor road/parking structure (no parking spaces immediately after access with ramp distributing to several levels of a parking structure)	3.6	800
Free-flow access (with adjacent parking)	5.0	580
Lifting-arm barrier without ticket issue (loop or other detection)	5.5	550
Lifting-arm barrier with automatic ticket issue (push button)	8.0	360
Lifting-arm barrier with access card (slot-based)	12.2	235
Lifting-arm barrier with transponder (Radio Frequency Identification [RFID])	7.5	380
Type of Exit	**Average flow (Sec /Vehicle)**	**Capacity (Vehicles/Hour/Lane)**
Ticket on entry and payment at a manned exit	19.5	150
Ticket on entry and variable payment by machine linked to the exit barrier	13.3	215
Ticket on entry and operation of the exit barrier with a prepaid ticket token	9.0	320
Free-flow exit		Analysis based on specific road layout

SOURCE: Adapted from The Institution of Structural Engineers, UK, "Design Recommendations for Multi-story and Underground Car Parks", 4th Edition, 2011 and SEMINAR '72" Los Angeles Parking Association, "Entrance-Exit Design and Control for Major Parking Facilities," 1972

7.3.1 Access Control Layout

Access control layout and location of all the entrances and exits in a parking facility is subject to a TIS. It also depends on the technology used for detection and access control.

Access to the parking facility could be:

1. Uncontrolled
2. Controlled
    a. Manual Access Control
    b. Automated Access Control

The principles of detection and payment are the same, regardless of the access control type and the technology used.

Detection can be in the form of any of the following, or a combination of the following:

1. Manned kiosk
2. Induction loops
3. Cameras
4. Manual card readers
5. Automated card readers with transponder
6. Automated detection with license plate recognition (LPR)

For an example of a typical layout with a manned kiosk and induction loops, refer to **Figure 7-5**. The exact layout and location should be determined as part of a completed TIS. Apart from the features shown in **Figure 7-5**, where required, LPR cameras can be in front of the barrier, within the island. This figure is developed for the Parking Design Vehicle (PDV). If other vehicles (refer to **Figure 4.4**) are expected to use the facility, appropriate design modifications should be made to comply with the process explained in **Section 4.**

The various induction loops used in the example, found in **Figure 7-5**, are described as follows:

Safety Loops

Induction loops used for safety are built to prevent barriers from raising or lowering while a vehicle is over the safety loop.

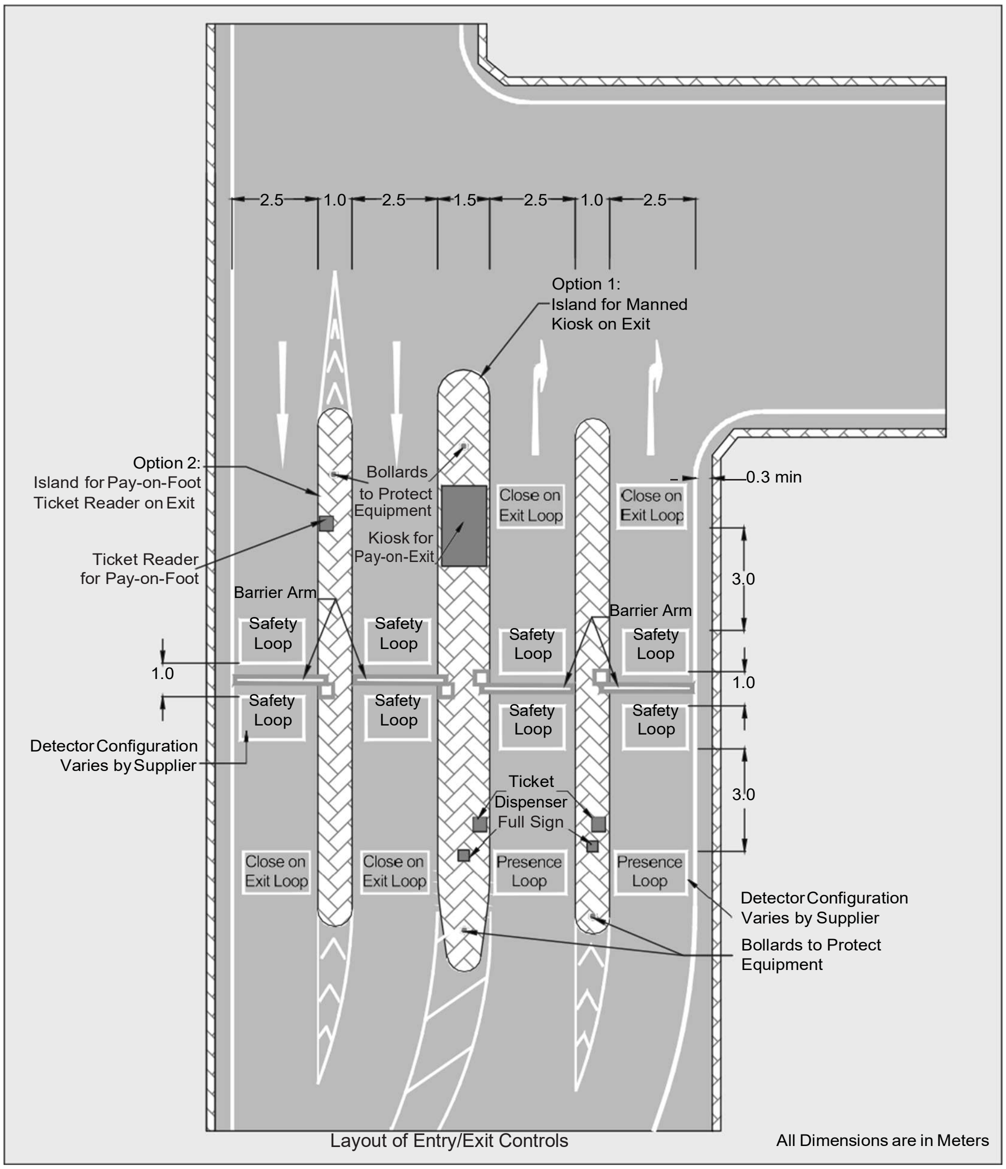
Presence Loops for Card Readers

Presence loops detect a vehicle at the card reader. The presence of a vehicle can also be detected with a LPR or a transponder.

Close-on Exit Loops

Close-on exit loops ensure that an existing vehicle has cleared the barrier, so it can be safely closed. A close-on exit loop should be located appropriately, allowing the PDV to completely clear off the barrier.

Adjacent loops should be at least 1 m apart, to prevent interference from adjacent loops.



SOURCE: Adapted from The Institution of Structural Engineers, UK, "Design Recommendations for Multistory and Underground Car Parks", 4th Edition, 2011

Figure 7-5 Access Control

7. Access Management

7.4 Access Queuing Areas

The type of access control impacts queuing and entrance/exit design. A queuing assessment is required for both the entrance and the exit, as part of a TIS. This section discusses the entrance elements. The same principles should also be applied to all the exits as well. Adequate area for the queue lengths should be provided for a parking facility to accommodate peak queues. Parking characteristics should be carefully evaluated, focusing on daily/seasonal variations. Queuing should be completely accommodated within the facility, and any spillover to adjacent streets must be prohibited.

The queuing area at an entrance or pay station between the vehicular control point and the property boundary at an entrance must be sufficient to allow a free flow of traffic that does not adversely impact traffic or pedestrian flows on the frontage road. No parking space maneuvers should be allowed to take place within the queuing area.

The length of the queuing area should be determined by considering the following:

1. Traffic volume on surrounding streets
2. The number of parking spaces in the parking lot
3. Anticipated peak entry/exit vehicle flow
4. Rate of vehicle entry/exit
5. Hourly parking volumes and turnover

In the absence of more specific guidance, the queuing area should be calculated from **Table 7-7** for a parking facility with boom gates and ticket-issuing devices at the entrance.

Table 7-7 Typical Queuing Lengths for Parking Facilities with Controlled Entrance

Capacity of the Parking Facility[1]	Peak Hourly In-Flow of Traffic	
	Up to 75% of Capacity[2]	More than 75% of Capacity[3]
<100 cars	The greater of a minimum of 2 cars or 3% of capacity	The greater of a minimum of 2 cars or 4% of capacity
100-200 cars	1st 100 cars: 3% of capacity 2nd 100 cars: 2% of capacity Additional cars: 1% of capacity A minimum queuing length of 3 cars/lane	1st 100 cars: 4% of capacity 2nd 100 cars: 2% of capacity Additional cars: 1.5% of capacity A minimum queuing length of 3 cars/lane

NOTE:

1 *Equal to the total number of parking spaces served by the entrance and proportioned where several entrances service a common parking area*
2 *Generally casual (short-term) and mixed patronage*
3 *Tidal traffic, typical of parking for a special event*

A detailed queuing analysis is desirable for facilities with more than 200 car parking spaces.

The number of cars calculated from **Table 7-7** should be rounded up to the next whole number, and a length of 6.0 m per vehicle should be allowed for in each lane.

In addition to the criteria for determining the length of the queuing area, the following parameters should also be considered while designing the queuing area:

1. The queuing area in parking lots with an attendant should be at least twice as long as the length provided in **Table 7-7**.

2. An adjacent, 2.0 m wide breakdown lane must be provided on one side of a single queuing lane.

3. If multiple lanes are provided, then each queuing lane should be a minimum of 2.5 m wide for the PDV.

4. Queuing areas in parking lots with multiple entrances should be based on the expected forecast directional peak hour traffic volumes served by each entry point.

The exit lanes should be carefully configured to ensure circulation within the parking facility and must not be impacted by queuing at the exit or the exit control. The queuing at the exit will depend on the nature of the facility, parking characteristics, and peak volumes at the exit. The queuing requirements at the exit should be assessed in the TIS. Information provided in **Table 7-6** can be considered as guidance for planning the exit requirements.

Section 8

Design of Parking Structures

8: Design of Parking Structures

This section provides the guidelines for designing the underground and multistory off-street parking structures. The basic design components, such as parking stall dimensions, aisle widths, and circulation used for off-street at-grade parking presented in **Section 6**, also apply to parking structures. In addition, there are some additional considerations that apply specifically to the design of car parking structures. The additional design parameters for parking structures and other relevant guidance are also included in this section. The dimensions and clearances mentioned in this section should apply to all covered at-grade parking including, canopy parking.

8.1 Vehicle Size Restrictions

It is important to protect structures from being damaged by oversized vehicles. The following guidelines should be implemented to restrict oversized vehicles:

- Maximum height restrictions should be clearly marked at all entrances and physically enforced using size-restriction barriers.
- Signage indicating headroom restrictions should be installed so it is visible to the driver before they commit to entering the parking facility and decide to follow an escape route if necessary for over-height vehicles.
- A movable bar, or any other warning device, should be mounted above the entrance, at the minimum headroom level, so that it alerts the driver that the vehicle is too high.
- Suitable warning devices should be installed prior to entering any area within the parking structure with headroom lower than that of the entrance.
- Vehicles larger than the PDV should only be allowed to park on the ground floor in designated areas, provided they satisfy the maximum height and weight requirements. Generally, oversized vehicles are not allowed on the ramps. In case the oversized vehicles like buses are required to access ramps and upper floors, all ramp-related dimensions should be determined based on that specific vehicle and approved by the Overseeing Authority.

8.2 Ramp Systems and Structure Types

This section explains the different types of ramp systems and related structures that can be used in different situations. There is no single combination of structure and ramp system that can best fit all situations. The choice should be based on topography, site shape, and parking demand characteristics.

8.2.1 Ramp Systems

There are a number of inter-floor ramp systems that allow vehicles to move at a distance of approximately 3 m from one parking level to another.

Ramps can be broadly divided into two categories based on the amount of interference between parking maneuvers and ramp traffic, as mentioned below:

1. **Clearway Ramps** have inter-floor travel paths that are completely separated from conflicting parking movements. Clearway ramp systems provide the safest inter-floor movements with the least delay and are preferred for medium- to large-sized self-parking facilities. These may not be feasible for small parking facilities.

2. **Adjacent Ramps** have access aisles along with circulation way for all travel between floors. This means that parking aisle maneuvering and ramp traffic movement happen simultaneously.

8.2.2 Rotation Limits and Direction

In practice, nearly all successful ramp systems utilize a circular path configuration between floors. However, the number of complete 360-degree rotations to circulate through the parking structure and ramps should be limited to five or six rotations. Depending on the use of the facility, this will also limit the user from passing through the maximum number of parking levels and parking spaces while moving through the parking facility.

A counterclockwise rotation is preferred in a parking layout to match the entrance and the exit movements in a parking facility. For helical (spiral) ramps, although not crucial for larger radii, the counterclockwise rotation is recommended for ramps with a minimum radius of 11 m.

Vehicles moving towards the upper floors of two-way ramps should move through the outside, along the larger radii. The vehicles moving toward the lower floors should be advised to use the inner ramp.

8.2.3 Parking Structures and Ramp Types

A designer has several choices of parking structures available that can be used in combination with a number of ramp systems. Time and convenience are important in designing the circulation between structures and ramps. Some of the commonly used structure systems are:

1. **Flat Deck (FD):** This type of structural layout has a flat parking floor. The floors are connected by external curved ramps or straight ramps, which are usually internal.

2. **Sloping Deck (SD):** This type of structure layout uses a sloping floor for the parking area to gain height. Grade should not exceed 5% where the accessible parking stalls are provided.

3. **Combined Flat and Sloping Deck (FSD):** This type of layout has flat decks on three sides in a two-module configuration and on all four sides of parking structures that are three or more modules wide.

4. **Split-Level Deck (SLD):** This type of structural arrangement splits the parking area into two parts, which are spaced half a level apart. This system uses shorter ramps to join the levels.

5. **Warped (Slab) Parking Deck (WPD):** This type of structure is a flat deck that is divided along the center. The inner edge is warped so that the level on one side is raised to connect with the lower level on the other.

6. **Minimum Dimensions Layouts (MDL):** This is the smallest practical size for any parking layout as dictated by the recommended minimum turning radii for the PDV. It does not have to be the entire length of the building, but it needs to be at the end of the parking aisles to accommodate turning dimensions. The MDLs are ideal for long and narrow sites.

7. **Circular Sloping Decks (CSD):** In practice, only two-way flow should be provided for this layout, which is based on a hollow circular shape or an ellipse.

The various structures can be combined with several ramp types. The following are some of the common types of ramps:

1. **Half External Ramps (HER):** This type of ramp has two semicircular external ramps that are typically connected to flat decks. It is very popular with drivers because it reduces apprehension associated with full 360-degree rotation.

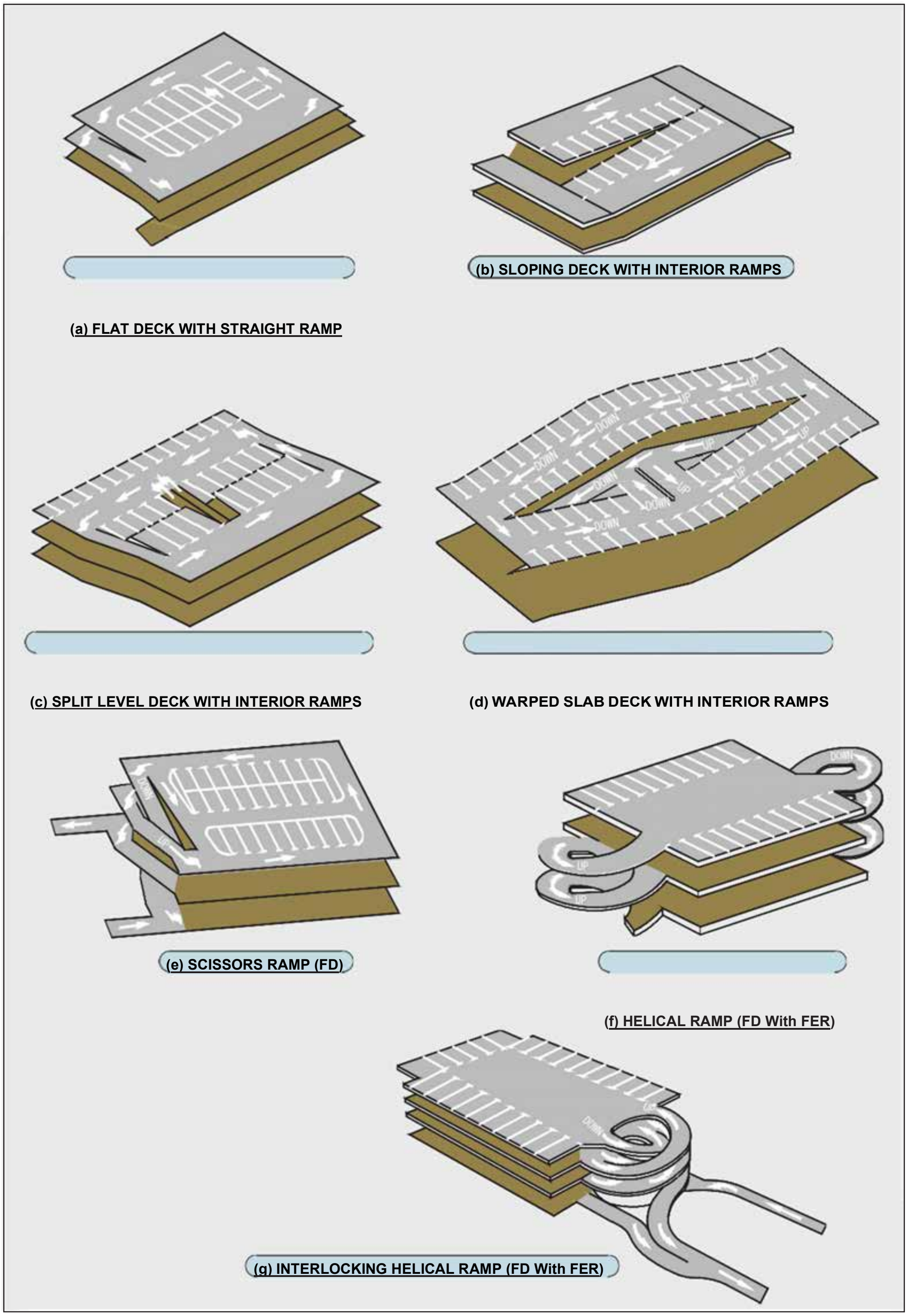
2. **Full External Ramps (FER):** This type of ramp functions independently of parking and is connected by access ways into and out of the parking decks. This type of ramp is used primarily in large-capacity parking facilities with high static capacity (total parking stalls). FER ramps can be straight ramps or helical (spiral) in structure. However, helical ramps are not very popular with users because they tend to have a radius that is too tight for drivers' comfort. The radius of helical ramps should be more relaxed than the PDV minimum turning radius to improve the comfort of the driver.

3. **Speed Ramps (SR):** These are external ramps that provide rapid outflow from higher floors to the ground level. These are well suited for parking facilities with peak flows, such as office parking with pronounced AM and PM peak volumes.

Flat decks may be linked by external or internal ramps with straight, scissors, helical, and interlocking helical configurations. **Figure 8-1** presents the most common parking structure and ramp systems. Typical three-bay parking structure systems (flat deck and split-level) are illustrated in **Figure 8-2**. Ramped floor parking structure systems are illustrated in **Figure 8-3**.

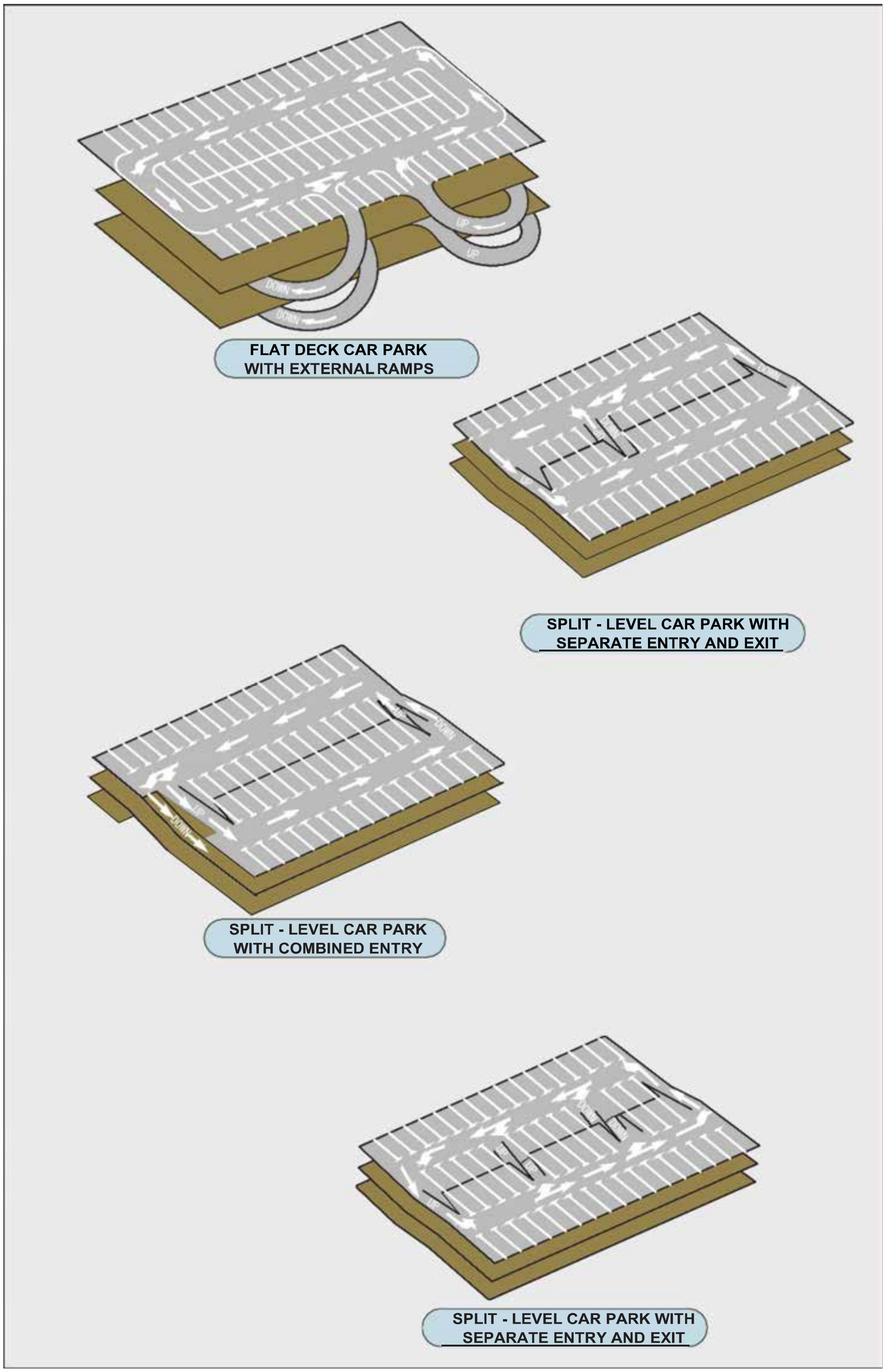
Different parking structure configurations can be formed with the combination of structure types and ramps. The most commonly used and the least complex parking structure configuration is a three-bay layout, as shown in **Figure 8-2**. This configuration works for most land uses and is easy for drivers to understand and to implement wayfinding. An interlocking helical configuration is less preferred because wayfinding can be quite difficult.

Two-way circulation is an effective design in parking facilities that have an odd number of parking bays. For example, a three-bay design with one-way flow on the outer bays and two-way flow in the center is a common design. A one-way aisle can be provided with perpendicular parking in conjunction with adequate signage and pavement markings to prevent wrong-way movements into opposing travel lanes.



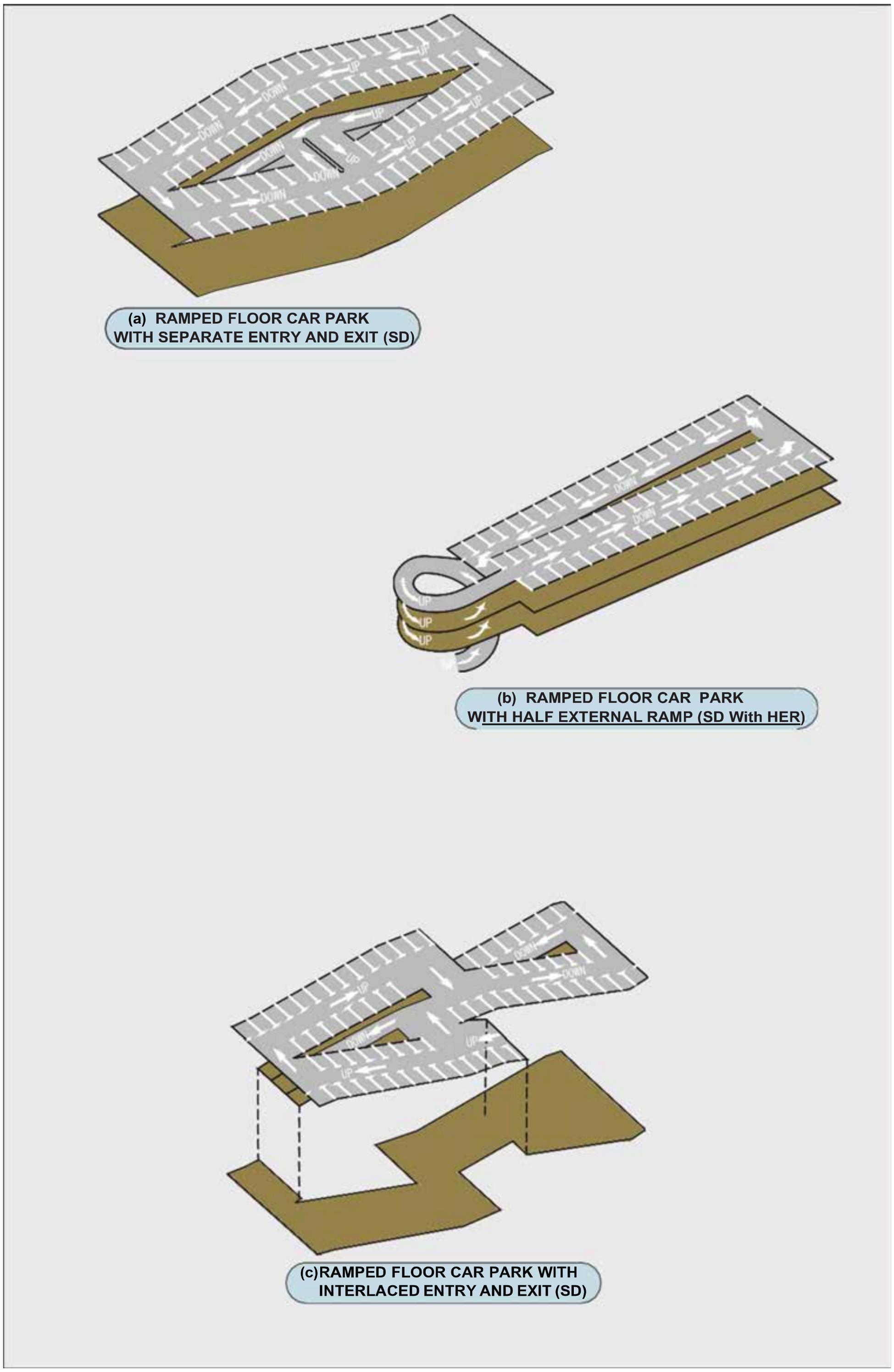
SOURCE: Adapted from The Institution of Structural Engineers, UK, "Design Recommendations for Multistory and Underground Car Parks", 4th Edition, 2011.

Figure 8-1 Common Parking Structure Ramp Systems



SOURCE: Adapted from The Institution of Structural Engineers, UK, "Design Recommendations for Multistory and Underground Car Parks", 4th Edition, 2011.

Figure 8-2 Three-Bay Parking Structure Systems



SOURCE: Adapted from The Institution of Structural Engineers, UK, "Design Recommendations for Multistory and Underground Car Parks", 4th Edition, 2011.

Figure 8-3 Ramped Floor Parking Structure Systems

8.3 Circulation Efficiency

Circulation efficiency of a parking layout on a single deck is defined as "the ratio of travel distance required to search all parking stalls in the deck to the minimum travel distance between parking stalls where the minimum travel distance is equal to half the width of a parking stall."

Some parking layouts allow drivers to search all (or most) parking stalls with just one circuit between aisles and cross-aisles. With other layouts, the driver may have to drive through aisles more than once to see all vacant parking stalls. In practice, for large parking facilities (500 parking stalls with a posted speed of 10 kph), congestion typically occurs when drivers search for a single path, which is defined as one complete circuit without retracing. Additional access points are recommended for layouts that have more than 500 parking stalls[1] in one search path.

Circulation efficiency is an important factor to be considered because it affects dynamic efficiency and the time required to park especially in large-capacity and multi-module layouts. Dynamic efficiency denotes the ease of maneuvering into the parking stall. For more information on dynamic efficiency, one may refer to **Section 8.4.3**. It is more important to assess the relative circulation efficiencies rather than a precise assessment. A precise measure depends on occupancy conditions of the parking facility such as fully occupied, empty, about to be filled, about to be emptied, or with people searching for parking. Adequate Variable Message Signs (VMS) also improve circulation efficiency, enabling drivers to bypass parking aisles that are already full.

Comparisons between circulation efficiencies of various layouts can be easily made if they are all measured in the same way.

8.4 Static and Dynamic Considerations

Parking layout selection is influenced by the following factors:

1. Purpose or land use
2. Turnover rate (number of vehicles using a parking space in unit time)
3. Access and payment control
4. Connection to external road network

The choice of a layout influences the static as well as the dynamic capacity of the selected layout, which are important measures to be considered in the design of a parking facility and are discussed in more detail in the following sections.

It is also important to allow flexibility in a design to accommodate parking layout changes in response to a change in purpose, turnover, and/or access controls.

[1] *SOURCE: "Car Park Designers' Handbook," Jim Hill, Thomas Telford Publishing, 2005.*

The values shown in the following sections are based on a vehicle design speed of 15 kph in the parking facility (10 kph posted speed) and standard parking stalls of 2.8 m wide by 6.0 m long, with 8.0 m wide aisles. Calculations are made for perpendicular parking and to illustrate the principles of parking layout, as it is not feasible to include all possible permutations in this Manual.

8.4.1 Static Capacity and Static Efficiency

Static capacity is the total number of parking stalls within a parking facility.

Static efficiency of a parking structure is calculated by dividing the total area of the parking deck, expressed in square meters (m^2), by the static capacity (total number of parking stalls), which results in area per parking stall. Static efficiency has a direct relation to the construction cost per space.

Static efficiency considers the total parking structure size, including the stairs, the elevators, and the non-parking ramps. Any retail space that is incorporated within the structure is also usually included in the calculation.

Typical static efficiency ranges reported in the best practices for parking structures built for a PDV of similar size to the Toyota Land Cruiser are presented in **Table 8-1**.

Table 8-1 Static Efficiencies from Best Practices for PDV

Category	Static Efficiency Range (Area in m^2 / Parking Space)
Short-span Structural System	31 to 36
Long-span Structural System	28 to 32
Mixed-use developments with retail, residential and parking	37 or more

Refer to **Section 8.5** *for short-span and long-span structural systems.*
SOURCE: "Parking Structure Design Guidelines" for Boise Idaho, USA, Kimley-Horn, August 2016

The values in **Table 8-1** are scaled to the proposed parking stall area considering 2.8 by 6.0 m parking stalls. Static efficiency is used as a measure of comparison between parking decks and is generally expressed as good, average, or poor.

Generally, high-capacity parking decks with large parking areas will have a better static efficiency than small-capacity decks, where a higher proportion of structure is comprised of ramps and accessways. A long, 2-module parking layout has a greater static efficiency than a shorter 3- or 4-module structure with a similar layout area, given a reduction in the area for access ways that are equivalent to the area of 4 parking stalls at each end of a module. Two-way flow layouts should only be used with perpendicular parking stalls.

8.4.2 Relative Static Efficiencies

Approximate measures of good static efficiency for five different parking deck capacities are shown in **Table 8-2**. The values presented are for illustrative purposes only to compare the static efficiency for various parking layouts and configurations relative to each other. A relative static efficiency analysis shows how various factors impact static efficiency. Parking stall size contributes to static efficiency. Changing parking stall dimensions will impact the number of stalls provided and the calculated static efficiency.

There can be significant variations in the calculation of static efficiency, especially in unusually shaped sites. The values in **Table 8-2** should be used as a screening guide for relative static efficiencies of various layouts. The designer should consider these values along with the site constraints to design an efficient parking design.

Table 8-2 Good Static Efficiencies for Selected Layouts

Stalls per Deck	Good Static Efficiency								
	Perpendicular Parking			60⁰ Angle Parking			45⁰ Angle Parking		
	Single Module[1]	External Module[2]	Internal Module[3]	Single Module	External Module	Internal Module	Single Module	External Module	Internal Module
	m^2 per parking space			m^2 per parking space			m^2 per parking space		
300	30	30	30	33	32	30	38	35	33
200	31	31	31	34	33	31	39	36	34
100	34	34	34	38	36	34	43	40	37
60	35	35	35	39	37	35	44	41	39
30	41	41	41	46	43	41	51	48	45
Variation Relative to Perpendicular Parking				11%	6%	1%	25%	17%	10%

SOURCE: "Car Park Designers' Handbook," Jim Hill, Thomas Telford Publishing, 2005 (Factored up for 2.8 by 6.0 m stalls because the source used smaller stalls for one-way traffic flows).

[1] Only one parking aisle is available with parking on both sides.

[2] This represents the endmost bays in a parking facility with multiple rows of parking.

[3] Internal modules are the parking aisles between the end modules.

8.4.3 Dynamic Capacity and Efficiency

Dynamic capacity is a measure of the rate at which traffic can pass through a location within the parking facility. It is the ability of a parking facility to process vehicles under normal operating conditions and is expressed in terms of vehicles per hour (vph).

Calculations for dynamic capacity should be checked against anticipated hourly vehicle volumes. It is generally accepted that 25% of parking facility static capacity should be able to enter or leave within a 15-minute period. **Table 7-6** can be referred to for information on the average flow in seconds per vehicle at the entry and the exit of the parking facility, given the type of access control. **Table 8-3** provides the average flow for internal circulation or through aisles within the parking facility under different conditions.

Table 8-3 Average Flow for Internal Circulation

Condition	Average Headway seconds/vehicle	Design Hourly Capacity vehicles/hour*
Clear Aisle or Ramp or No Parking	2.0	1,200
Straight Ramp with Bend at End	2.2	1,000
Circular Ramp, 9 m Radius at Center Line	2.2	840
Aisle with Adjacent 2.8 by 6.0 m Inbound	3.5	830
Aisle with Adjacent 2.8 by 6.0 m Outbound	8.6	335

*Taken as 80% of maximum rate

SOURCE: "Entrance-Exit Design and Control for Major Parking Facilities, Seminar '72," Los Angeles Parking Association, 1972.

Dynamic efficiency of a parking facility depends on the bay size and the layout of the parking lot. Reducing the angle from perpendicular (90-degree) to 80 degrees results in a significant increase of dynamic efficiency because it makes it easier to do a forward in parking. However, any further decrease in the angle provide little additional ease in forward parking.

Reducing the angle, however, reduces the static efficiency because it requires more floor area for parking. This requires a balance between dynamic capacity and static efficiency.

The maximum possible theoretical dynamic capacity of a ramp is 1,500 vph for a 4.6 m wide ramp. Theoretically, the dynamic capacity of a parking aisle with a 15 kph design speed would also be 1,500 vph in the absence of parking maneuvers, regardless of the length of the parking aisle.

The average minimum capacity (notional dynamic capacity [NDC]) for an 8.0 m wide aisle with perpendicular parking stalls is shown in **Table 8-4**. These values are from an International Best Practices review (adjusted to the proposed widths) and are the average of 15-minute observations in a number of car parks. The time taken for entering and exiting the parking stall is affected by the width of the stalls. Wider stalls result in relatively less time for entering, exiting, or both. This improves dynamic efficiency, which results in higher capacities. This can be used for a quick and high-level comparison of layout efficiencies in a parking facility.

Table 8-4 Notional (Minimum) Dynamic Capacities by Stall Widths

Perpendicular Stall Width 8.0 m wide aisles (m)	Inflow (forward-in) (vph)	Outflow (back-out) (vph)
2.8	860	750
2.9	910	800
3.0	950	840

SOURCE: Adapted from "Car Park Designers' Handbook," Jim Hill, Thomas Telford Publishing, 2005.

The NDC outflow values shown in **Table 8-4** are generally lower than the inflows due to the hesitation associated with backing out of parking stalls. As the number of parking stalls increase, the Actual Dynamic Capacity (ADC) of the parking facility approaches the NDC. The ADC, regardless of the aisle length and capacity, would be somewhere between the NDC (in **Table 8-4**) and 1,500 vph. The NDC for the entire parking facility is the sum of the NDC of each aisle at each level, which can be calculated by the formula:

ADC = 1500 – (a x b x c x 1/d)

Where:

a = 1,500 minus NDC

b = number of adjacent stalls divided by "a"

c = number of aisles

d = stall turnover rate

Adjacent stalls for inflow are defined as the number of available entry route stalls on both sides (if both sides are accessible), starting from the entrance to the first inter-floor ramp or exit. Similarly, for outflows, adjacent stalls are defined as the number of outflow route stalls in one aisle. The calculations for outflow should be from the topmost floor to the exit floor.

With larger facilities, some aisles will need to be driven more than once, thus decreasing the ADC further. This calculation can be used to decide between layouts to identify where congestion is likely to occur for a given layout.

8.5 Structural Grid Options

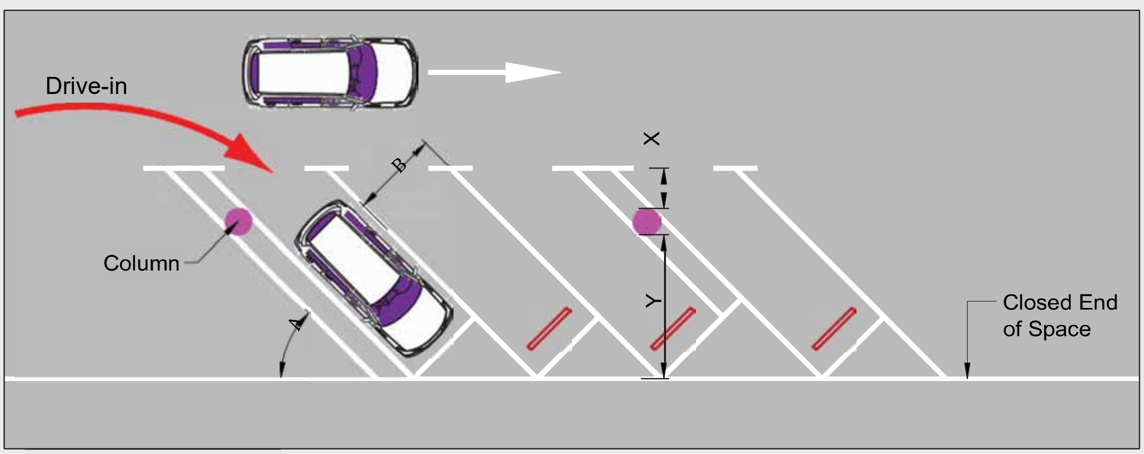
The location of the support columns is one of the most critical decisions in achieving an economical and functional car park. Construction using large, clear spans offers the following benefits:

- Better security
- Improved visibility
- Increased interior lighting efficiency
- Ease of cleaning and maintenance
- Greater number of cars per unit area of available floor space

There are two commonly adopted structural arrangements with reference to the column locations, short-span and long-span arrangements. Long-span structures have large column-free spaces but are higher in construction costs than short-span structures. Parking within a long-span structure is generally safe for users, have better visibility, better interior lighting efficiency, and are easier to clean and maintain. Long-span structures also have a more efficient layout of parking bays; hence, the bays can fit in more parking stalls per unit area. However, when a building such as an office, shopping center, or an apartment complex is planned above the parking facility, which may place additional load on the structure, short-span construction may be more suitable.

Columns in short-span structures should be located to cause minimal interference with traffic circulation, parking maneuvers, and driver visibility. They should not be located at the edge of a parking aisle or directly opposite the location of an opening car door. The number of columns should be carefully considered because too many columns make drivers uncomfortable and make it difficult to achieve an efficient parking layout. The choice of column shape depends on the parking angle. A rectangular column is best for perpendicular parking, while round columns are more adaptable to other parking angles.

The recommended dimensions for column offsets in a short-span structure are provided in **Figure 8-4** and **Table 8-5**. The figure is for illustrative purposes only. Column offsets should be evaluated based on the actual parking layout for a particular facility. Column spacing must allow for the additional space that may be required for maneuvering and passing at bends and intersections. Column spacing should be at least three parking stalls wide. The use of suitable materials around the columns at these locations is to minimize the impact and damage that can be caused in case vehicles collide with the columns. Refer to **Section 20.8** for column guards.



Notes:

$ = Angle of Parking
B = Width of Parking Stall
Y = Distance of Column from End of Space
X = Column Offset from Aisle

Figure 8-4 Short-Span Column Offset Layout

Table 8-5 Short-Span Structure Column Offsets

Parking Angle	Minimum Offsets (m)	
A	Column Offset from Aisle (X)	Column Offset from End of Space (Y)
45^0	0.55	2.58
60^0	0.65	3.16
Perpendicular	0.75	3.65

SOURCE: Adapted from The Institution of Structural Engineers, UK, "Design Recommendations for Multistory and Underground Car Parks," 4th Edition, 2011.

If columns are located in the parking area, they should be appropriately located, as shown in **Figure 8-5**. The main span is typically perpendicular to the aisle and the setback of the columns from the aisle, determining the span. Columns should be located so that they do not interfere with opening of car doors. It should also be kept in mind that placing them at the edge of the aisle severely restricts accessibility into adjoining spaces. In determining the other dimensions of the grid, columns should be arranged at lateral spacings, enabling full-width stalls between column faces.

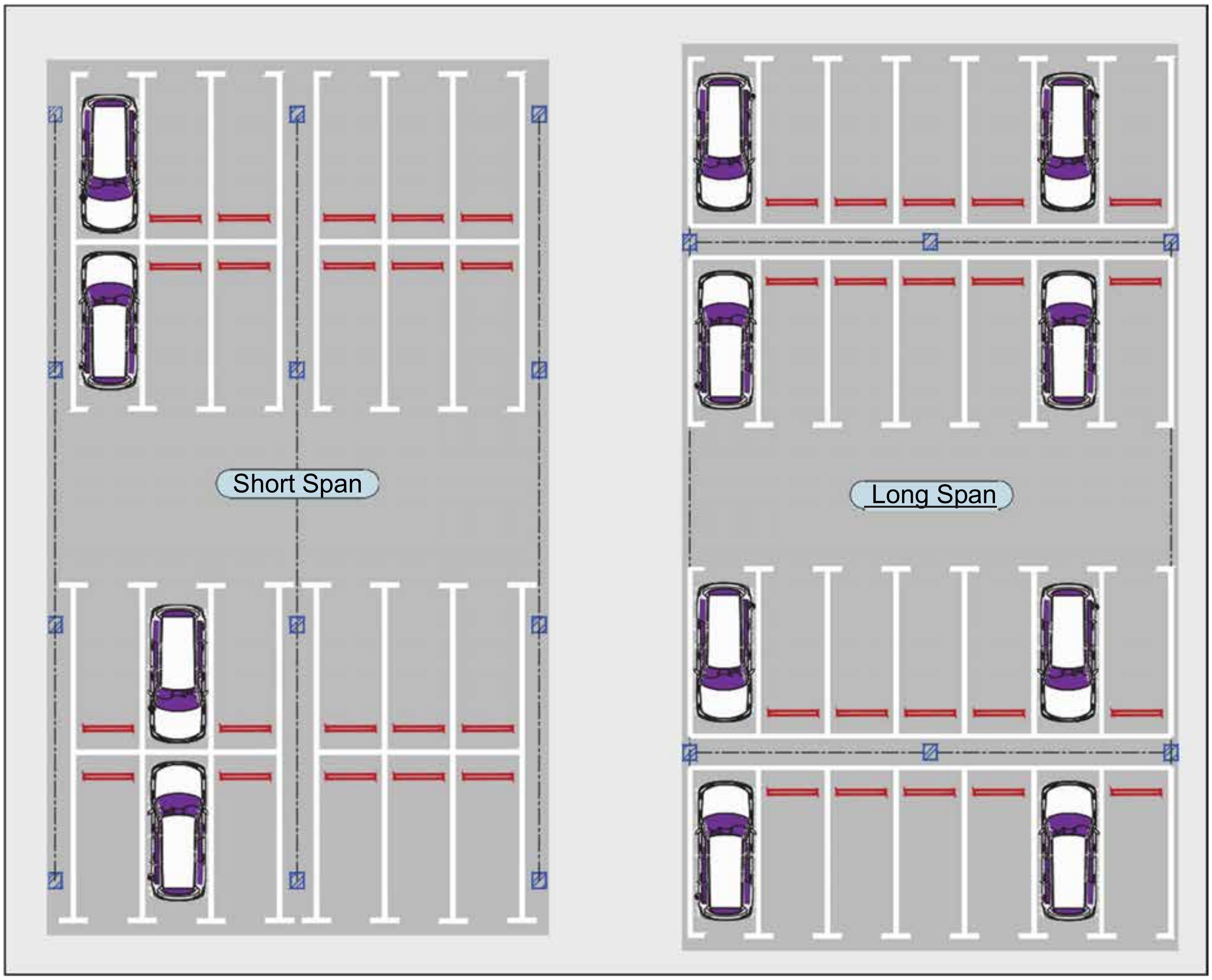


Figure 8-5 Short-Span and Long-Span Column Locations

8.6 Parking Circulation

Parking circulation in parking structures should generally be two-way because it is a more efficient use of space, unless one-way circulation is necessary due to physical limitations. It is recommended that only perpendicular parking be provided with two-way aisles. One-way circulation makes parking maneuvers easier but is susceptible to violation by drivers. There should be a clear search path that is easy to follow and takes the incoming user past the maximum number of spaces. For larger structures of 200 parking spaces or more, there should also be a rapid exit route, allowing departing vehicles to do so by the shortest practical route, passing the minimum number of spaces on the way. **Section 8.3** may be referred to for information on parking circulation efficiency.

The circulation path should be free from physical and visual obstructions. A standard sight triangle check should be included in the design of circulation paths. Pedestrian and bicycle routes should be carefully planned considering vehicle movements. The pedestrian and bicycle path should not conflict with vehicle movements.

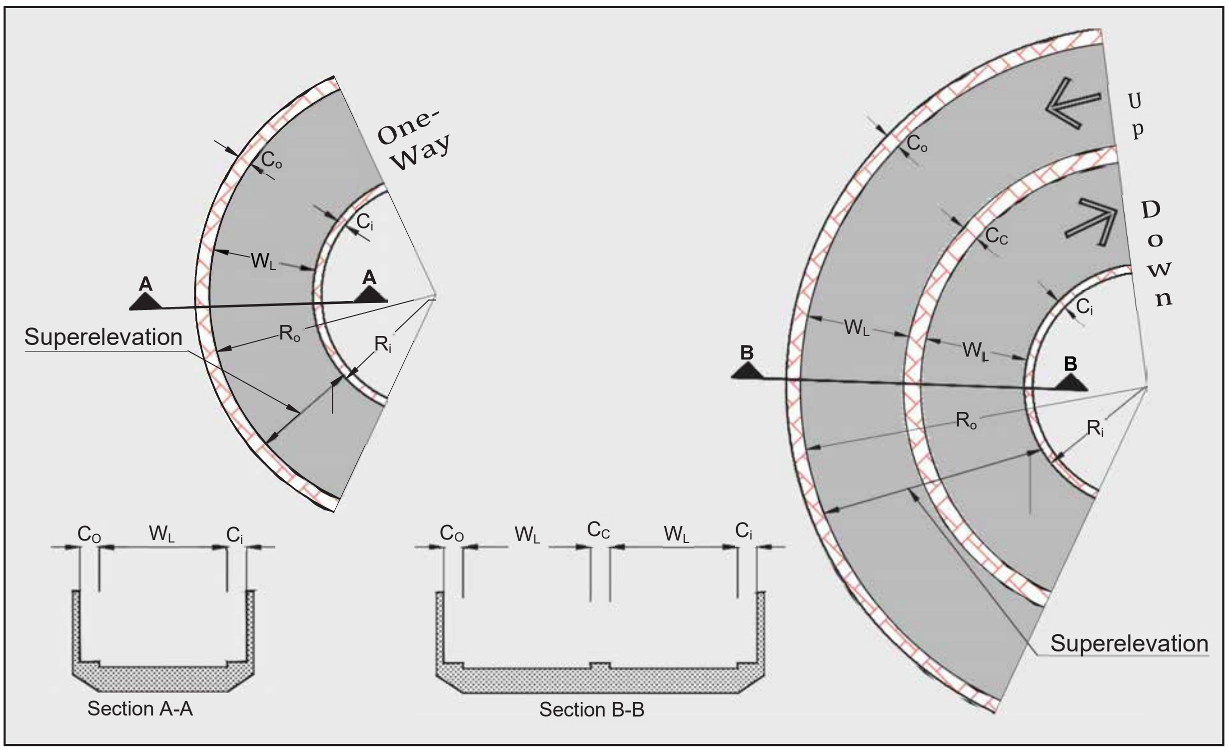
The locations of pedestrian crossings should be determined upon consideration of possible conflicts and should address all safety aspects. Standard pavement markings, speed calming, and visible signage should be adopted at places where pedestrian paths cross vehicle circulation paths.

8.7 Ramp and Circulation Roadway Design

8.7.1 Circulation Roadways and Ramps

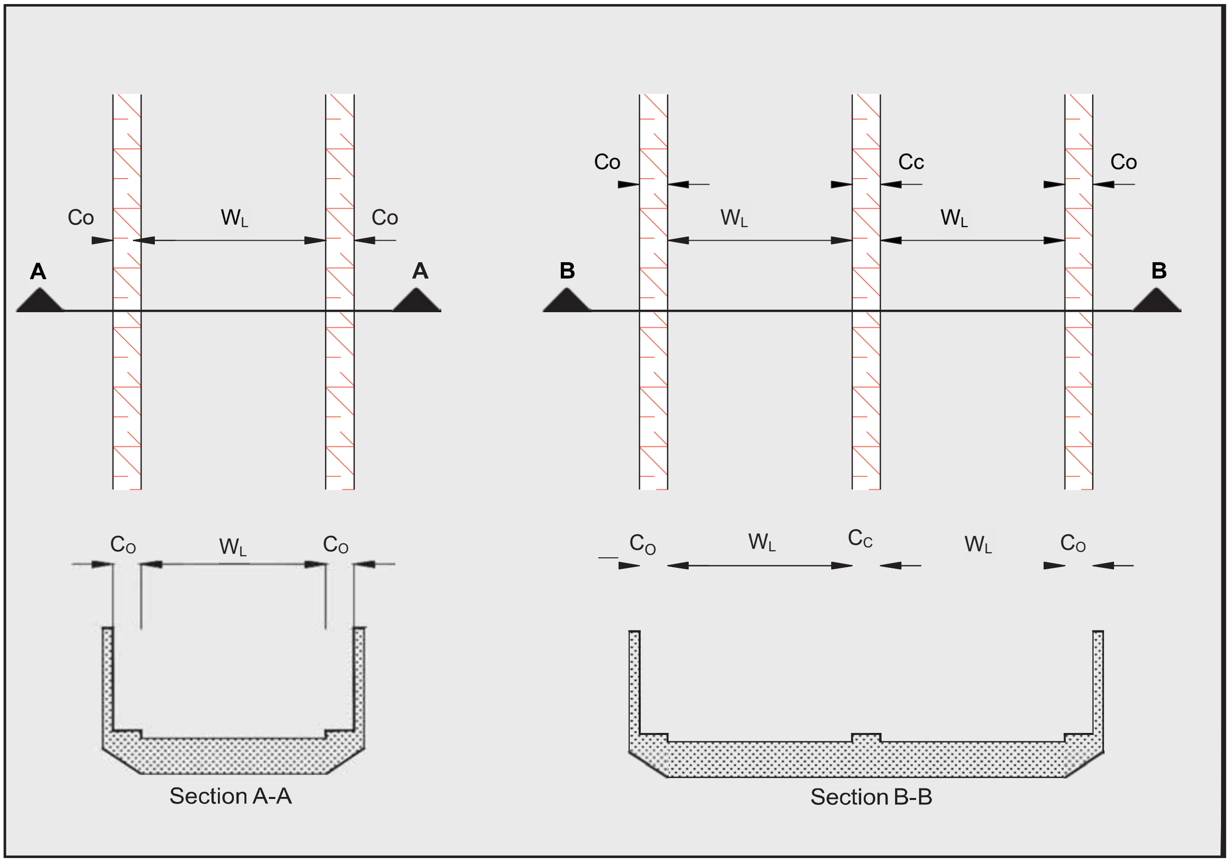
Typical details of circulation roadway and ramp layouts are shown in **Figure 8-6** and **Figure 8-7**. Minimum dimensions of various design parameters of circulation roadways and ramps are shown in **Table 8-6**. For curved circulation roadways and ramps, the inner and outer radii should be appropriate for the design vehicle. The recommended radii are larger than the minimum radius of the PDV for drivers' comfort. It should be even larger for full-circle helical ramps.

Minimum curve radii for one-way traffic are 4.0 m (inner) and 8.6 m (outer), which is appropriate for the PDV. This is to give a minimum lane width of 4.6 m. For helical ramps, curve radii are increased to 6.0 m and 11.0 m, respectively.



SOURCE: Adapted from Site Plan Requirements for Proposed Development Projects, MOTC, Section 5: On-Site Circulation Roadways, Parking Aisles, and Ramps.

Figure 8-6 Curved Circulation Roadway and Ramp Layout



SOURCE: Adapted from Site Plan Requirements for Proposed Development Projects, MOTC, Section 5: On-Site Circulation Roadways, Parking Aisles, and Ramps.

Figure 8-7 Straight Circulation Roadway and Ramp Layout

Table 8-6 Circulation Roadway and Ramp Minimum Dimensions

Characteristics	Minimum Dimensions (m)	
	One-Way Traffic (Section A-A)	Two-Way Traffic (Section B-B)
Outside radius (R_o)	8.6 minimum	11.4 minimum
Outside radius (R_o) for Helical Ramps	11.0 minimum	Not Applicable
Inside radius (R_i)	4.0 minimum	4.0 minimum
Inside radius (R_i) for Helical Ramps	6.0 minimum	Not Applicable
Lane width (W_L)	4.6 minimum	3.4 each lane
Clearance to Obstruction		
Inside (C_i)	0.3 minimum	0.3 minimum
Outside (C_o)	0.5 minimum	0.5 minimum
Between paths (C_c)	Not Applicable	0.6 minimum
Superelevation	1 in 20 (5%) maximum	1 in 20 (5%) maximum

SOURCE: Adapted from Site Plan Requirements for Proposed Development Projects, MOTC, Section 5: On-Site Circulation Roadways, Parking Aisles, and Ramps.

NOTE:

1. *C_o and C_i must be sufficient to ensure that the outside vehicle wheel can touch the curb prior to the vehicle body coming into contact with an obstruction.*
2. *For straight circulation roads and straight ramps, C_o should be provided on both sides.*
3. *A swept path analysis for all unique locations should be conducted to demonstrate that the minimum clearance between the design vehicle and all obstructions should be 0.3 m (C_i) and 0.5 m (C_o), and the minimum clearance between design vehicles and all oncoming vehicles should be 0.6 m (C_c).*

A W_L of 4.4 m for one-way ramps and 3.3 m for two-way ramps can be adopted as departure from standard for the following specific cases:

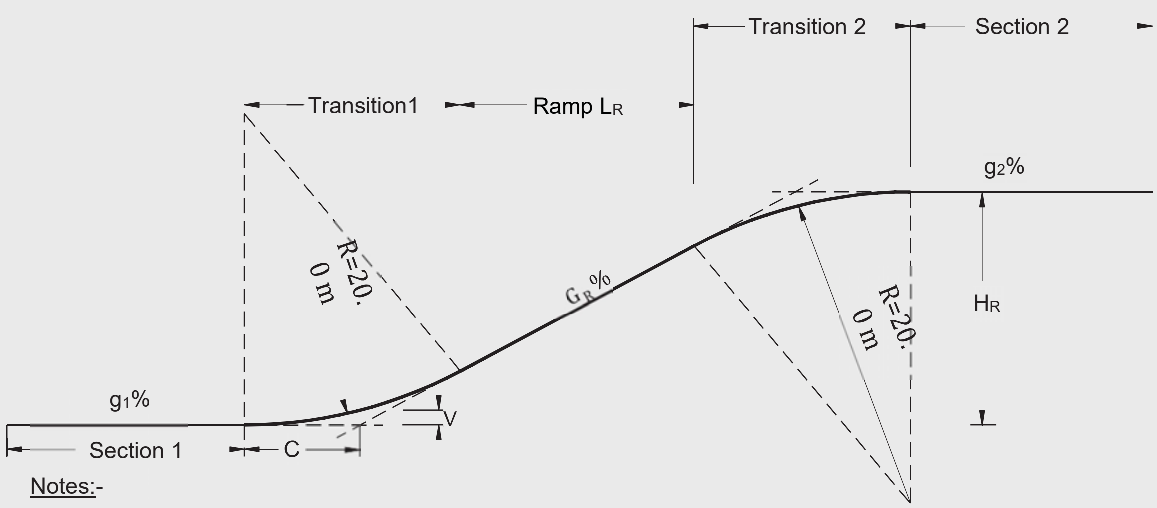
- Plot area is less than 600 m^2.
- Parking facility is in an area of heritage and cultural importance and must be preserved.
- Specific planning guidelines (bylaws, regulations, and zoning codes) allow reduction in dimensions.
- Appropriate traffic analysis, safety assessment, and signage design prove to be satisfactory.
- Meets the process and conditions of departure as stipulated in **Section 22** of this Manual.

The Overseeing Authority reserves the right to decide the departures on a case-by-case basis and issue approval.

8.7.2 Grade Rounding or Transition at Top and Bottom

Headroom needs to be checked carefully at the top and bottom of ramps for the reduced effective height of a vehicle passing over a change in grade. Generally, no adjustments are required for grade differences less than or equal to 12.5%. **Section 4.1.3** serves as a reference for additional information on headroom.

There are two ways to deal with changes in grade of more than 12.5%. These are by rounding or by providing a transition between two grades to eliminate the risk of vehicle grounding. Where possible, the transition should be a curve, as shown in **Figure 8-8**.



<u>Notes:</u>-

L_R = Length of Ramp in Meters

H_R = Height of Ramp in Meters

G_R = Ramp Grade = [H_R x 100] / L_RPercent

g_1 = Grade of Section 1

g_2 = Grade of Section 2

C = Distance to Center of Rounded Curve = $(G_R - g_1)/100 - R/2$, where R = 20.0 m

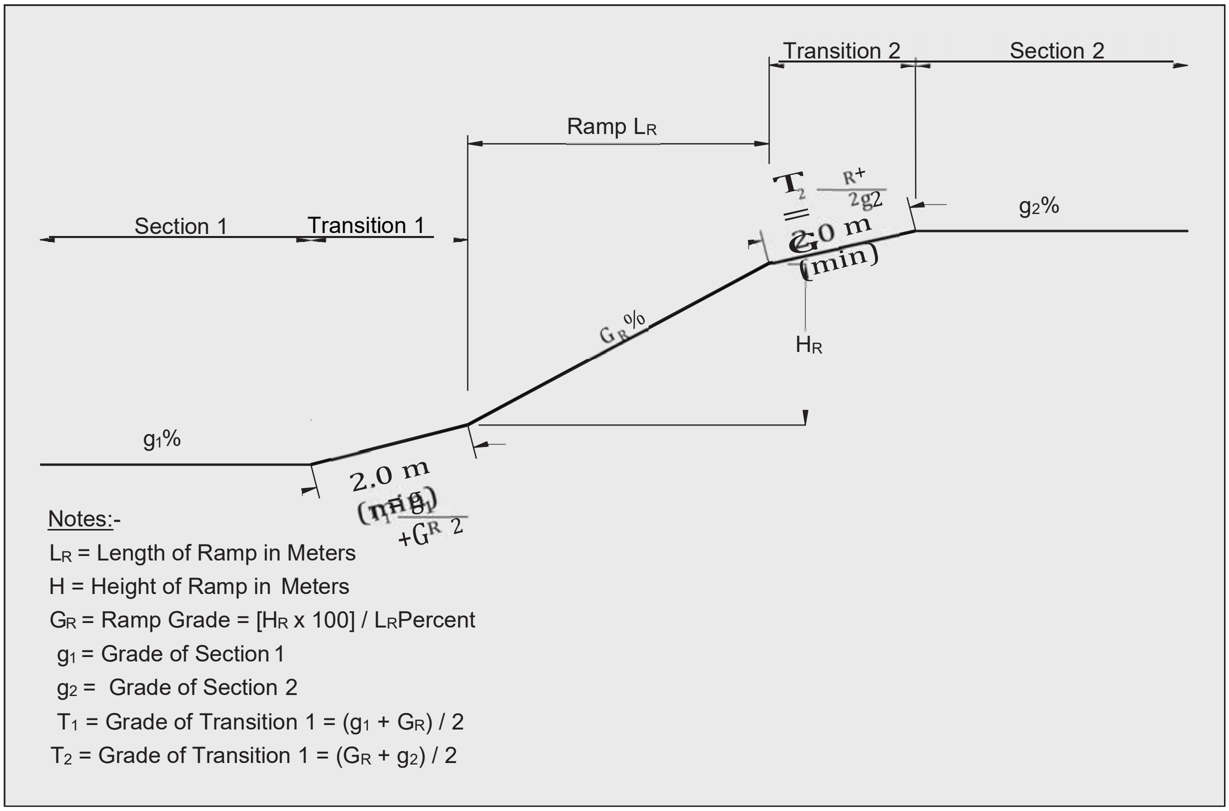
V = Height to Center of Rounded Curve = $1/2xR - C^2$, where R = 20.0 m

SOURCE: Car Parks in Steel, Arcelor Mittal, 1996.

Figure 8-8 Grade Differential Rounding > 12.5%

If the difference in grade is less than or equal to 20%, where rounding is not an option, a grade transition of 2.0 m in length at-grade of half the difference between the two grades should be provided at the top and bottom of the grade, as shown in **Figure 8-9**. The transition length is based on computer aided design tests performed using the PDV and smaller vehicles with lower ground clearance. A ground clearance of 100 mm is considered adequate.

The grade change is computed by subtracting one grade from the adjacent grade, both expressed as percentages and taking into account the algebraic sign which, for a given direction of travel, is either uphill (positive) or downhill (negative).



SOURCE: Car Parks in Steel, Arcelor Mittal, 1996.

Figure 8-9 Grade Differential Transition > 12.5%

8.7.3 Grades

The recommended maximum grade requirements on circulation roadways and ramps in multistory car parks are provided in **Table 8-7**. For curved ramps, the grade should be measured along the inside curb as provided in **Table 8-7**.

Table 8-7 Circulation Roadway and Ramp Maximum Grades

Type of Ramp	Length of Road Segment or Ramp	Maximum Grades and Requirements
Straight Ramp	> 20 m	1:6 (16.7%)
	≤ 20 m	1:5 (20%), with a minimum 2.0 m grade change transition required for differences in grade: > 1:8 (12.5%) for summit grade change >1:6.7 (15%) for sag grade change
Curved Ramp	Same as straight ramps except the grade is to be measured along the inside edge of the curve (See **Figure 8-6**, measurement R_i)	

8.8 Common Design Elements

Some of the design features, like headroom, blind aisles, and speed-reducing features of a multistory parking facility, are generic and are discussed in **Section 4** and **Section 6**. For design of these respective elements, reference should be made as indicated below:

- Headroom **Section 4.1.3**
- Blind aisles **Section 6.3**
- Speed-reducing features **Section 6.4**

Speed-reducing features are generally preferable on direct exits and rapid exit routes. These may not be warranted where exit routes involve passing through parking aisles.

8.9 Special Considerations

Designing a parking structure for mixed-use development requires careful considerations of the users' needs. Such parking facilities are used by various types of users, such as retail customers, office staff, residents, and hotel guests that have different parking needs. In addition to that, multiple tenants or owners within a single-use building may also have different needs. The user needs are linked to arrival-departure profiles, parking duration, access validation, payment requirements, walking distances, and customer experience.

It is advised to follow the user needs while developing an efficient parking zoning system in a large parking structure. Parking zoning can be enabled for both single and multiple levels to segregate the users. The lower levels generally should be assigned to short-term parkers, while upper levels should be reserved for long-term ones. Long-term parkers usually follow a tidal arrival-departure profile. This means that they arrive in the morning and depart in the evening. The mixing of short-term and long-tern parkers creates congestion across the ramp and the circulation system, thus, affecting the user's experience. Therefore, it is important to segregate the users through an appropriate zoning system and provide sufficient access or egress capacities and control systems.

It is also advised to consider dedicated ramps that directly connect the parking zone or floor for different uses in a large parking facility that caters to specific user groups. Physically separated entry and exit speed ramps can also be considered for better operational efficiency and safety. These arrangements reduce the need for circulation through each floor, enhancing the efficiency and customer satisfaction. It is advised to develop the access, ramp, and parking circulation strategies together, carry out assessment using simulation software discussed in **Section 4.8.3**, and seek approval from the Overseeing Authority.

Section 9

Supporting Infrastructure

9: Supporting Infrastructure

9.1 Introduction

Parking facilities, based on their respective nature and functions, require several supporting infrastructure to satisfy operational needs. The common supporting infrastructure are parking fee collection equipment, entry and exit barriers, storage for shopping carts, elevators, and garbage bins. This section covers these parking infrastructure items along with their respective features, design considerations, standards, etc.

9.2 Parking Fee Collection Equipment

Various types of equipment and systems are used to collect parking fees. On-street and off-street parking collection systems are customized according to the location and parking characteristics. Parking fees can be paid at the entry, at pay machine before exit, or at the exit. The type of entry and/or exit control is an important feature which is typically determined by the payment collection method. In general, an entry to a car parking facility should not be permitted unless an appropriate parking space is available within the parking lot. Entry to a parking lot may be controlled by a lifting arm or a rising-step barrier.

9.2.1 On-Street Parking Fee Collection Systems

The following types of payment collection equipment and systems are generally used for the collection of on-street parking fees:

- **Pay and Display Meters:** In this system, the users are required to walk to a central pay station to make their payment and leave their receipt or parking ticket on the dashboard. The pay and display meters, if placed outside, should be in kiosks or otherwise installed in a safe manner.

- **Pay by Phone:** With this technology, the users can pay for parking by phone, text message, or with a smart phone application. This system typically requires users to preregister and provide payment method details, such as those of a credit card. This system charges for parking in two different ways. In the first option, which is called the "Start-Duration," the user is asked to enter a code associated with the parking space location and to select the duration of parking time anticipated. In the second option, which is called the "Start-Stop," the users are required to contact the system on arrival and departure.

- **Pay by license plate:** In this method, the users enter their license plate number while paying for the parking, in advance, at a central pay station.

- **Pay by space:** This method is similar to "pay and display." Instead of placing the payment receipt on the dashboard, the user, while paying at the central pay station, has to enter the number associated with the parking space. Enforcement officers, as part of monitoring, will have to check the pay station for a list of paid spaces.

The following guidance applies to “pay and display” meter installation:

- Parking meters must be installed at visible locations.
- A multi-space parking meter can serve up to 25 parking spaces, and the walking distance to the parking meter from any parking space should be limited to approximately 30 m.
- Standard dimensions of on-street parking meters must be:
  - Height: 1,440 to 1,645 mm
  - Width: 230 to 400 mm
  - Depth: 230 to 330 mm
- It is recommended that the parking meters be installed on concrete mounting pads, so that the user faces the road/street while operating the meter.
- If parking meters are close to the parking stall, they must be protected on the curbside by energy-absorbing bollards, placed 200 mm from the equipment.
- All users, including the disabled (for locations where accessible parking is paid), must be able to access the parking meters. Reference must be made to Americans with Disabilities Act (ADA) requirements concerning meter height, access, and space around the meter, as well as placement of ramps. ADA prescribes an unobstructed reach range of 380 to 1,220 mm for parking meters and other kiosks.

9.2.2 Off-Street Parking Fee Collection Systems

The typical payment collection systems used for off-street parking are as follows:

- **Pay stations (pay on foot):** The user pays at the pay station for the amount of time that they use at the parking space. This is often referred to as “pay on foot.” Prepayment is an option that can be decided on a case-by-case basis. These are located inside the parking facility, or outside, or in some cases, in a kiosk. Typical dimensions are:
  - Height: 1,700 to 1,750 mm
  - Width: 500 to 800 mm
  - Depth: 500 to 555 mm
- **Manned payment kiosks at exit:** The user takes a ticket upon entering the parking facility and presents the ticket at the exit with the payment.
- **Automated payment kiosks at exit:** The user takes a ticket upon entering the facility, inserts the ticket into a machine at the exit, and makes the payment.

- **Pay on entry:** This is a system in which the user pays for parking while entering the facility. This type of payment is often used for event parking. This system usually has a fixed parking fee. This can also be used to allow users to pay a deposit and receive a portion of that money back on exit, if there is more than one rate in effect at the given time.

9.2.3 Automatic Number Plate Recognition

Both pay stations and manned or automated payment at the exit can be integrated with Automatic Number Plate Recognition (ANPR) or License Plate Recognition (LPR) technology. For pay stations, the ANPR/LPR system detects and/or records the vehicle number at the entry. After parking the vehicle, the user enters the license plate number in the nearest pay station to validate the vehicle. For facilities with automatic exit barriers, the user makes the payment at a pay station by entering the license plate number before his exit. During the exit, the ANPR/LPR at the exit barrier gate automatically recognizes the vehicle, retrieves the payment information, and allows the vehicle to leave the facility. If payment is to be made on exiting, the system indicates the parking fee and the cashier collects the payment.

9.3 Entry and Exit Barriers

The entry and exit barriers might be required for off-street parking facilities. The two common types of parking barriers are explained in the subsequent sections.

9.3.1 Lifting-Arm Barriers

Lifting-arm barriers (**Figure 9-1**) are generally preferred since they are highly visible and easy to operate. These could be operated using an electromechanical device or ANPR or LPR instrumentation. While the mechanism is robust, the arms are easily damaged accidentally or by vandalism, and it may require frequent maintenance and repair. Incorporating shear bolts or breakable plates help to prevent/minimize damage to the mechanism.

In areas with restricted headroom, articulated arms may be needed. Some barrier and vehicle detection are unreliable for the detection of powered two-wheelers. This should be considered when selecting barriers for use in car parking facilities that are accessible to powered two-wheelers. A preferred option is to have a separate control lane for bicycles and powered two-wheelers.

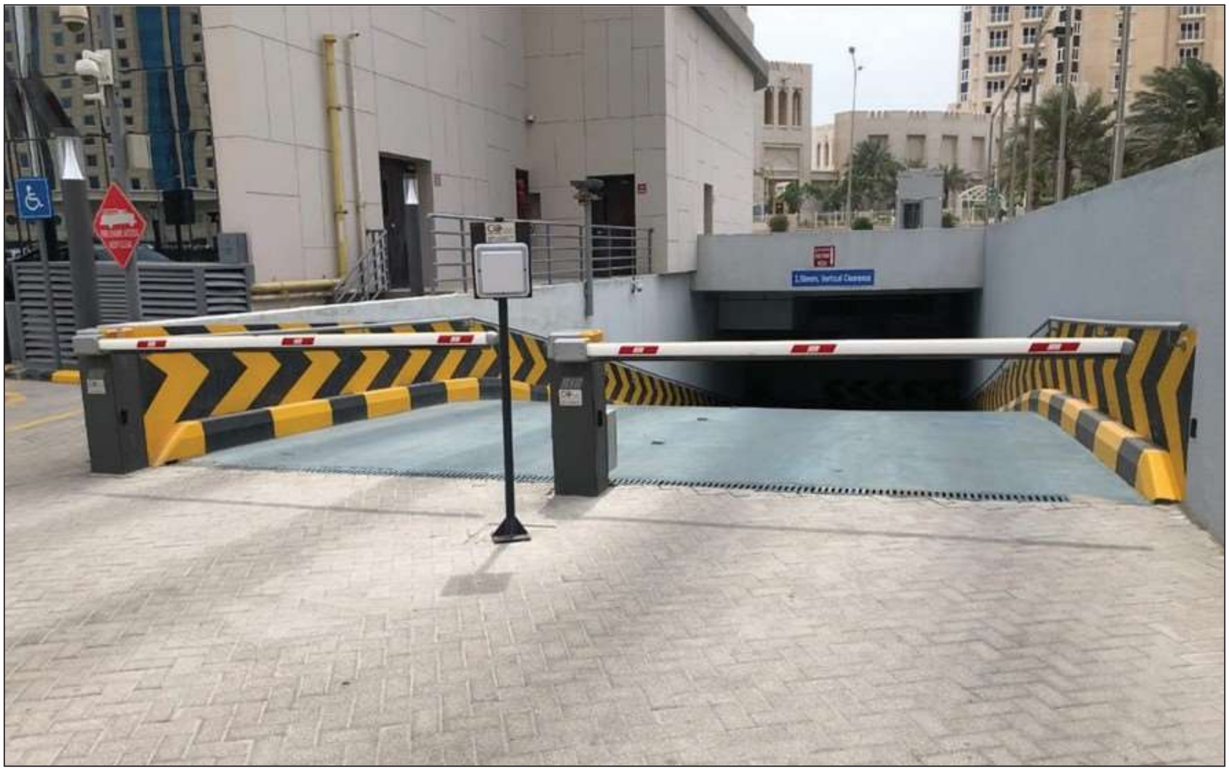


Figure 9-1 Lifting-Arm Entry Barrier

9.3.2 Rising Step Barrier

Rising step barriers consist of a steel plate that can be mechanically raised from a lower position, that is in level with the roadway, to an upper position, that extends above the road surface to form a barrier to the traffic. This type of barrier is more expensive than a lifting arm, but it is typically more vandal-resistant and provides a more substantial vehicle barrier. Some instances of vehicle damage have been reported either from a barrier malfunction or lack of visibility.

A rising step barrier, as shown in **Figure 9-2**, should be accompanied by a lifting-arm barrier or a traffic signal that shows red until the barrier is fully lowered to avoid possible damage by equipment malfunction or driver error.

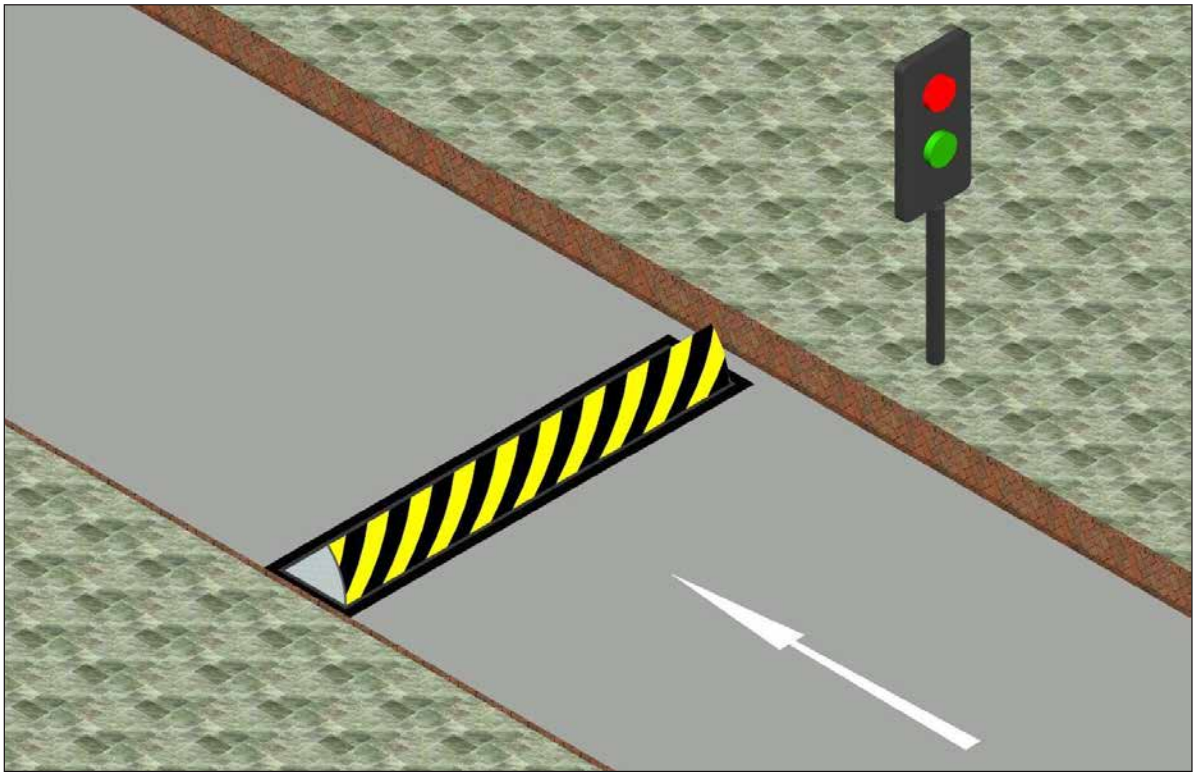


Figure 9-2 Rising Step Barrier with Traffic Signal

9.4 Shopping Cart Storage

As applicable, designated areas must be set aside for shopping cart return and storage, as shown in **Figure 9-3**. Parking areas for businesses with shopping carts must:

- Provide a safe and efficient location for returning and storing retail shopping carts.
- Ensure all parking area aisles and pedestrian walkways are kept clear of shopping carts.

Shopping cart storage facilities, or corrals, are often modular in design, which enable them to be conveniently located within any given car park layout. Shopping cart collection points should be clearly indicated on each parking level.

The empty carts must be returned to their respective stores. Returning the empty shopping carts might necessitate additional elevators in some cases.

Design of the storage space for shopping carts depends on multiple variables, like nature of the business, area of the establishment, adjacent land uses, brands occupying the facility, accessibility, and the proximity to public transport. The following general guidelines can be followed for planning and designing of shopping cart corrals:

1. A supply of two to three carts can be provided for 100 m^2 of Gross Floor Area (GFA) for the supermarkets/ hypermarkets at the parking lot. Similar space will also be required at the entrance of the supermarket. This leads to an assumption that the corrals will be cleared every 30 minutes.

2. A minimum of one cart should be provided for 200 m^2 of retail GFA for retailers, other than the supermarkets/hypermarkets served by a parking facility. Similar space will also be required at the entrances. It can be assumed that the corrals will be cleared every 30 minutes.

3. Shopping cart corrals must be visibly marked.

4. Shopping cart collection points must be clearly indicated on each parking level of multilevel parking facilities.

5. Parking area infrastructure must accommodate pedestrian paths with dropped curb crosswalks to allow pedestrians to move with shopping carts.

6. Shopping cart collection areas should have slopes or other provisions to retain carts and prevent them from rolling (e.g., stops/wheel guard).

7. Centrally located single, double, and triple lane corrals may be provided, depending on the demand and space availability.

8. National Motor Freight Classification (NMFC) codes 164390-A and 164393-A of National Motor Freight Traffic Association (NMFTA) can be used as design guidelines of a shopping cart storage area, in consultation with the Overseeing Authority.

9. Shopping cart corrals must be a minimum of 0.5 m from the parking stalls and aisles.

10. Supermarket/hypermarket and other retail staff must regularly collect and remove carts from the parking areas.

Figure 9-3 Shopping Cart Corral

9.5 Elevators

Elevators (alternatively, lifts) are one of the important components of off-street multilevel parking facilities (alternatively, parking garages). The general design of the elevators should comply with the local standards and specifications laid out by Ministry of Municipality and Environment (MME) and Qatar Civil Defense Department (QCDD). The following additional considerations are advised for elevators serving multilevel parking facilities:

1. The parking facilities are often attached to a building. The characteristics of the building, such as land use type and density, pedestrian demand profile, number of floors, pedestrian demand by floors, stopping requirements at different floors, pedestrians accessing from the parking lot, etc. are major parameters for planning and designing the elevators.

2. Parking garages must be provided with a minimum of one elevator bank containing two elevators. Additional banks of two elevators must be provided as required to meet the estimated demands.

3. Elevators must be placed at points that are convenient to access while being compatible with garage architecture and structural design.

4. At least one elevator in the elevator bank should be ADA-compliant with appropriate dimensions and accessibility requirements.

5. Elevator door widths must be adequate to accommodate the need of users, like shopping carts in a garage for shopping mall.

6. Appropriate signage directing users to the elevators should be provided in the parking facility, as mentioned in **Section 17**.

7. Weather-protected waiting areas must be provided at all exposed levels of the elevators. Elevator entrances must be protected.

8. Mandatory safety precautions for the operation of elevators should be adopted and followed. Each elevator unit must be provided with a separate telephone line and flush-mounted speaker phone with built-in auto dialer and ringer to permit two-way conversations.

9. Emergency communications equipment in the elevators must comply with ADA requirements, including service for hearing and speech-impaired persons. The device must be incorporated into the car operating panel and be vandal resistant.

10. Each elevator system must have an elevator controller and a device that is compatible with a central monitoring system.

9.6 Garbage Bins

The requirement of garbage bins and the appropriate location of placing the garbage bins in an off-street parking facility depends on the type of land use, nature of operations, and waste disposal mechanism. As general guidelines, the garbage bins must not be placed in parking aisles or in travel lanes. Garbage bins must be placed such that garbage pick-up and drop-off operations do not impede vehicular circulation.

The placing of garbage bins must not:

1. Encroach parking or circulation space.

2. Obstruct pedestrians, movement of wheelchairs.

3. Obstruct access to manholes.

4. Obstruct emergency vehicle access.

5. Obstruct entry exit to any development.

6. Obstruct operation of delivery vehicles.

7. Obstruct access of the disposal vehicle.

In locations where garbage bins and related collection operations must be accommodated along curbside, adjacent to on-street parking, they must be at the end of the parking aisle, and the garbage collection must be restricted to certain off-peak hours to minimize impact to other users.

Garbage bin placement and collection must not:

1. Obstruct pedestrians or access to manholes, traffic signal boxes, and fire hydrants.
2. Obstruct entry/exit to adjacent properties.
3. Impede operation of delivery vehicles.
4. Be located less than 15 m from a school crossing, pedestrian crossing, or bus stop.
5. Be placed in a median or on a traffic island.

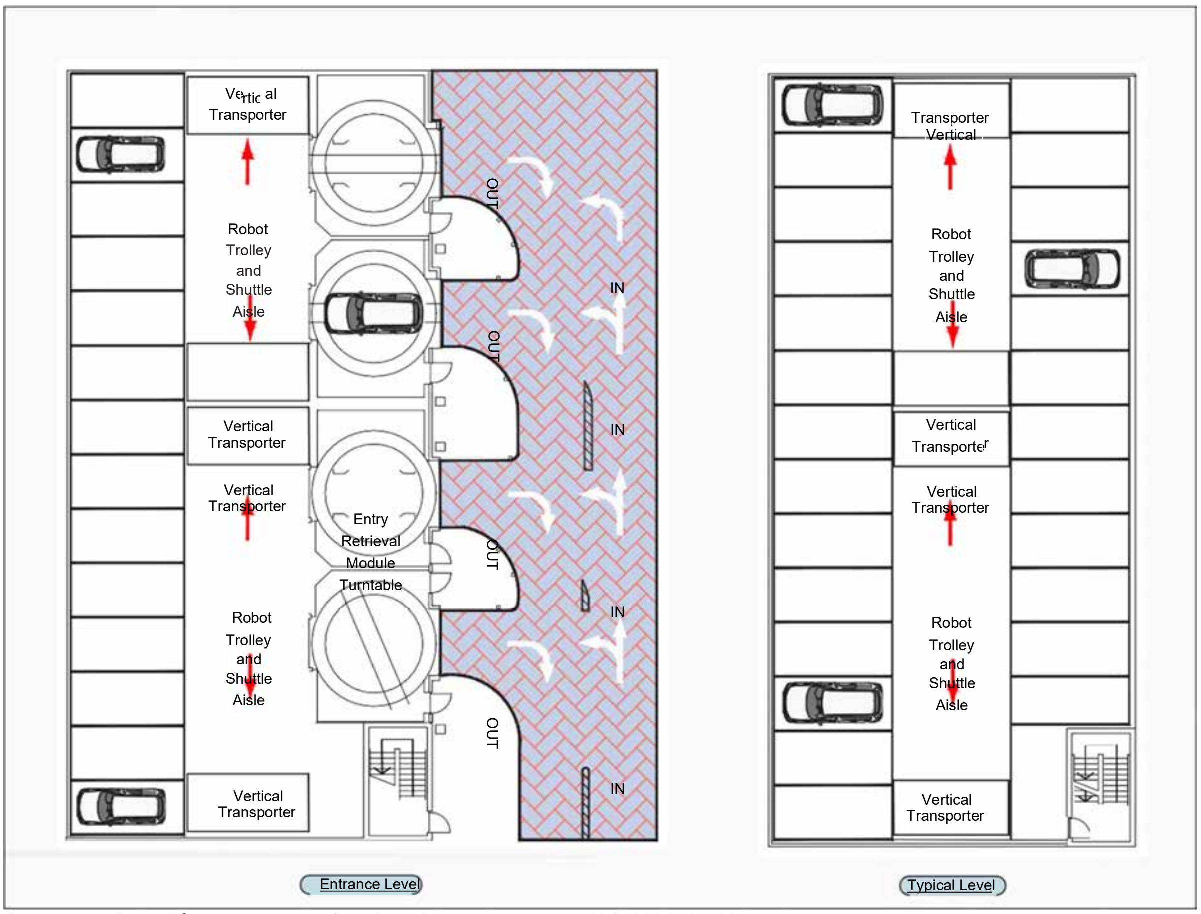
Section 10

Automated Parking

10: Automated Parking

An Automated Parking System (APS) for cars is a mechanical system designed to minimize the area and spatial volume required for parking cars. Similar to a multistory parking garage, an APS provides parking for cars on multiple levels, stacked vertically to maximize the number of parking spaces, while minimizing land usage. The APS uses a mechanical system to transport cars to and from the parking spaces. This eliminates the space allocated to ramps and helps in maneuvering within a typical multistory parking garage. While a multistory parking garage is like multiple parking lots stacked vertically, an APS is more of an automated storage and retrieval system for cars. APS, being an evolving technology, has dynamic requirements. Accordingly, designs that are being contemplated should be adaptable to the future technology and operation dynamics. Any APS project should elaborate the system, operational parameters, design, etc., and seek the approval from the Overseeing Authority.

APS is also known by a variety of other names such as Automated Parking Facility (APF), Mechanized Parking System (MPS), Automated Vehicle Storage and Retrieval System (AVSRS), Car Parking System, Mechanical Parking, Carousal Parking, and Robotic Parking Garage. **Figure 10-1** provides an indicative layout of a typical APS, and **Figure 10-2** shows an automated parking facility in operation.



SOURCE: Adapted from "Automated Parking System-Patents-US8632290B2," 2014.

Figure 10-1 Robotic or Automated Parking System Typical Layout

SOURCE: swiss-park.com[1]

Figure 10-2 Automated Parking System

For new parking proposals, approved APS should be considered as a provision for meeting the parking requirement.

10.1 Advantages and Disadvantages

An APS should only be provided where warranted; it is not suitable for all conditions. Installation of such a system requires a large front-end cost. Generally, an APS is most suitable for long-term, low-turnover parking, such as for offices and low-turnover residential developments. Advantages and disadvantages of an APS are summarized in **Table 10-1**.

Table 10-1 APS Advantages and Disadvantages

Advantages	Disadvantages
Requires less space and can be constructed where conventional multilevel parking with ramps might not be possible	High cost to maintain high parking demand
Reduced land cost	Higher cost to construct
Efficient “no contract” parking	Restricted access and egress delivery

(table continued in next page)

[1] https://swiss-park.com/en/products/automatic-parking-systems

Table 10-1 APS Advantages and Disadvantages (continued)

Advantages	Disadvantages
Easier facade integration since there are "no ramping" floors or openings in exterior wall	Limited peak entry and exit capacity
No time spent on searching for parking	Requires an on-site operator at all times
Low emissions from vehicles	No user access to parked cars
Does not need open sides for ventilation	Additional space needed for entry/exit plaza and loading/retrieval

Recent experiences of mechanical car parks in the region have suggested that the equipment is susceptible to breakdowns caused by sand contamination. Hence, specific measures should be taken to safeguard against this. The designer should ensure that the vendor provides maintenance, including safeguarding against sand contamination.

In addition to saving space, many APS designs provide several secondary benefits:

1. Parked cars and their contents are secure due to the elimination of public access to vehicles.
2. Minor parking lot damage, such as scrapes and dents are eliminated or reduced.
3. Driver and passenger safety is improved by eliminating the walk to and from parked cars.
4. Mobility impaired access is improved.
5. Spatial volume and visual impact of the parking structures are minimized.
6. Construction time is reduced.

10.2 Adopting an Automated Parking System

APS is still at its nascent stage in the State of Qatar. It is normally preferred in locations where there is high parking demand and land is at a premium. The decision to adopt APS should be appropriately substantiated by the need and suitability at the proposed location. Approval from the Overseeing Authority should be obtained with regard to citing and the proposed plans for APS.

10.3 Automated Parking Guidelines

Automated parking systems can be broadly categorized into two groups. These are "lateral displacement systems" and "vertical displacement systems." Some APS structures may have elements of both types of displacement systems. The following APS guidelines are associated with providing APS parking and the facility layout:

- In addition to parking facility layout approval from the Overseeing Authority, the operational aspects of the parking system, such as fire safety, should also be approved from relevant authorities.
- Developers must provide upfront, clear information to the prospective owners, customers, or users about the proposed use of automated parking in the development.
- APS must not limit the type of cars that can use the facility.

10.3.1 Lateral Displacement Systems

In a lateral displacement system, cars are parked on movable platforms. The platforms can move automatically along guide rails that are laid flat on the floor to make a passageway for unimpeded access.

The dimensions for a lateral displacement automated parking system, considering PDV dimensions, are summarized in **Table 10-2**. One-way systems allow entry from one side and exit from the other. Two-way systems allow both the entry and the exit from the same side. Circulation dimensions for one-way and two-way traffic systems are shown in **Figure 10-3** and **Figure 10-4**, respectively.

Table 10-2 Lateral Displacement System Requirements

Description	Size
Platform Size (min)	5.5 m long by 2.7 m wide
Min. Maneuvering Space (sideways)	3.0 m
Min. Maneuvering Space (lengthways)	7.2 m
Min. clear Driveway Width (after installation)	
One-way traffic	3.6 m
Two-2-way traffic	6.0 m
Holding Bay	At Entrance and Exit

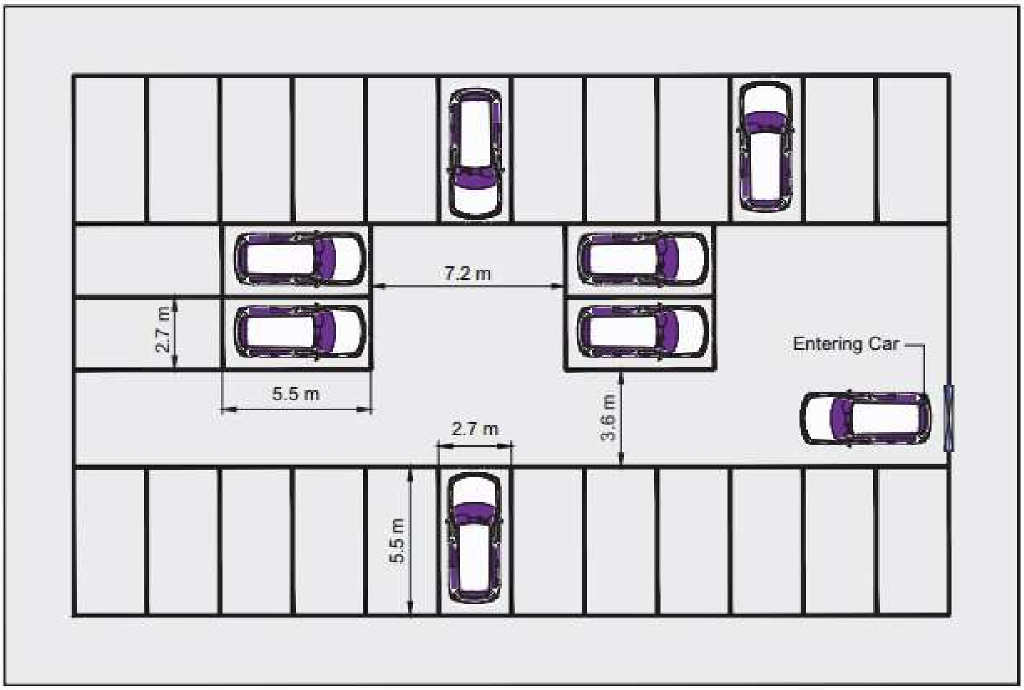


Figure 10-3 Lateral Parking System (One-Way) Dimensions

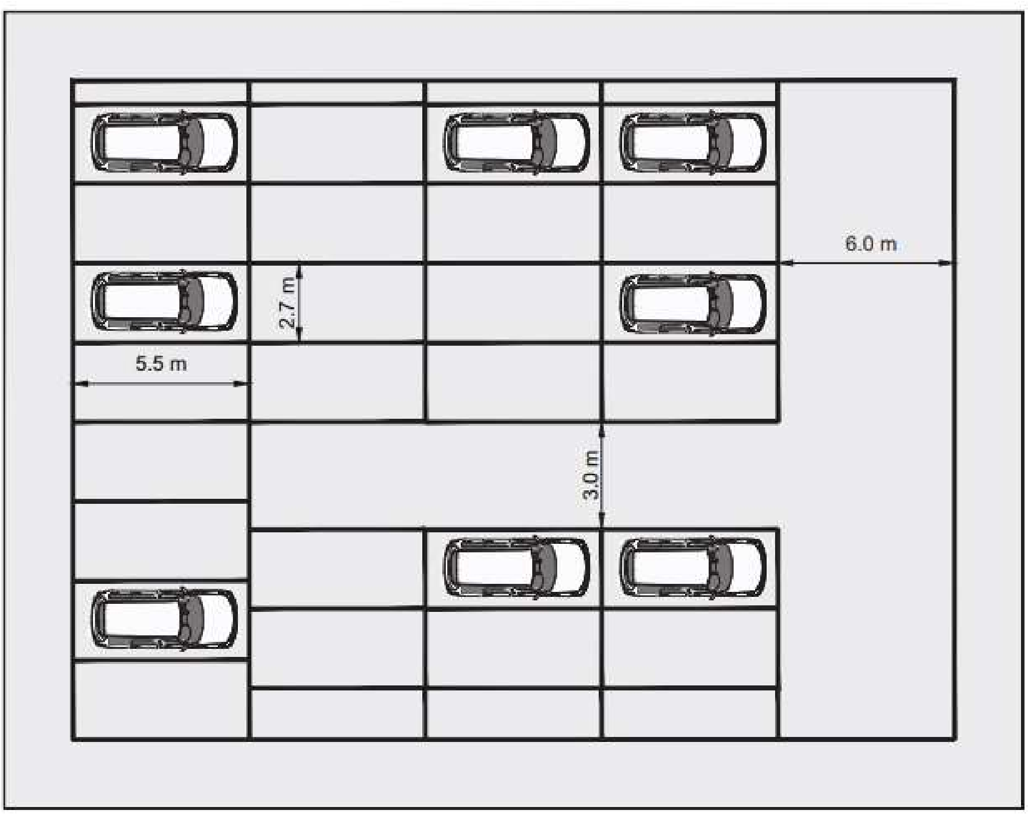


Figure 10-4 Lateral Parking System (Two-Way) Dimensions

10.3.2 Vertical Displacement Systems

In this system, cars are parked either on a vertical Ferris wheel or lifted vertically and positioned into storage spaces. Such systems allow cars to be parked and retrieved automatically.

Dimensions for a vertical displacement automated parking system are summarized in **Table 10-3**. Holding bay dimensions are shown in side view in **Figure 10-5** and in front view in **Figure 10-6**.

Table 10-3 Vertical Displacement System Requirements

Description	Size
Platform Size (min)	5.5 m long by 2.7 m wide
Holding Bay	At Entrance and Exit
Height Limit	2.4 m clear (excluding conduits and fixtures for lighting, MEP, etc.)

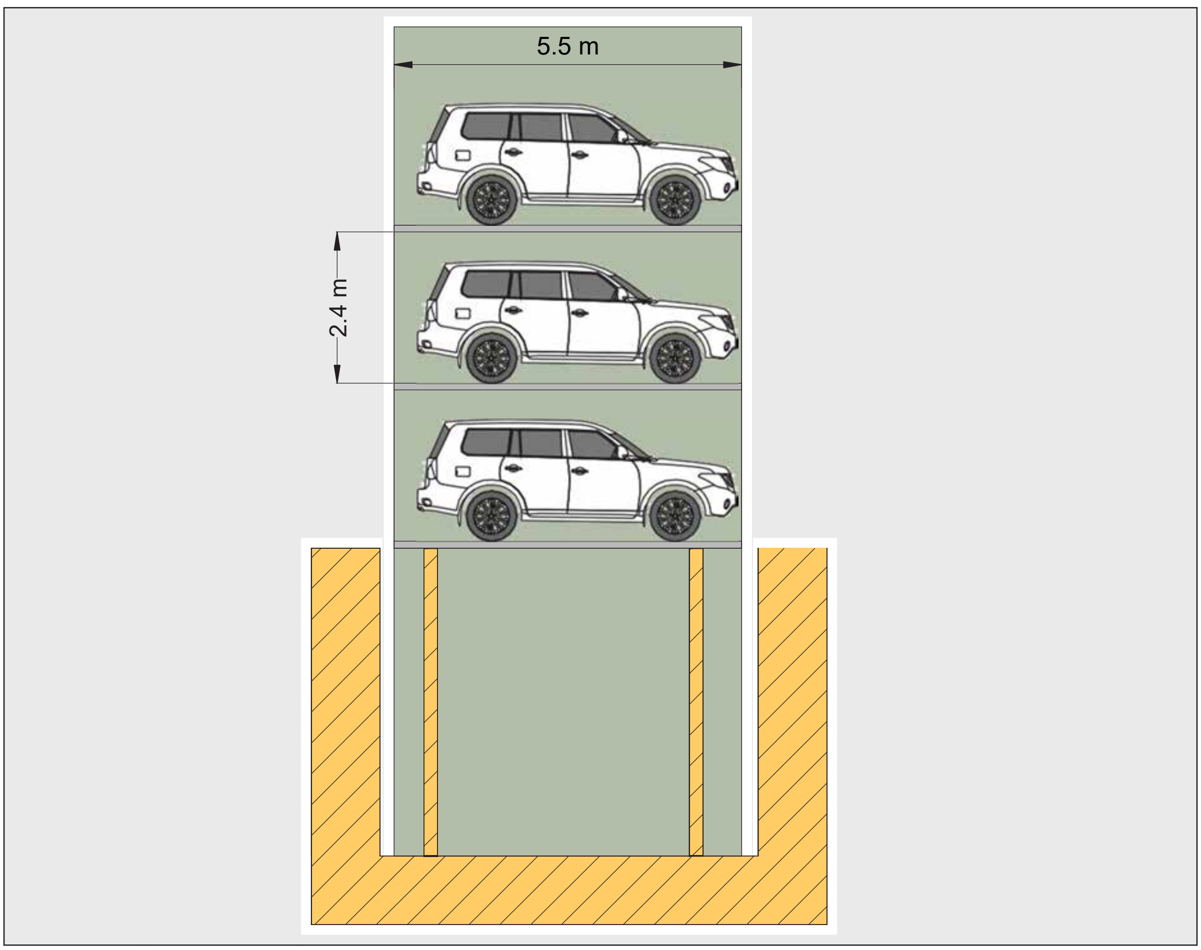


Figure 10-5 Vertical Parking System (Side View) Dimensions

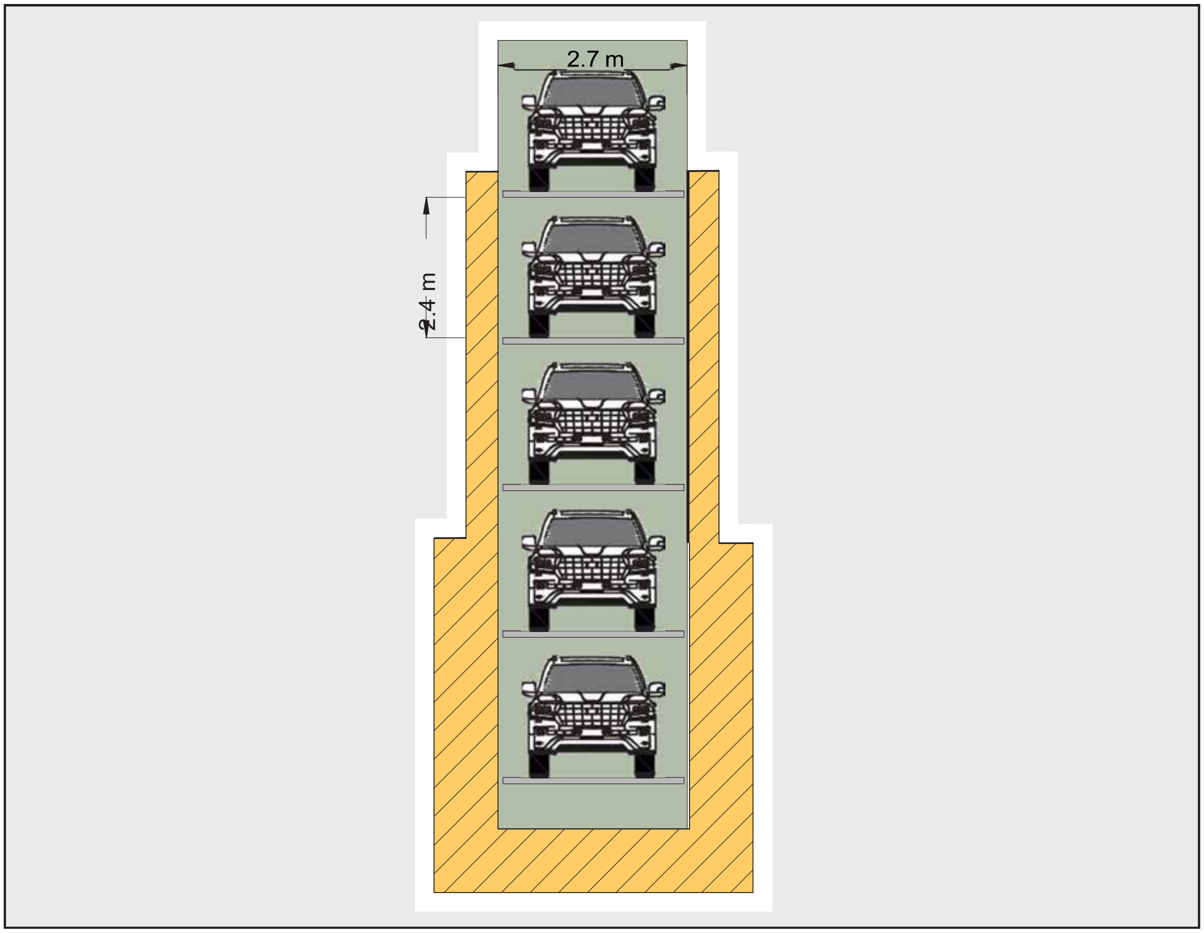


Figure 10-6 Vertical Parking System (Front View) Dimensions

10.4 Automated Parking Features

10.4.1 Access

Access driveways to APS facilities should be designed in accordance with the guidelines in **Section 7**. The preferred design is a single access driveway from the main road. Access driveways must provide sufficient vehicle storage to ensure that the vehicle entrance queues do not extend beyond the APS facility property boundary. All vehicle queues must be accommodated on site.

Space for queueing and the design of the holding bays are key elements associated with APS facility access.

10.4.2 Queuing Space

Vehicle queuing storage required is determined by calculating the queue lengths and number of vehicles to be accommodated. Conventional queuing theory will be applied to estimate mean arrival rates during normal peak periods and mean service rates under continuous demand. Calculations will be based on observational data from similar facilities. The storage area will be designed to accommodate the estimated 95th percentile queue condition. This must be computed on a case-by-case basis.

- The 95th percentile means that 95% of the queue length expected in the facility are lesser than the 95th percentile queue length.
- Access ramps from the driveway entrance to the service gate of the APS structure can be considered as the queuing space.
- The entire queuing space should be within the boundaries of the development.
- At the APS facility entrance, the minimum queuing length should be 15% of the total parking spaces proposed in the structure.
- At the facility exit (where it is separate from the entrance), a minimum of one-car-length holding space must be provided within the boundary of the development.

10.4.3 Holding Bays

The holding bay is the area in front of the entry module turntable/loading bay. Holding bays are not considered within the queuing space. There must be space for at least one vehicle in front of each car elevator.

10.4.4 Car Elevators

Car elevators replace access ramps for vertical distribution of cars to upper parking floors. All other requirements for the parking design remain the same as the conventional parking places and spaces defined in **Section 6**.

Typical dimensions of a car elevator for automated parking are summarized in **Table 10-4**. Dimensions can differ based on the supplier. Vendors usually show discharge capacity, which could vary with the vendor and the type. The typical dimensions for a single car elevator are shown in **Figure 10-7**. Elevators can also be for several or multiple cars. The car elevator guidelines in **Table 10.4** are for reference. The actual values will depend on the vendor specifications. From the different specifications available, the appropriate ones satisfying the proposed requirements should be adopted.

Table 10-4 Car Elevator Guidelines

Description	Recommendation
Car Elevator Internal Dimension	5.5 m long by 2.7 m wide
Car Elevator Shaft Dimension	6.0 m long by 3.8 m wide
Car Elevator Door Width	2.4 m
Minimum Speed	30 m/minute

(table continued in next page)

Table 10-4 Car Elevator Guidelines (continued)

Description	Recommendation
Height Limit	2.4 m clear
Minimum Discharge Capacity	30 cars/hour
Holding Bay	At the entrance and the exit
Queuing Spaces	15% of car spaces served by a car elevator
Minimum Number of Elevators	Minimum two
Recommended Number of Parking Spaces served by one Elevator	50
Maximum Parking Spaces served by one Elevator	200*

**More than 50 parking spaces per elevator should be justified and require special approval of the Overseeing Authority*

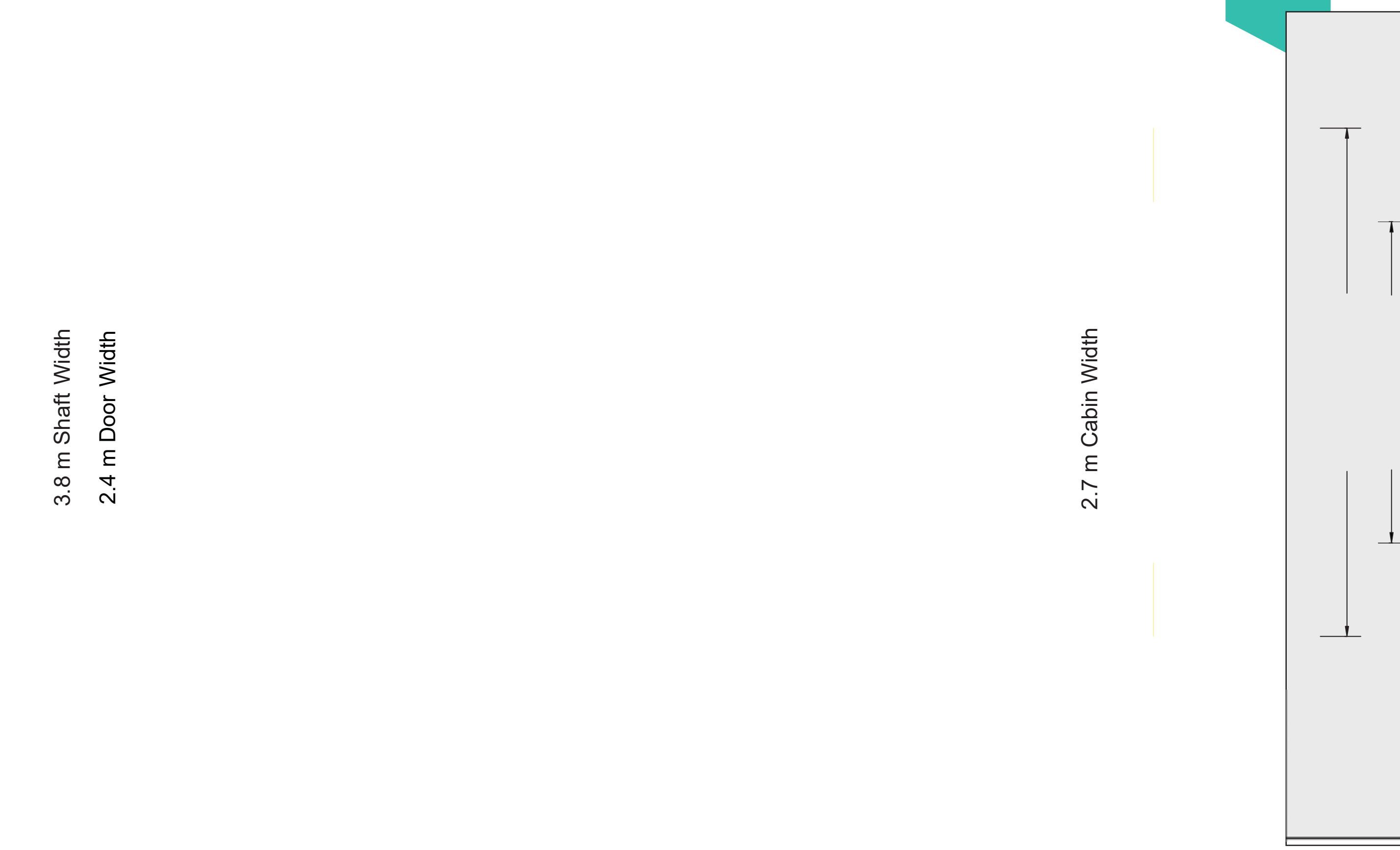


Figure 10-7 Typical Single Car Elevator

Typical layout of an APS facility is presented in **Figure 10-8**.

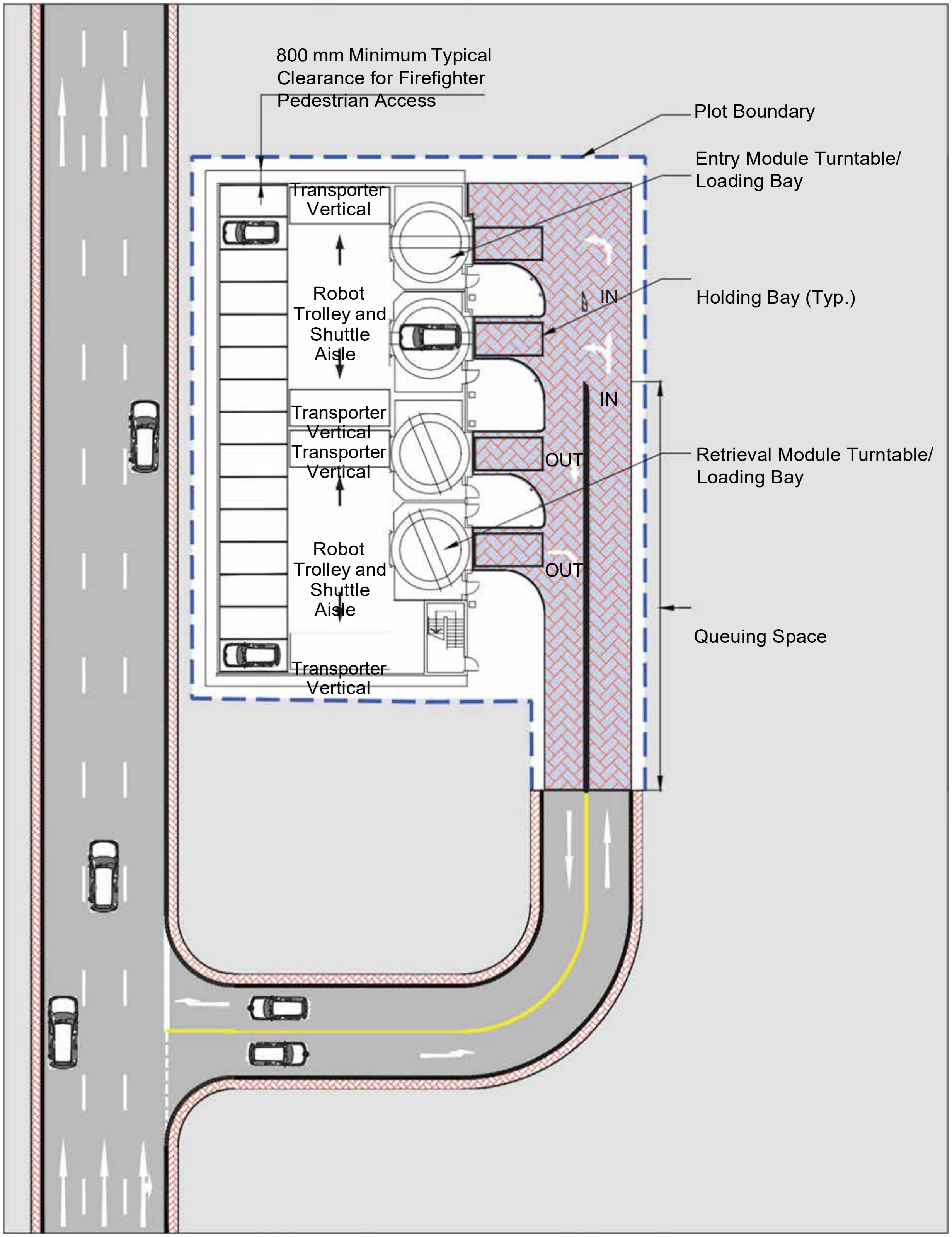


Figure 10-8 Typical APS Layout and Access

10.4.5 Performance Indicators

To design an efficient APS, it is important to understand the performance efficiency of the selected system.

Based on the International Best Practices and the evidence on the performance of existing automated parking systems across the globe, the following have been identified as the key performance indicators of an APS:

Throughput: It is the measure of the number of cars processed (i.e., storage and retrieval cycle of the system parking capacity). The units for throughput can either be in cars/hour or percentage of the capacity. Throughput of any automated parking facility depends on the capacity of the facility. Throughput of some of the most efficient automated parking facilities in operation is 30 to 36%. This means that 30 to 36% of the vehicles can be stored/retrieved from the facility without affecting each other.

Retrieval Time: It is the time elapsed from placing the vehicle retrieval request to the delivery of the vehicle to the driver. Retrieval time does not provide any indication of system performance during peak hours. The average retrieval time over an extended period of time serves as an indication of the stability of the APS. The average retrieval time observed at operational automated parking facilities is 120 to 180 seconds.

The value of the key performance is based on the current practice. Any variation of values in a proposed system should be agreed upon with the Overseeing Authority.

10.4.6 Fire Safety

National Fire Protection Association (NFPA) 88A includes fire safety guidance for automated parking facilities. The following guidance, in conjunction with the Qatar Civil Defense Department (QCDD) Standards and prior approval, should be appropriately considered in the design and construction of an APS:

1. Access requirement: Horizontal walkways at intervals of 6 m vertically and 30 m horizontally

2. Ventilation requirements: Minimum of 2 ACH (air changes per hour)

3. Fire extinguisher types:

    i. Conventional water sprinklers

    ii. Alternative methods of fire detection and suppression, such as foam, mist, and gas (may be supported)

    iii. In-rack sprinklers at about every 1.2 m^2 (NFPA 13)

4. Firefighter Pedestrian Access:

    i. When designing firefighter pedestrian access paths, pinch points and ladders accessing gantry systems must consider and be able to accommodate the additional size of an air cylinder worn on the back of a firefighter, as well as that of the equipment to be carried.

ii. Pinch points should not be narrower than 700 mm.

iii. Permanent safety ladders must have an increased clearance.

iv. The minimum clearance in front of the ladder, between the ladder and all permanent objects that are not part of the ladder installation, should be as follows:

a. Measurements should be from the nosing of the tread, measured perpendicular to the slope of the ladder.

b. The ladder should be at 1.20 m for a 70-degree inclination to the horizontal, increasing proportionally to 1.30 m when the ladder is inclined at 60 degrees to the horizontal.

c. A minimum lateral clearance of not less than 2.0 m from permanently unobstructed space, with a height above floor level, should be maintained.

d. Appropriate padded protection and hazard signage should be provided where warranted.

e. Minimum firefighter pedestrian access clearances should be 800 mm, with an allowance of 100 mm, where pipes or other obstructions are met.

Section 11

Accessible Parking

11: Accessible Parking

Parking for the disabled or mobility-impaired individuals, which is termed as accessible parking (alternatively, disabled parking), is a critical requirement in the design of any parking facility. There are three primary attributes of accessible parking applicable for both on-street and off-street facilities:

- Parking spaces are to be located in close proximity to the intended destination.
- Access should be safe and free of obstructions or conflicts.
- Oversized parking stalls with additional space for wheelchair or mobility device access are to be provided.

Reference is made to the Americans with Disabilities Act (ADA) for guidance on various design parameters related to accessible parking.

11.1 Location and Restrictions

Disabled drivers and passengers have unique requirements related to the size, location, and orientation of the parking space. Accessible parking requirements include, but are not limited, to the following:

- Spaces are to be located in the shortest accessible path to an entrance. Ideally, they should be at the ends, and not in the middle, of the parking bays, except if the nearest destination entrance is located adjacent to them.
- Spaces should be located in close proximity to the entrance of the destination they serve, such as hospitals, medical facilities, schools, civil centers, shopping centers, and parks.
- Dropped curbs are to be near accessible spaces between the parking space and the walkway.
- Street furniture should be adapted for the disabled. No obstructions should be present in the accessible parking area or along the path from the parking area to the destination.
- For parking structures, accessible parking spaces must be provided near elevators on floors that are not located on the same level as the primary entrance to the destination.

Appropriate pavement markings and signage must be clearly visible and evident to ensure that accessible parking stalls are available for qualifying users, as mentioned in **Section 17**.

Accessible parking stalls should be within 30 m from the main entrance or lift lobby of the building served by the parking facility. Accessible parking should be located such that the access from the parking space to the building entrance or to a safe travel path avoids vehicular traffic.

11.2 Accessible Parking Space Requirements

The minimum number of accessible parking space requirement is based on the total number of parking spaces in a facility, as shown in **Table 11-1**. Where multiple parking facilities are provided on a site, the required number of accessible parking spaces for each facility must be calculated separately. It is advised to refer to Qatar Standards for Accessible Transport (QSAT) also for the accessible parking rate and agree with the Overseeing Authority.

Table 11-1 Minimum Number of Accessible Parking Spaces in a Parking Facility

Total Parking Spaces Provided	Minimum Number of Accessible Parking Spaces
1 to 25	1
26 to 50	2
51 and over	3, plus one for each additional 100 parking spaces

SOURCE: Adapted from Engineering Guide for Planning and Regulatory Standards for Persons with Disabilities for Buildings and Establishments, Section 2.3.4.1.

Additional accessible parking spaces are required at places offering medical facilities. **Table 11-2** should be adopted as guidelines for estimating the minimum number of accessible parking space requirements for such facilities.

Table 11-2 Medical Facility-Accessible Parking Space Requirements

Medical Facility	Accessible Parking Space Requirement
Hospital Outpatient Facilities	10% of outpatients' and visitors' parking spaces
Rehabilitation Facilities and Outpatient Physiotherapy Facilities	20% of outpatients' and visitors' parking spaces

11.3 Off-Street Accessible Parking Stalls

According to the QHDM, Volume 1, Part 3, Section 6.2.13, accessible parking spaces must be designed so that a disabled person does not travel within the maneuvering lane for vehicular traffic to reach the safe travel path to a building or other site location. Accessible parking spaces should be 90 degrees to the curb. The gap between the parking spaces, defined as an accessible aisle, must have diagonal striping on a 45-degree angle, using a 0.3 m wide stripe at 0.6 m spacing. Concrete curb stops should be provided for each parking space. A minimum 1.6 m width must be provided adjacent to each parking space leading to the accessible ramp. There must be an additional 1.6 m diagonal striped area between a regular parking space and an adjacent accessible space.

11.3.1 Accessible Aisles

Accessible parking space for cars should have an access aisle of at least 1.6 m wide, located adjacent to the designated parking space. Access aisles should be wide enough to permit a person using a wheelchair to enter or exit the car and to swivel around 180 degrees. These parking spaces should be identified with a sign and should be located on level ground.

11.3.2 Parking Stall Dimensions

The dimensions of off-street parking spaces, as shown in **Figure 11-1**, should provide a rectangular space at least 6.0 m long and 3.5 m wide for the Parking Design Vehicle (PDV), along with additional spaces, as follows:

- Where the stalls are marked perpendicularly to the parking aisle, an additional width of at least 1.6 m along each side shall be added.
- Where accessible stalls are adjacent, space can be saved by using the same 1.6 m access aisle to serve the stalls on both sides.

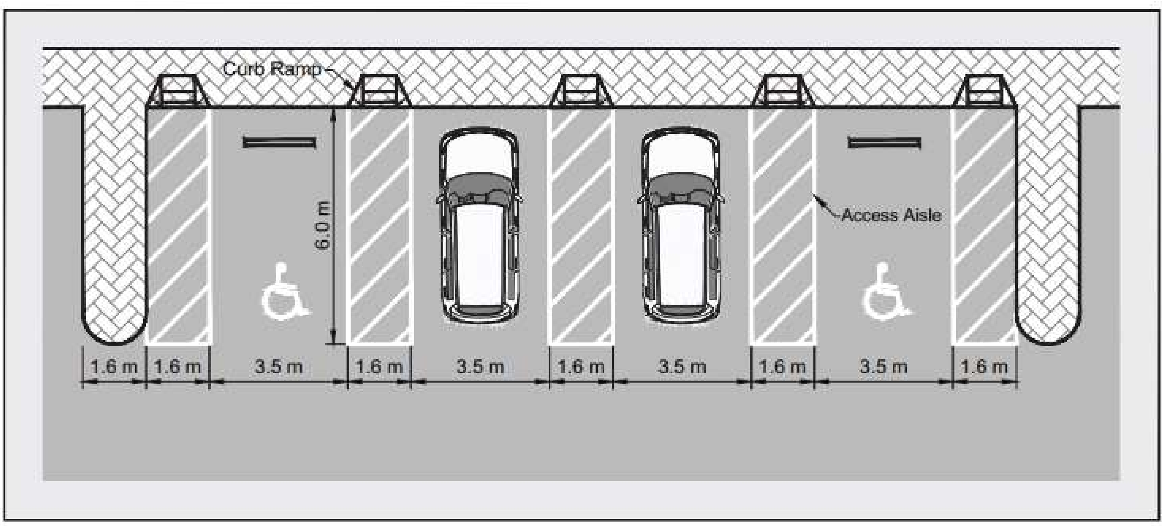
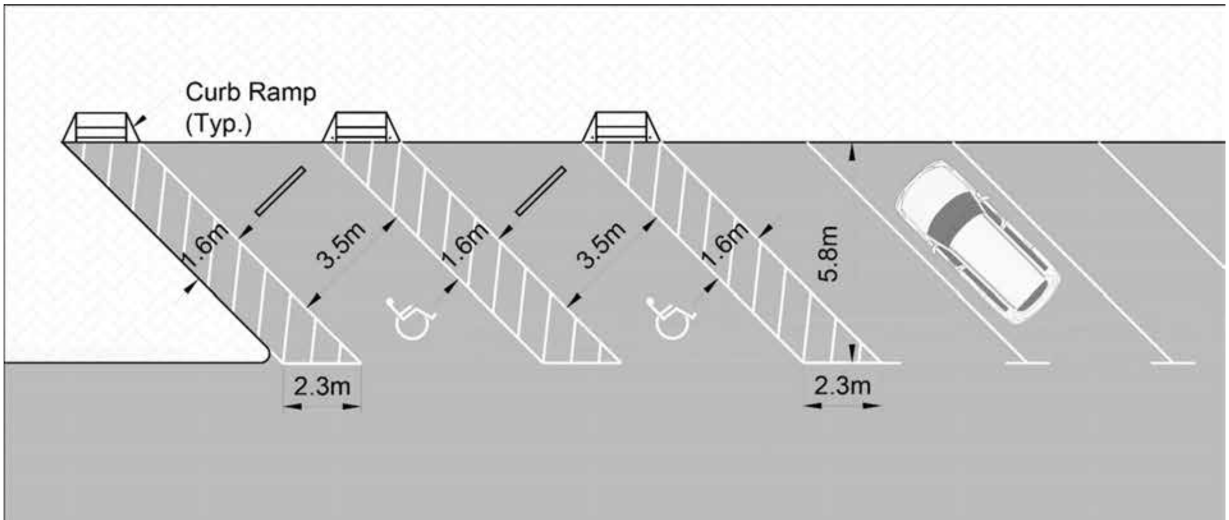


Figure 11-1 Off-Street Accessible Parking Stall Layout

11.4 On-Street Accessible Parking Stalls

Reference should be made to the QHDM, Volume 1, Part 3, for design of on-street accessible parking. Key contents from the QHDM are reproduced in this section.

All on-street accessible parking requires the approval of the Overseeing Authority. According to the QHDM, Volume 1, Part 3, Section 6.2.13, parallel accessible parking spaces are not provided on public streets. However, when angle parking stalls, preferably 45 degrees (unless other angles are approved by the Overseeing Authority), are provided on public streets, it is recommended that the end spaces adjacent to the corner crosswalks be made available to the disabled accessible vehicles, where warranted. Accessible ramps are not permitted at the curb of the street unless they are located on both sides of the street and within a striped crosswalk. **Figure 11-2** and **Figure 11-3** provides 45 degrees and perpendicular on-street accessible parking layouts, respectively.



Note: Refer to QHDM for dimensions of regular parking.

Figure 11-2 Forty-Five-Degree On-Street Accessible Parking Layout

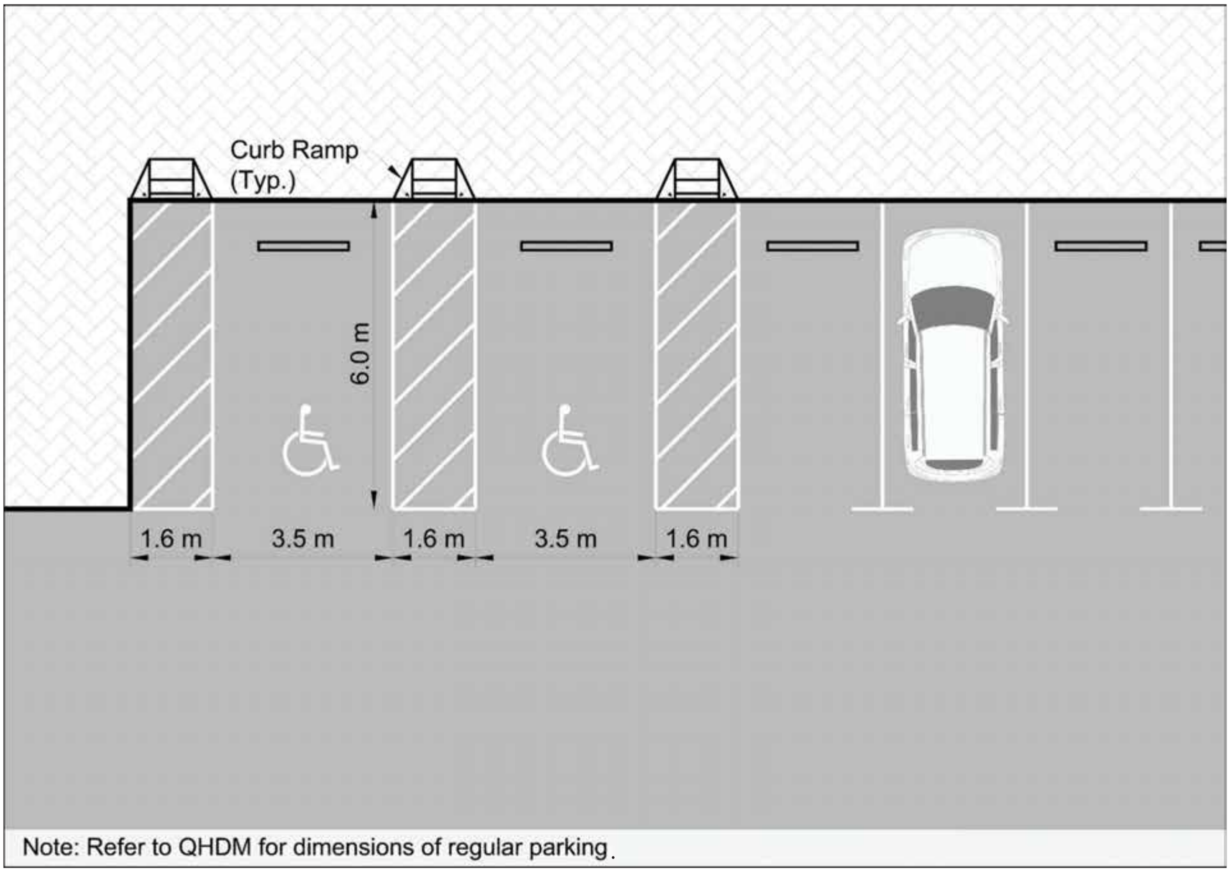


Figure 11-3 Perpendicular On-Street Accessible Parking Layout

On-street parallel parking should only be provided to vehicles transporting disabled passengers who are able to board/alight on the passenger side. The vehicle's driver should not have any kind of physical disability. On-street parallel accessible parking stalls must meet the following requirements:

- Minimum length of 6.0 m
- Maximum length of 8.0 m, where required, after discussion with the Overseeing Authority
- Minimum width of 2.5 m
- Minimum width of 2.4 m for adjacent access aisles along the length of the parking space

The required dimensions for on-street parallel accessible vehicle parking stall with an access aisle is shown in **Figure 11-4**.

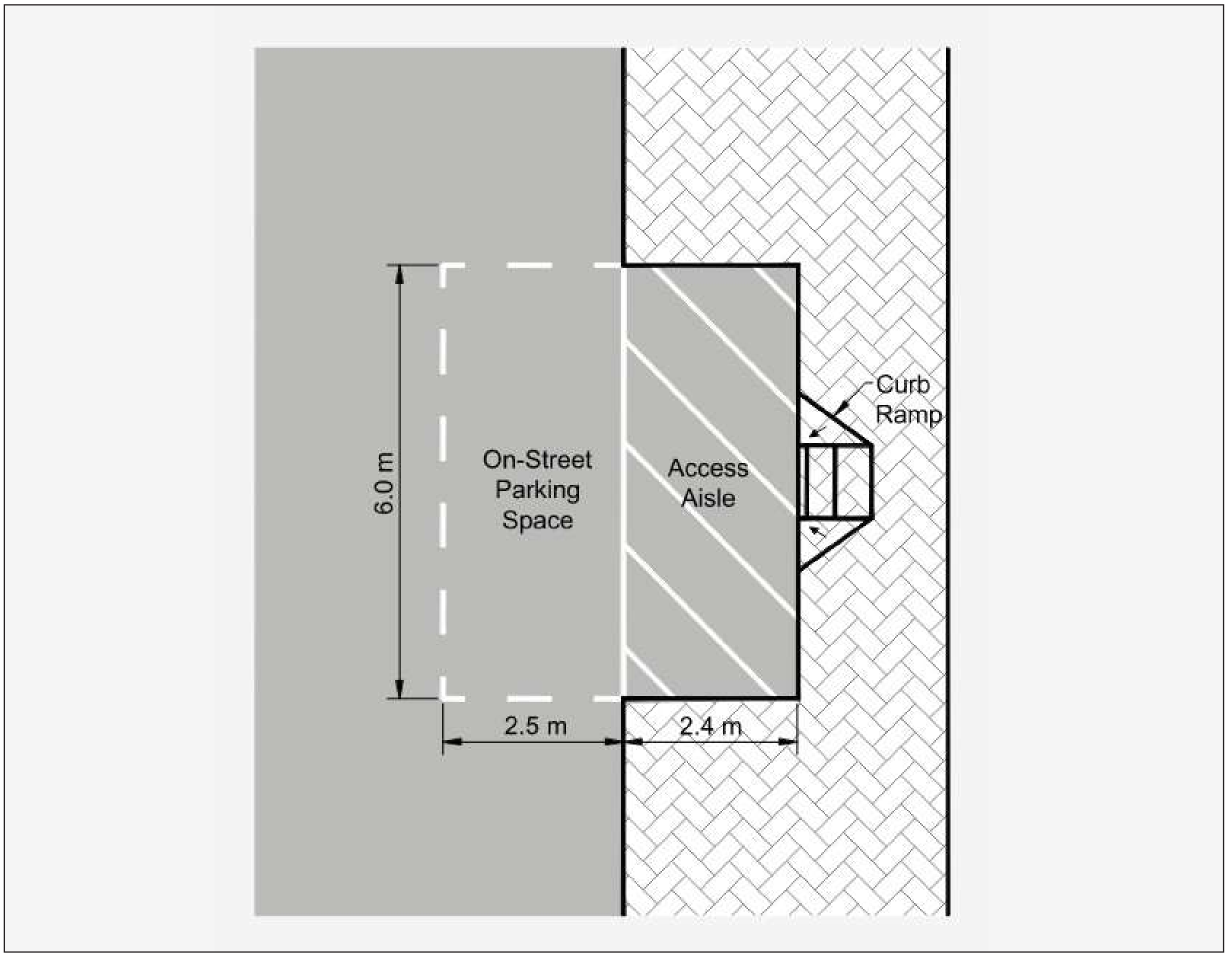


Figure 11-4 On-Street Parallel Accessible Vehicle Parking Stall Layout

11.5 Accessible Routes

An accessible route is a continuous, unobstructed path connecting accessible parking spaces to a destination, such as a building or a site. It is advised to refer to the ADA guidelines for further instructions. The required minimum width of an accessible route should be 1.2 m and 2.0 m with passage clearance for one and two wheelchairs, respectively. Tactile paving may be considered, where warranted, to assist pedestrians with impaired vision. It is advised to refer to QHDM Volume 1, Part 8, Section 5 and the QHDM Volume 3, Part 19, Section 4 for additional guidance on tactile paving.

11.5.1 Stairs, Ramps, Bollards, Elevators, and Escalators

Pedestrian routes to and from car parks, with parking spaces for the disabled, should be free from stairs, bollards, and steep grades. Accessible ramps should be short, with grades ideally no steeper than 5% (maximum). These grades also apply to any sloping pathways in a parking facility. Handrails must be provided on both sides of the ramps and staircase.

Elevators with automatic doors or escalators should be used wherever the vertical distance is large and not suitable for a ramp. Accessways should be wide enough for all users, and seating arrangements should be provided close to the elevator entrances for those who are unable to stand for extended periods of time.

11.5.2 Dropped Curbs

According to the ADA guidelines, dropped curbs must be flush with the road surface for easy access to the sidewalks from the parking areas. Measures must be taken to protect pedestrians who are visually impaired. For example, dropped curbs should not line up with the entrances to public buildings. If a dropped curb is located mid-block, it might allow a visually impaired person to walk out into the traffic. **Section 12.2.1** may be referred to for details on dropped curbs.

11.5.3 Crossfalls

Side slopes, also called crossfalls, should not be steeper than 1:48 to aid off-loading of wheelchairs at the side and rear of the vehicles. It is important to ensure that drainage is not compromised while designing crossfalls.

11.5.4 Other Considerations

The currency slots of the pay stations or pay machines, ticket dispensers, and machine display screens should be at a suitable height, in the range of 1.00 m and 1.40 m above the adjacent surface. This height excludes the support base (plinth) of the machine.

Section 12

Pedestrian Access

12: Pedestrian Access

Safe pedestrian access to and around parked vehicles is an important component of the parking layout design. This section provides the parking design requirements for pedestrian access. The recommendations made in this section are appropriately referred to in Qatar Highway Design Manual (QHDM), Volume 1, Part 2, Section 11, QHDM Volume 3, Part 19, Section 4, Pedestrian Facility Guidelines (PFG), Qatar Standards for Accessible Transport (QSAT), and Qatar Pedestrian Crossings Master Plan (QPCMP).

12.1 Sidewalks

Sidewalk is the paved path for pedestrians by the side of a road. It represents the pedestrian realm in a road corridor. The term "sidewalk" will be limited to on-street parking area in this Manual.

A clear sidewalk width of 1.5 m is adequate for most road situations. The following requirements have been recommended for sidewalks, which comply with the QHDM recommendations:

- Minimum of 1.8 m and desirable 3.0 m wide sidewalk for urban local and service roads
- Minimum of 2.0 m and desirable 3.0 m wide sidewalk for urban minor and major collector roads
- QHDM Volume 3, Part 19, Section 4, is to be referred to for higher category roads with on-street parking
- Absolute minimum of 1.8 m wide sidewalk in areas where two wheelchairs will be required to pass
- Minimum of 3.0 m width in high pedestrian traffic areas, such as commercial, shopping malls, schools, and mosques

12.2 Pedestrian Paths

Pedestrian path is a primary design element in a parking facility, which connects the primary use(s) of the site with the parking area and the external sidewalk network.

The following are the main objectives of pedestrian paths in parking facilities:

- Inclusive design that caters to the needs of all users
- Ease of access/convenience to the users
- Clear guidance to the users
- Safe pedestrian connections within a parking facility

The following design principles should be followed for designing an off-street parking facility to ensure pedestrian safety:

- Separation of entrance and exit for vehicles and pedestrians
- Prohibition of pedestrians on vehicle circulation roads
- Location of pedestrian crossings away from major concentrations of vehicular movement
- Positioning of pedestrian crossings at right angles with the traffic flow to maximize sight distance
- Usage of signage and pavement markings as a guide to pedestrian crossings points
- Usage of raised pedestrian paths in large parking facilities (> 1,000 spaces) to provide safe walking conditions in high-volume pedestrian locations
- Usage of parking layout to encourage pedestrians to walk parallel to the aisles of the parked vehicles
- Connection of pathway network to pedestrian vehicle aisle crossings
- Provision of highly visible direct pedestrian pathway access to the building's entrance
- Usage of curb extensions[1] at crossing points
- Non-encroachment of vehicle overhangs onto the pathway

A safe pathway design should adopt the following design criteria:

- Distinct surface color contrast and texture from vehicle paths
- Consistent level
- Slip-resistant hard surfacing
- A minimum pathway width of 2.0 m
- A wider pathway in areas with a large number of mobility-challenged users, such as in hospitals
- Minimum width of 3.0 m for pedestrian paths in areas with high pedestrian traffic, like commercial areas and schools

[1] *A "curb extension" is a traffic calming measure that includes extending sidewalks to shorten pedestrian crossing distances and improving visibility between drivers and pedestrians where parked cars may limit visibility.*

Figure 12-1 presents, for illustrative purposes only, an indicative and simplified off-street car parking facility layout with Parking Design Vehicle (PDV) parking and defined pedestrian paths. The exact requirement of pedestrian path, connection to sidewalks and external roads, site plan layout, signage, and markings must be assessed as part of the planning studies for respective facilities.

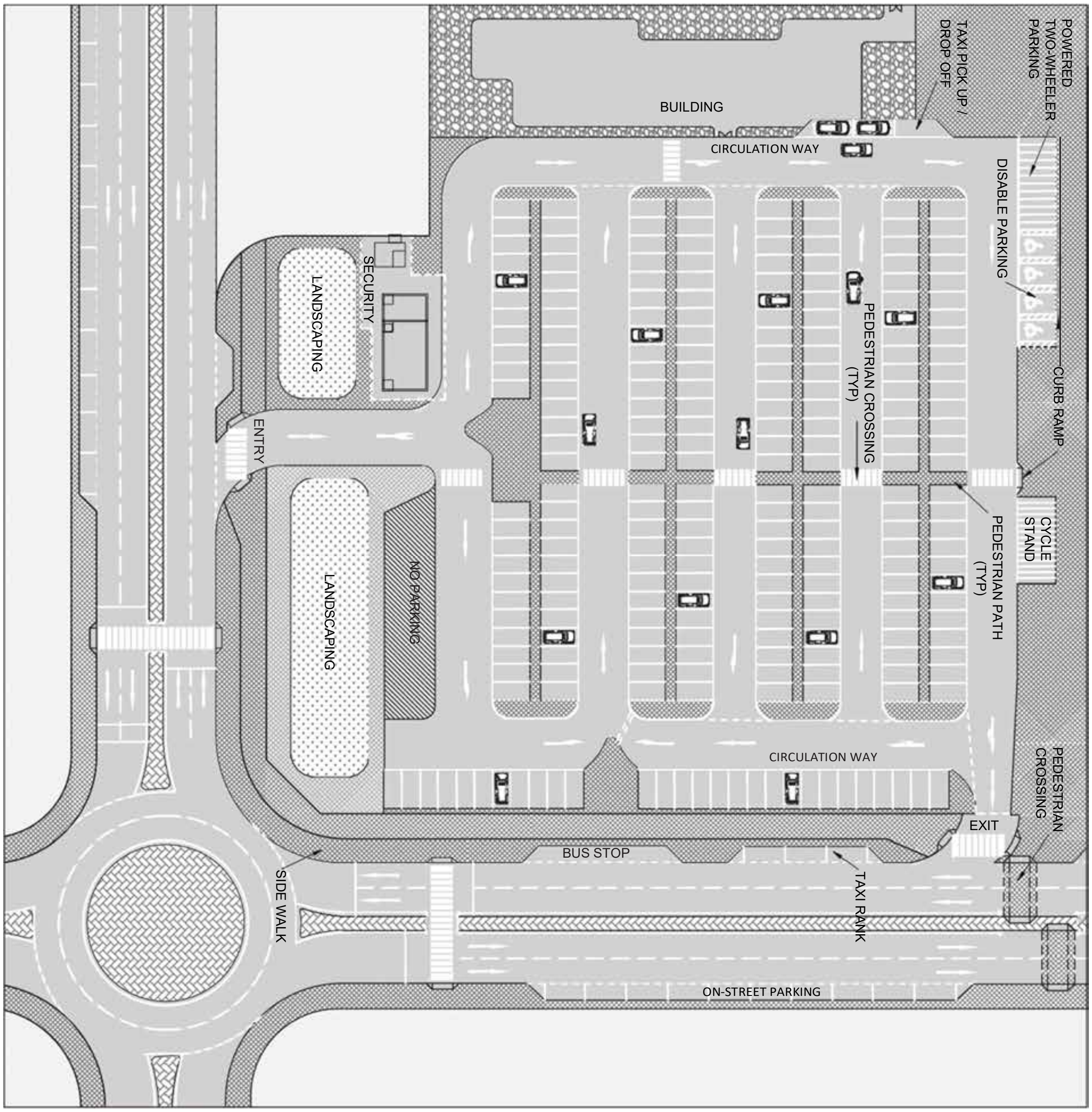


Figure 12-1 Integrated Car Parking with Designated Pedestrian Paths

12.2.1 Dropped Curbs

Dropped curbs must be provided at all pedestrian crossings to create a smooth transition from the raised pedestrian path level to the roadway level. This will enable a safe and convenient movement for pedestrians, people pushing prams or strollers, and wheelchair users. A dropped curb laid flush with the roadway must be provided across the entire width of the crossing. Typical details are shown in **Figure 12-2**.

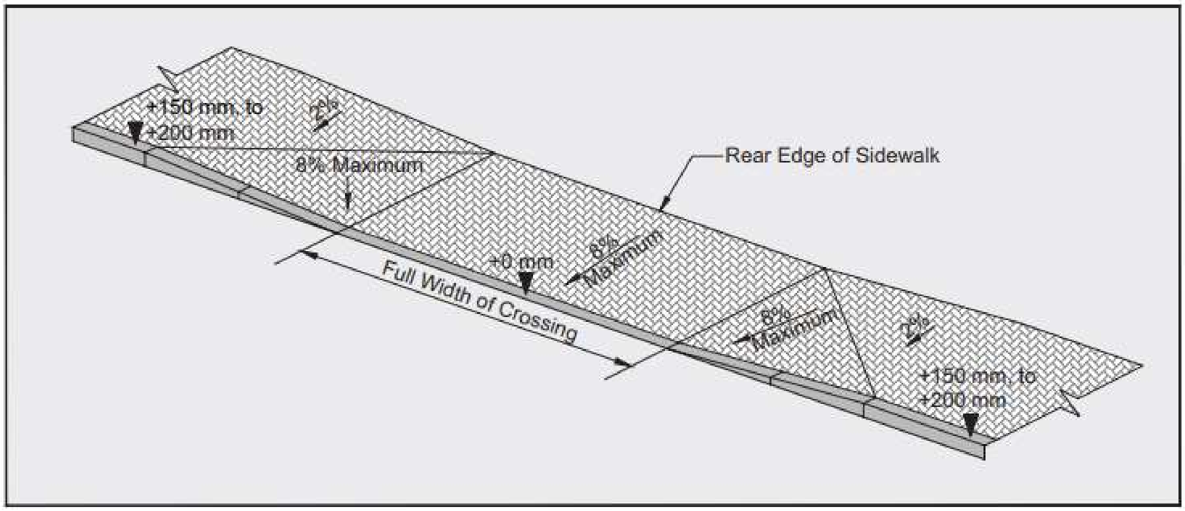


Figure 12-2 Typical Dropped Curb

12.3 Average Walking Distance

Pedestrian convenience is represented in terms of the walking distance between the parking space and the nearest pedestrian entrance at the destination. The acceptable walking distance varies in parking type and the size of the urban population (Weant & Levinson 1990).

Considering the climatic conditions of the State of Qatar, the acceptable walking distance that is followed in other countries must be reduced to half. The recommended distance for the different types of parking facilities are presented in **Table 12-1**.

Table 12-1 Acceptable Walking Distance

Parking Type	Acceptable Walking Distance
Designated loading and convenience use	< 15m
Short-term parking	< 125 m
Medium-term parking (e.g., retail, entertainment, work)	< 175 m
Long-term parking	< 250 m

These figures have been corroborated by surveys conducted in Doha in 2019 as part of the Qatar Parking Master Plan (QPMP).

12.4 Public Transport Interface

Pedestrian path requirements for public transportation facilities are discussed below:

- Bus bays and bus hubs adjacent to the large commercial developments should be located conveniently near the parking area and the main entrance to the building. The layout should allow adequate separation from parking-related traffic flow. This allows for better interface with pedestrian circulation and a shorter walking distance.

- Bus travel paths, intersections, and the entrance/exit of bus facilities must be safe and clear of all car parking spaces. Bus travel paths should be designed in a manner that does not impede pedestrian circulation or cause undue delays in bus service. See **Figure 15-14** for a typical layout of a pedestrian path for a park-and-ride facility.

12.5 Special Pedestrian Circulation Components

Generally, the pedestrian circulation enhances pedestrian orientation in parking lots to complete missing pedestrian linkages, prevent pedestrians from cutting paths to create a quicker or shorter walk and provide adequate separation between pedestrian and vehicular facilities as discussed in detail in earlier sections. The other components of pedestrian circulation include vertical transportation, refuge area, and emergency exit. The design considerations for these components are detailed as follows:

12.5.1 Vertical Transportation

Multilevel car parks must provide vertical transportation of pedestrians to different levels of the parking facility. Vertical transportation consists of elevators and escalators. Vertical transportation must be accessible to the disabled and accommodate users, including those with shopping bags and children in strollers. Elevators should be located so that they can be monitored from manned points, such as a control room or parking attendant booth. Closed-circuit television (CCTV) is desirable. Elevators should be vandal resistant. **Section 9.5** provides broad guidelines on elevators.

Elevators are preferable to escalators in parking facilities. Escalators must have trained on-site staff who can deal with emergency situations instantly. Escalators are not a substitute for elevators in complying with disabled access requirements.

Following are the requirements of the vertical transportation within a multi-storied parking facility:

- All parking structures, with three or more levels, must have an elevator.

- All parking structures, with accessible parking on levels other than the ground level, must have an accessible elevator for the disabled.

- Location of elevators must be prominently marked.

- Stair shafts must be located adjacent to each elevator, or bank of elevators, and clearly signed.

- In split-level parking structures, stair shafts must connect all levels.
- Safe, visible routes and protected paths should be provided to the pedestrians to access the parking space at all levels.
- All approaches to the stair shafts and elevators should be positioned to ensure pedestrian safety and security.

12.5.2 Refuge Area

An area of refuge (alternatively, refuge area or fire assembly point) is a location in a building designed to hold occupants during a fire or other emergency when evacuation may not be safe or possible. Occupants can wait there until rescued or relieved by the emergency response team. It is recommended that a refuge area be provided in every parking floor. These areas are to be provided with fresh air supply, adequate fire protection, lighting, and a two-way communication system.

12.5.3 Emergency Exits

Fire safety provisions in a parking facility must comply with the requirements of the Qatar Civil Defense Department Fire Safety Standards. The main factors governing the escape provision are:

1. Number of occupants that may have to escape from the facility
2. Travel time from any point in the building to a place of safety

The number of occupants determines the width of exits, and the travel time determines the number of exits.

An emergency exit plan is a comprehensive development/building-wide plan that follows an evacuation strategy (**Section 20.5.4**). The plan also includes parking facilities. The comprehensive emergency exit plan should be developed upon consideration of the following terms:

- Protected routes of escape
- Travel distances to the exit or refuge areas
- Smoke venting/control systems
- Places of safety
- Number of exits to the street
- Fire safety management and warning systems
- Separation of high fire risk areas from the safe exit routes
- Clearly defined and illuminated routes with exit and fire safety signage

Escape routes are the most important component of an emergency exit plan. Following recommendations are made for planning and designing of the escape routes for parking facilities:

- At least two exits should be provided for each parking facility. In a split-level parking structure, each level should be provided with two exits, one of which must be a final exit and the other may be to an exit on an adjoining level.
- Travel distance to the exit must be 100 m for open parking, 122 m for parking structures protected by fire suppression sprinklers, and 91 m for structures not protected by automatic sprinklers. Such exits must be distanced and located on the opposite sides of the parking structures to avoid dead ends. For more guidance, it is advised to refer to the Qatar Construction Specifications (QCS).
- Parking bays and/or service vehicle loading bays must be designed with unobstructed access to the exit points. All exit should be visible and adequately signed.
- The appropriate width of escape routes is determined by the number of persons likely to be in the parking structure (including surge loading, if applicable). In the absence of specific information or guidance from the local fire authority, total occupancy is typically assumed to be two people per parking space in public parking facilities and 1.5 people per parking space in private parking facilities.
- The minimum width of stair shaft escape routes in all parking levels is calculated using the applicable standards shown in **Table 12-2** but should not be less than 1.2 m. Assuming two people per space, the number of people that can be accommodated in each staircase increases with the number of floors and the width of the staircase.

Table 12-2 Emergency Stair Shaft Width Requirements

Number of Floors (f)	Number of people one stair shaft can accommodate during evacuation (P)		
	Escape Route Stair Shaft Width (w)		
	1.2 m	1.5 m	1.8 m
1	240	300	360
2	285	360	435
3	330	420	510
4	375	480	585
5	420	540	660
6	465	600	735
7	510	660	810
8	555	720	885
9	600	780	960
10	645	840	1035

SOURCE: The Institution of Structural Engineers, UK, "Design Recommendations for Multistory and Underground Car Parks," 4th Edition, 2011.

NOTE:

1. *P = 200w + 50(w – 0.3) (f - 1) (for stair shaft widths 1.1 m or wider)*
   P = number of people that can be served
   w = width of the stair
   f = number of floors served by the stair
2. *Separate calculations should be made for stairs/flights serving basement floor and those serving upper floors.*
3. *The person flow rates in the table are for one stair shaft exit. These numbers should be divided by the number of stair shaft exits available for exit.*
4. *The information in the Table 12-2 is a part of the International Best Practices. It is mandatory to obtain approval from Qatar Civil Defense Department and Overseeing Authority.*

- Signage and wayfinding along the escape routes should be according to the standards set forth in the Qatar Standards for Accessible Transport (QSAT), Volume II – Design Manual, 23. Signing and Wayfinding, October 2018, MOTC. Reference should be made to **Section 17** of this Manual for signage and pavement markings.

- Any method of communication should be well-signed and easy to understand. Examples include intercoms, public telephones, alarms, and electronic locking devices.

12.6 Additional Guidance

Refer to Pedestrian Facility Guidelines (PFG), Qatar Pedestrian Crossings Master Plan (QPCMP), Qatar Standards for Accessible Transport (QSAT) and QHDM for additional guidance.

Section 20.7 may be referred to for details on lighting. In general, the guidelines of the Chartered Institution of Building Services Engineers (CISBE) should be followed.

Section 13

Bicycle Parking

13: Bicycle Parking

The usage of bicycles is increasing around the globe. Thus, the arrangement for its parking has become an essential element of a multimodal transportation system. In order to encourage bicycling, the facilities provided should be safe, convenient, well-designed, and well-maintained. The Qatar National Bicycle Master Plan (QNBMP) provides overall guidance on bicycle transportation and parking to encourage and support bicycle usage in the State of Qatar. This section appropriately refers to QNBMP, Qatar Pedestrian Crossings Master Plan (QPCMP), and Qatar Highway Design Manual (QHDM). It also provides planning and design guidelines for bicycle parking.

Bicycle parking is an effective way to address the needs of multimodal transport (bicycle – public transport) users for their first and last mile connections. High-quality bicycle parking facilities are required to meet successfully the needs of cyclists and to encourage and support bicycle use in the State of Qatar. Provision of a conveniently located bicycle parking facility is also crucial to stop the use of roadway objects, such as sign pole, fencing, or railing, for bicycle parking.

According to the QPCMP:

1. A bicycle parking hub must be located within 200 m from a public transport station.

2. A minimum effective sidewalk width of 3 m must be maintained where unsegregated pedestrian and cyclist paths are considered. The bicycle parking should be clear of the sidewalk.

3. The minimum vertical clearance for bicycle facilities should be 2.4 m.

It is recommended that cycle path should be designed in conjunction with the QPCMP and the QHDM guidelines.

The following are the general design guidelines for bicycle parking, which are elaborated further in this section:

- Bicycle parking should be provided at convenient locations with arrangement for adequate access.
- Safety and security measures should be given high priority.
- A minimum clearance of 0.9 m from the car parking stalls should be maintained.
- The bicycles should be parked at a minimum of 0.6 m from curb face of a travel lane.
- The location of the bicycle parking should be in highly visible areas with ample illumination.
- Enough space should be allowed to safely stop, dismount, park, lock, or retrieve a bicycle that is not in a travel or parking circulation lane.
- Bicycle parking access should be provided in parking facilities (lots and structures) with walkways or paths that are separated from the vehicular traffic.

13.1 Classification

Bicycle parking facilities are classified by the level of security they provide, as summarized in **Table 13-1**.

Table 13-1 Bicycle Parking Facility Classification

Class	Security Level	Description	Primary User
1	High	Fully enclosed individual bicycle lockers	"Bike and ride" commuters at rail stations
2	Medium	Locked compounds; communal access using numerical code locks, duplicate keys, or electronic swipe cards	Regular employees who use the location as their regular place of work, students, and bike and ride commuters
3	Low	Bicycle racks that allow both the frame and wheels to be secured with a user-provided lock	Employees, shoppers, and visitors using bicycle parking facilities supervised by security personnel

SOURCE: Adapted from QHDM, Volume 3, Part 19, Section 5.7, Bicycle Parking.

13.2 Key Strategies

There are different strategies that should be considered while accommodating exclusive parking spaces for bicyclists. The three main strategies that should be considered are as follows:

1. **Access Strategies**

   - Access should be close to the building entrance.
   - Access should be at/from the ground level (i.e., by ramps, elevators).
   - There should not be any obstacle, such as stairs or steep slopes.
   - There should be separate, dedicated bicycle ramps moving into the parking facilities.
   - The wayfinding signage should be clearly displayed.

2. **Safety and Security Strategies**

   - Racks or lockers should be made of high-quality materials, and they must be secured firmly to the ground, floor, or wall.
   - The areas should be intermittently monitored by security personnel.

- The access should be located in a well-lit area.
- Short-term bicycle parking should be located in a busy, public area to increase informal surveillance.
- Long-term bicycle parking should be located in a separate, access-controlled area.

3. Locational Strategy

- The facility provided should be easily located and remain accessible to the user.
- They should be easily accessible for short-term (**Section 13.3.1**) and long-term (**Section 13.3.2**) users.
- They should be situated close to the bicycle-friendly routes, wherever possible.

13.3 Bicycle Parking Types

There are two types of bicycle parking facilities, which are dependent on parking durations, namely, short-term and long-term. All design principles and guidelines are reliant on the needs of these two parking types. These types are explained below:

13.3.1 Short-Term Bicycle Parking

A short-term bicycle parking facility is generally intended for visitors, customers, delivery personnel, and others who are expected to park for less than two hours. Effective short-term bicycle parking is generally located close to the destination and is easily accessible. Some land use, like commercial, retail, community centers, medical and sports facilities require short-term bicycle parking facility.

The most common bicycle racks recommended for short-term parking are circular, inverted loop, and inverted-U types. These racks can also be used for long-term parking (**Section 13.3.2**). Post and ring-type racks and wide post racks are also advised to be used, following the aesthetical requirements. It is advised to refer to **Figure 13-1** for commonly used types of bicycle racks.

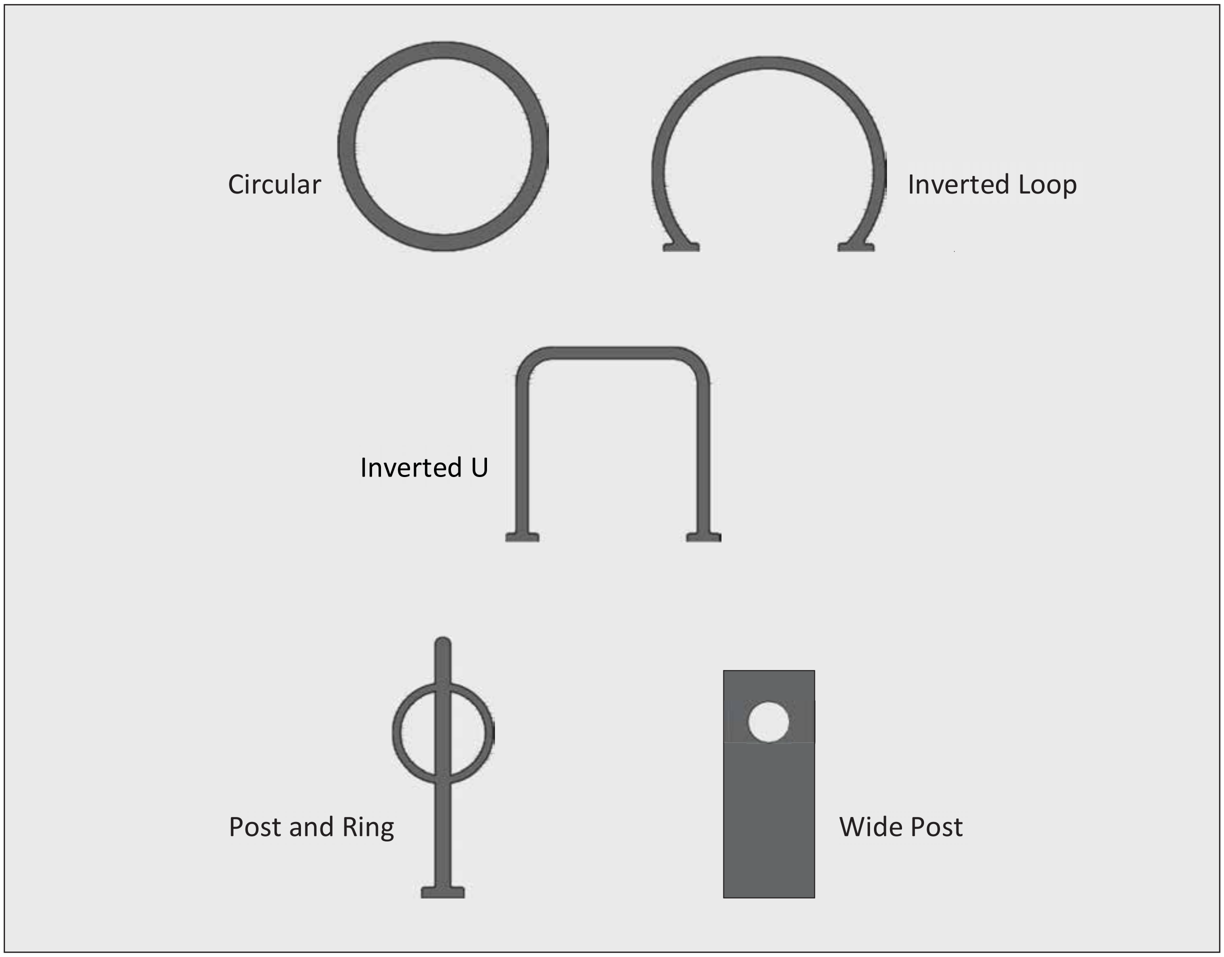


Figure 13-1 Common Bicycle Racks for Short-Term Bicycle Parking

The American Association of State Highway and Transportation Officials (AASHTO) recommendations regarding the specifications for bicycle parking are presented in **Table 13-2**. These values are also adopted in the QHDM and are recommended to be used for short-term bicycle parking in the State of Qatar.

Table 13-2 Bicycle Parking Facility Dimensions

Distance	Requirements
Between Racks	• Rack aligned end-to-end should be located a minimum of 2.4 m apart. • Rack aligned side-by-side should be located a minimum of 0.9 m apart.
From Curb	• Racks located perpendicular to a curb should be a minimum of 0.9 m from the back of curb. • Racks located parallel to a curb should be a minimum of 0.6 m from the back of curb.
From a Wall	• Assuming access is needed from both sides, inverted-U racks located perpendicular to a wall should be a minimum of 1.2 m from the wall. • Racks located parallel to a wall should be a minimum of 0.9 m from the wall.

SOURCE: "AASHTO Guide for the Development of Bicycle Facilities," 2012, 4th Edition, Chapter 6, Section 6.3.1.

Short-term bicycle parking should preferably be within 50 m of the ultimate destination. On-street parking is preferred for short-term parking. On-street bicycle parking can be on the sidewalk or a converted car parking space. Important considerations for bicycle parking are:

1. **On sidewalks:**

    - The minimum distance (clearance) from the curb must be 0.6 m where bicycles are parked parallel to the curb and 0.9 m where bicycles are parked perpendicular to the curb.
    - The minimum spacing between the racks must be 0.9 m.
    - Racks must be so oriented and located that a clear width of 1.8 m is available for pedestrians.
    - **Figure 13-2** provides typical details of bicycle parking on the sidewalks.

2. **On converted car parking space:**

    - This is to be provided only for the areas with high bicycle demand, transit proximity and shared demand, inadequate width of the sidewalks, low speed (<50 kph) streets, adequate sight distance, and good illumination.
    - Prior approval should be sought and obtained from Overseeing Authority.
    - Access and egress preferably should be from the sidewalk.
    - Sides of the parking space except on the curb must be protected with bollards/curb to ensure bicycle user safety.
    - Bicycles must be parked perpendicular to the curb and the minimum distance (clearance) from the curb must be 0.9 m.

- The spacing between the racks must be 0.9 m.
- **Figure 13-3** provides a typical layout for bicycle parking in a converted on-street parallel car parking space.
- **Figure 13.4** provides a typical layout for bicycle parking in a converted on-street angled (45-degree) car parking space.
- **Figure 13.5** presents an on-street bicycle parking facility.

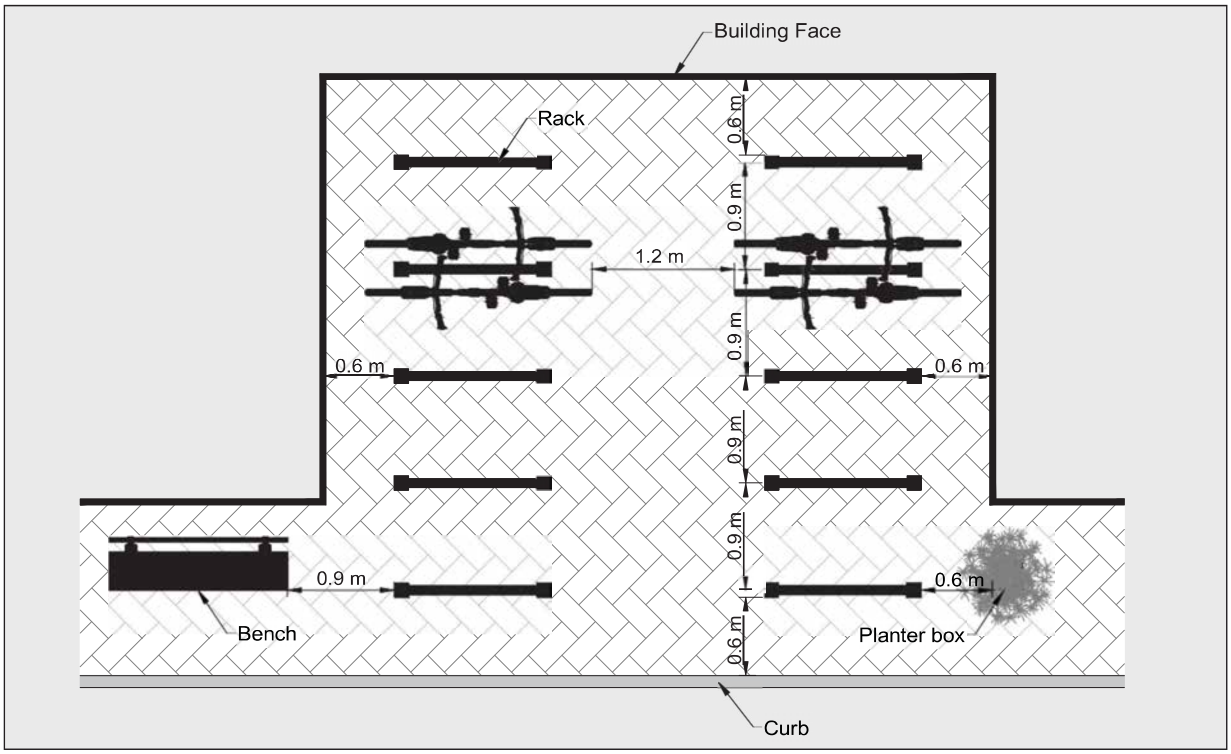


Figure 13-2 Typical Bicycle Parking Layout on Sidewalk

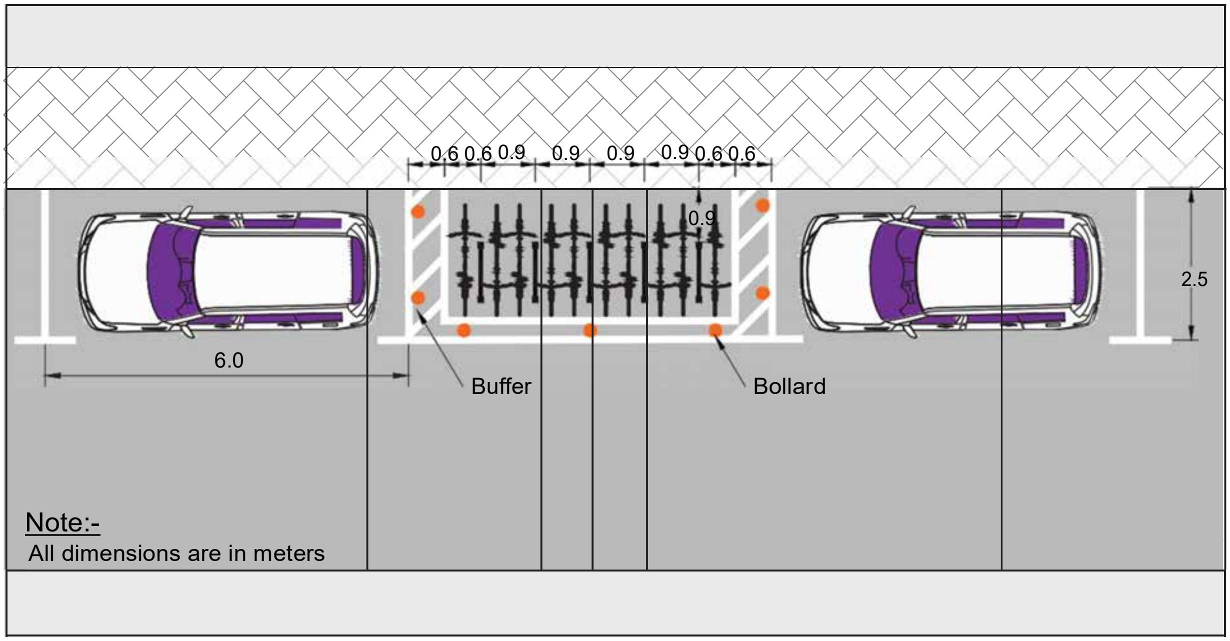


Figure 13-3 Typical Layout for Bicycle Parking in Converted Parallel On-Street Car Parking Space

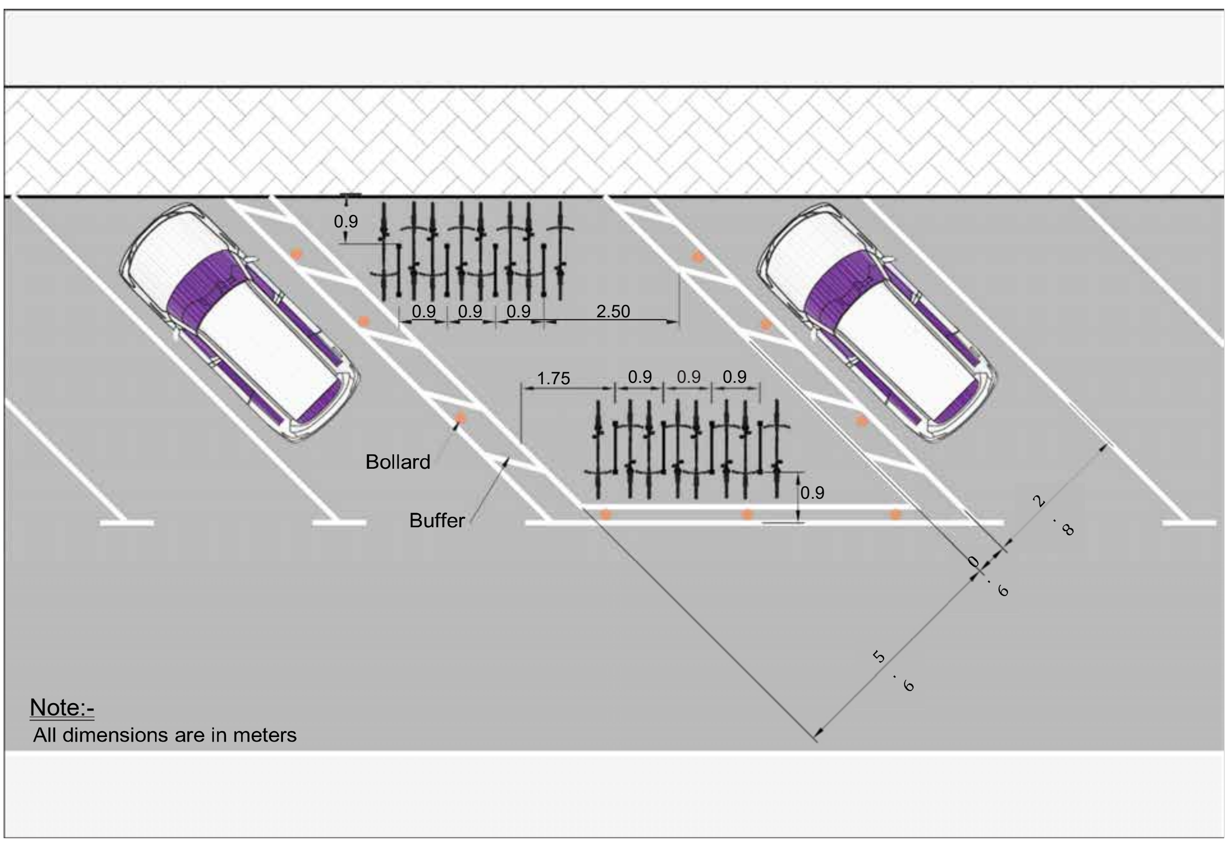


Figure 13-4 Typical Layout for Bicycle Parking in Converted Angular On-Street Car Parking Space

SOURCE: https://www.bikedocksolutions.com/local-authority.

Figure 13-5 On-Street Bicycle Parking

An inverted-U bicycle rack that accommodates two bicycles is preferred for short-term bicycle parking. Racks should be constructed out of strong metal tubing and securely anchored to the ground, unless the rack is large and heavy enough to prevent easy removal. The parking area underneath the rack should be a concrete or asphalt surface. The guidelines for designing racks are as follows:

- It should support the bicycle at two points above its center of gravity.
- High-security U-shaped bicycle racks should be used.
- Locks should be accommodated to secure the frame and one or both wheels (preferably the front wheel of the bicycle).
- Any protruding elements or sharp edges should be avoided.
- It should not bend the wheels or damage other parts of the bicycle.
- Lifting the bicycle off the ground should be prevented.

Bicycle parking racks can be grouped into corrals. **Figure 13-6** and **Figure 13-7** show corral groupings of circular and wide post bicycle parking racks.

Figure 13-6 Circular Rack Bicycle Parking (Msheireb Downtown)

Figure 13-7 Wide Post Rack Bicycle Parking (Msheireb Metro Station)

Provision for application-based rental bicycles (or bikes) should be considered appropriately for the future developments. This is essential for large parking lots, including shopping malls and public parking. This will be treated as short-term bicycle parking for design specifications. Convenient locations, such as near the mall entrance, should be allocated for a minimum 50 m^2 area. The rental bicycles might require their own parking applications. Provision of rental bicycle parking should be discussed and agreed upon with the Overseeing Authority.

13.3.2 Long-Term Bicycle Parking

Long-term bicycle parking is located in areas where bicycles are expected to be left unattended for more than two hours. Long-term bicycle parking facilities should provide a high degree of security and protection from weather and theft. These facilities typically serve multifamily residential complexes, schools, offices, parks, libraries, and public transport stops. It is advised to provide showers, lockers and other supporting infrastructure like shading and cooling system near the end of the bicycle trip location as per QNBMP recommendations.

Long-term bicycle parking is generally provided either as bike lockers or as shaded secure enclosure as shown in **Figure 13-8**. This offers high level security as entry is limited to those with permission to use the facility via a key or electronic card/code. It is still important to provide racks to lock bicycles inside the facility as an added security measure. The racks presented in **Figure 13-1** can be used inside the facility. It is recommended to submit the bicycle parking rack design to the Overseeing Authority to obtain their approval.

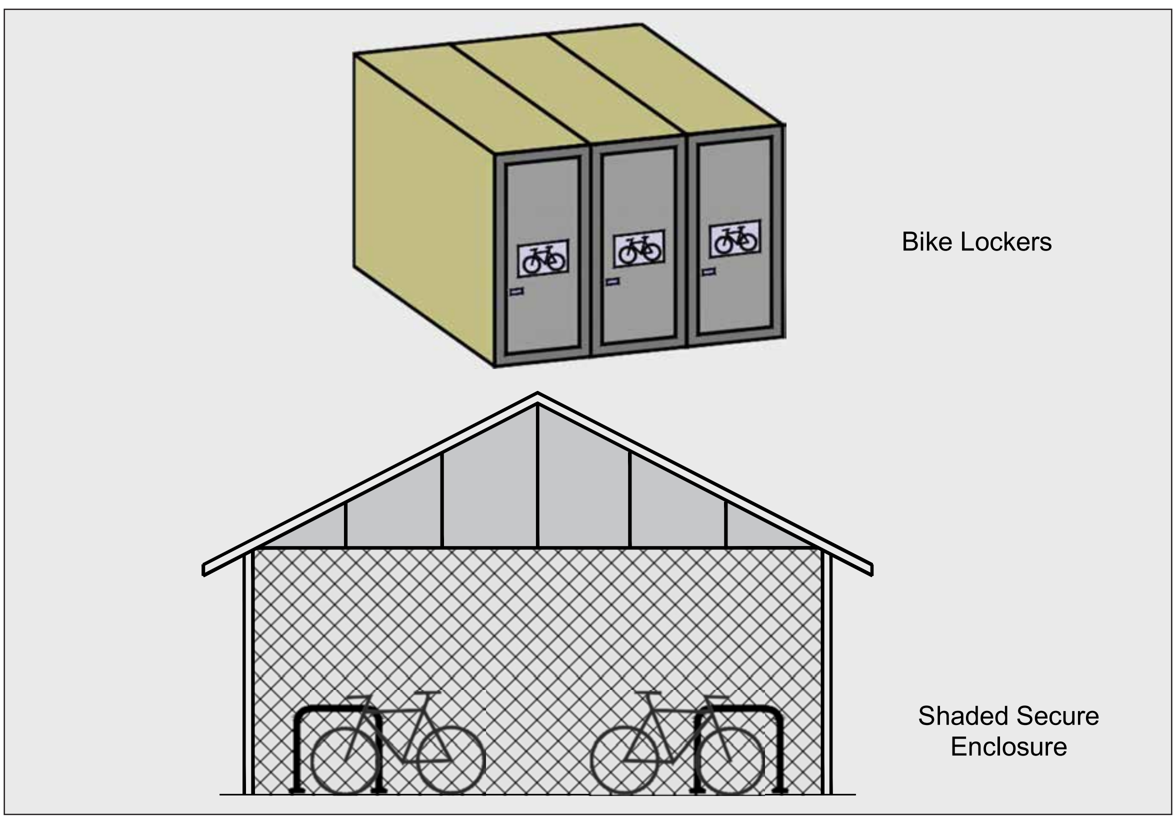


Figure 13-8 Long-Term Bicycle Parking

Use of two-tiered racks, as shown in **Figure 13-9**, can provide increased parking capacity in areas with limited space. A mechanism to assist the user in lifting bicycles onto the second level must be provided. This is suitable for long-term bicycle parking.

SOURCE: bikerackcompany.com[1].

Figure 13-9 Two-Tier Bicycle Rack

Dimensions of a two-tier bicycle rack for long-term parking is provided in **Figure 13-10**.

1 *https://www.bikerackcompany.com/shop/commercial-bike-racks/cycle-racks-stands/shopcommercial-bike-rackstwo-tier-rack/*

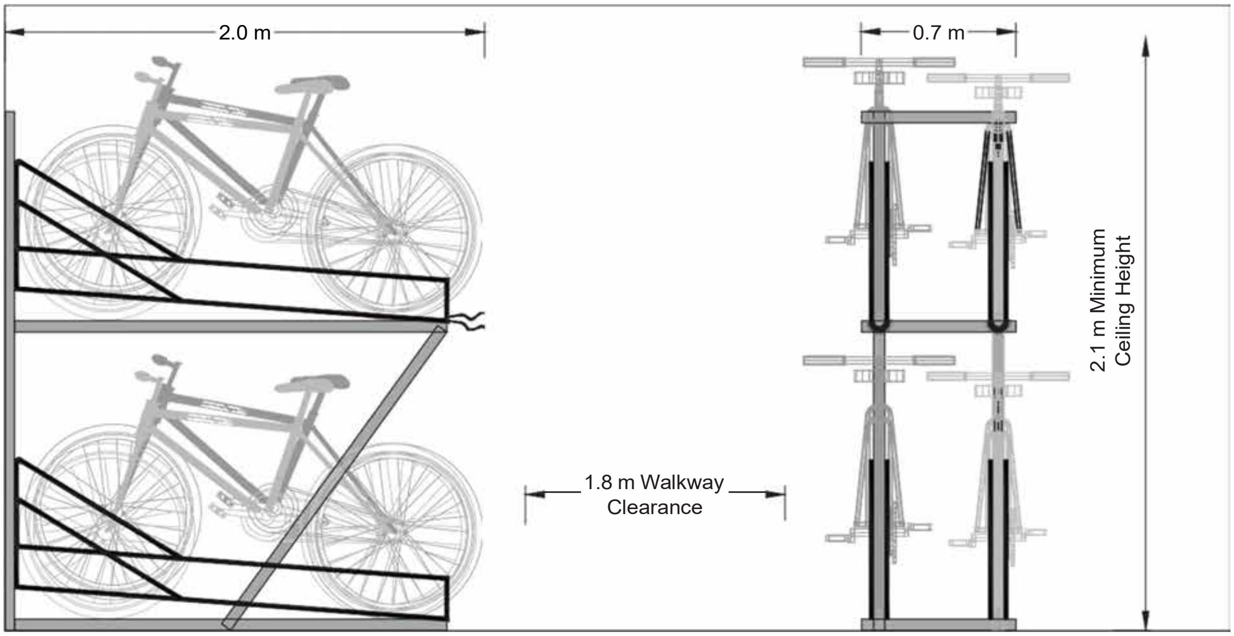


Figure 13-10 Two-Tier Bicycle Rack Dimensions for Long-Term Parking

13.4 Bicycle Parking Space Requirements

QNBMP stipulates the bicycle parking requirements for various land uses. These requirements are adopted as a part of this Manual. The values are also classified for Transit-Oriented Developments (TOD) and non-TODs. **Table 13-3** provides the bicycle parking space requirements for residential land use. Bicycle parking requirements for residential uses are calculated by dwelling unit. **Table 13-4** provides the bicycle parking space requirements for non-residential land uses. For non-residential land uses, bicycle parking requirements are a percentage of the car parking requirement, in addition to the car parking spaces.

Table 13-3 Bicycle Parking Space Requirements for Residential Land Uses

Bicycle Parking Space Requirements per Dwelling Unit				
	Long-Term Bicycle Parking		Short-Term Bicycle Parking	
Land Use	Non-TOD	TOD	Non-TOD	TOD
All Residential Land Uses	1	1.5	0.2	0.5

SOURCE: Adapted from Qatar National Bicycle Master Plan, Section 8.1.2.2, Bicycle Parking Development Standards.

Table 13-4 Bicycle Parking Space Requirements for Non-Residential Land Use

Bicycle Parking Space Requirements as Percentage of Required Car Parking Spaces				
	Long-Term Bicycle Parking		Short-Term Bicycle Parking	
Land Use	Non-TOD (%)	TOD (%)	Non-TOD (%)	TOD (%)
Hotels, Industrial Land Uses	10	20	5	10
Hospitals and Nursing Homes	10	20	10	20
Banks, Retail Shops, Restaurants	10	20	15	30
Office Buildings and Other Employment	15	30	10	20
Stadiums, Shopping Centers, Museums	10	20	20	40
Primary and Secondary Schools	15	30	40	80
Colleges and Universities	15	30	60	120

SOURCE: Adapted from Qatar National Bicycle Master Plan, Section 8.1.2.2, Bicycle Parking Development Standards

Section 14

Powered Two-Wheeler Parking

14: Powered Two-Wheeler Parking

The motor-powered two-wheelers, which include motorcycles, mopeds, and scooters, are common vehicles used for private transportation. These vehicles are termed as powered two-wheeler in the Qatar Parking Design Manual (QPDM). This section covers parking requirements for powered two-wheelers, both for on-street and off-street parking facilities.

Parking requirements for powered two-wheelers should be estimated following the Parking Design Process **(Section 2.2)** for all developments. The parking spaces for powered two-wheelers should be designed such that they are visible, well lit, safe, and located close to the pedestrian access points.

Typical powered two-wheeler dimensions are shown in **Table 14-1.** In absence of a more detailed local study of typical dimensions and lacking data on the 85th percentile size, reference is made to Institute of Highway Engineers (UK) for the powered two-wheeler dimensions. The 95th percentile dimensions provided in the reference is considered as dimensions of Parking Design Vehicle (PDV) for parking design purposes and is presented in **Table 14-1**.

Table 14-1 Indicative Dimensions for Powered Two-Wheelers

Vehicle Class	Length (m)	Width (m)	Weight (kg)
Moped	1.60	0.65	85
Middle-Weight Motorcycle/Scooter	1.90	0.80	230
Large Motorcycle	2.30	0.90	350
Parking Design Vehicle	2.00	0.80	260

SOURCE: Adapted from Institute of Highway Engineers (UK), Guidelines for Motorcycle Parking, 2005[1].

Based on the above as well as regional best practices, it is recommended that the parking stalls for powered two-wheelers be 1.5 m wide and 2.5 m long. These values consider the clearance required for mounting and demounting of riders and clearance from the curb. This length of 2.5 m allows the on-street powered two-wheeler parking stalls to fit perpendicularly into a standard on-street parallel parking stall, as shown in **Section 14.1.** The standard parking stalls have been designed to fit PDV. The off-street arrangements are explained in **Section 14.2**.

The dimensions of the PDV to be adopted for designs should be based on the largest powered two-wheeler anticipated in a facility. The parking stall dimensions must be based on the selected PDV . The design for powered two-wheeler parking should also be supported with appropriate signage and markings, following the recommendations made in **Section 17**.

1 http://www.motorcycleguidelines.org.uk/the-guidelines/6-0-motorcycle-parking/6-5-motorcycle-parking-resources/

14.1 On-Street Powered Two-Wheeler Parking

On-street powered two-wheeler stalls must be 1.5 m wide by 2.5 m in length, as shown in **Figure 14-1**, which also shows an example of on-street parking for powered two-wheelers.

A standard on-street parallel vehicle parking stall can accommodate four powered two-wheelers.

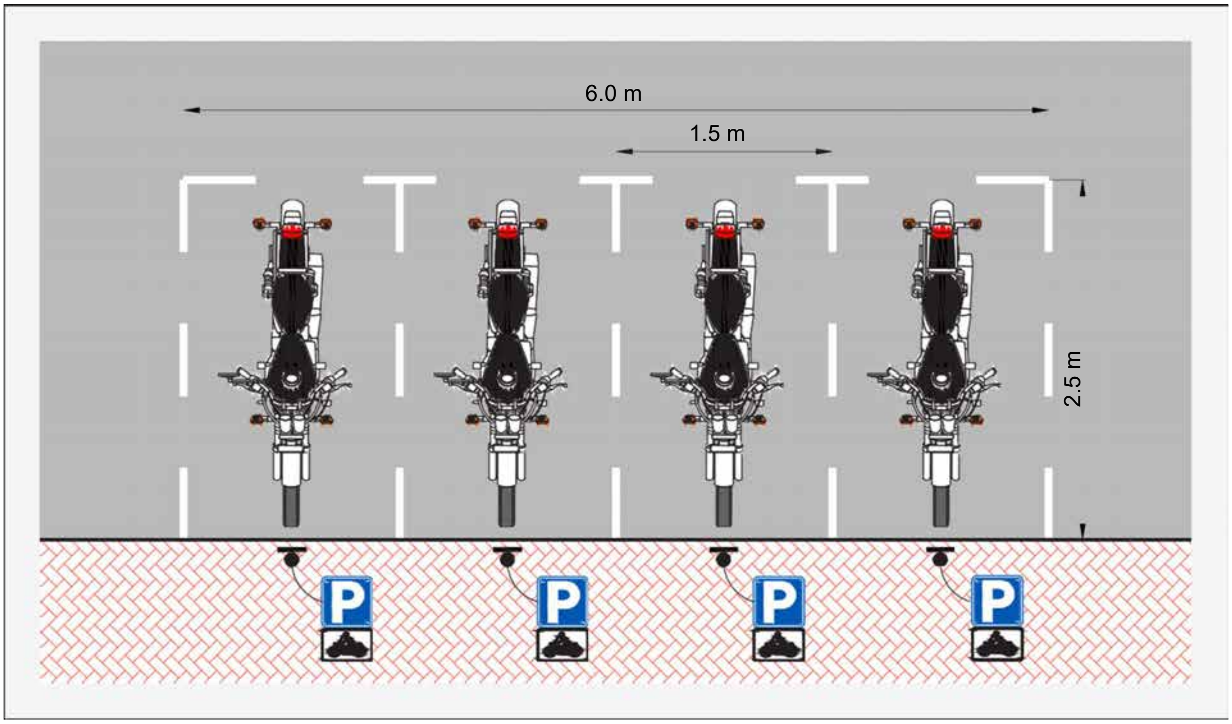


Figure 14-1 Powered Two-Wheeler Parking Stall Dimensions

14.2 Off-Street Powered Two-Wheeler Parking

Powered two-wheeler parking requirements with respect to the floor areas are shown in **Table 14-2.** These values are for reference only and the exact requirement will be reviewed and approved by the Overseeing Authority.

Table 14-2 Powered Two-Wheeler Parking requirements

Criteria	Parking Requirements
Ten or more household units or 1,000 m^2 or more floor area	2% of total car parking spaces
Less than 10 household units or less than 1,000 m^2 floor area	To be considered on case-by-case basis

Powered two-wheeler parking can be located in the unused spaces in the corners of a parking facility, as shown in **Figure 14-2**. Bollards should be suitably placed in spaces where the parking lots for powered two-wheelers are adjacent to the car parking lots, to avoid encroachment by cars.

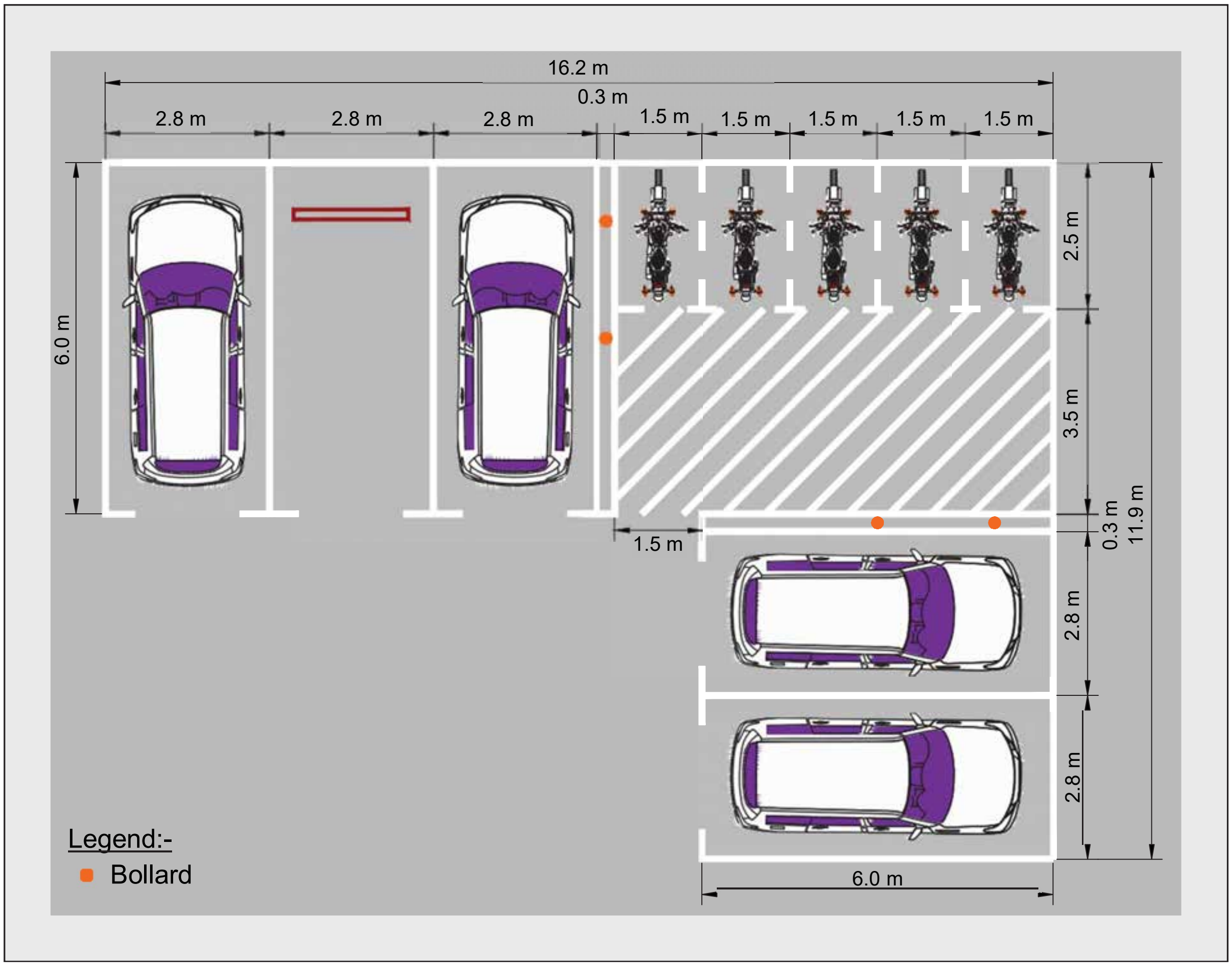


Figure 14-2 Corner Off-Street Motorcycle Parking

Section 15

Bus Parking

15: Bus Parking

A bus is a vehicle for surface transport designed to carry many passengers at a time. There are different types of buses, such as city transit buses, intercity coaches, school buses, shuttle buses used on a campus, and company/labor buses, that are in operation in the State of Qatar. **Section 4.2** mentions different types of buses, that are referred to in the Qatar Highway Design Manual (QHDM).

This section covers key elements related to bus parking, such as bus parking layouts, off-street parking stall dimensions, on-street bus stops, and lay-bys. Features of park and ride facilities and typical layouts of different park and ride facilities are also included in this section. A bus parking can be appropriately used at different locations, like bus stations, schools, offices, hotels, park and ride stations, etc. The appropriate design vehicle for bus parking areas should be identified and agreed upon with the Overseeing Authority.

The associated and supporting infrastructures for bus parking, such as roads, sidewalks, and shelters, should be designed following the QHDM and approved by the Overseeing Authority. The Qatar Traffic Control Manual (QTCM) should also be referred to for designing the signage and markings.

A bus station is a high-activity node in the transportation network and an important location for the bus parking. **Figure 15-1** details the types of activities that are typically associated with the activity nodes.

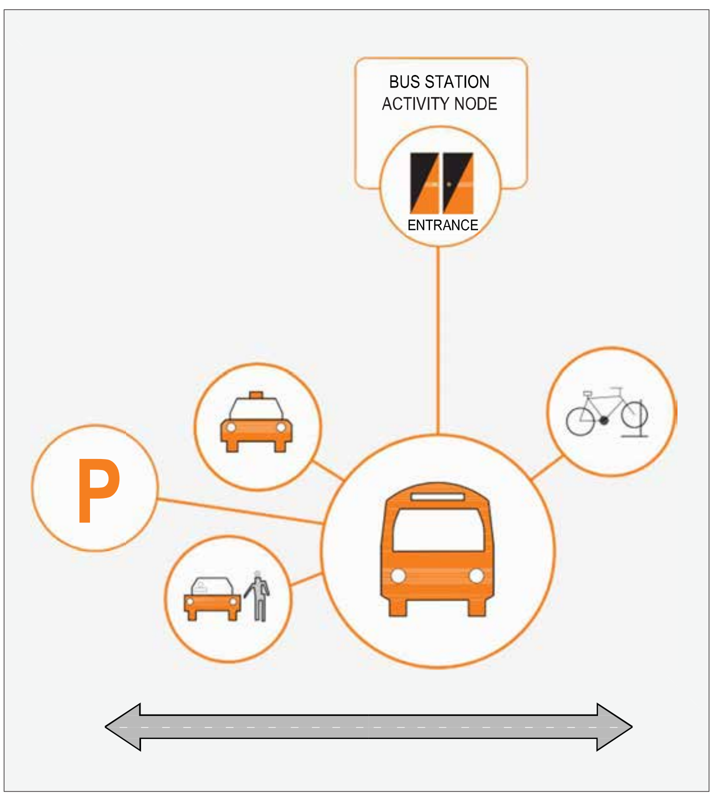


Figure 15-1 Bus Station Activity Node

The bus station activity nodes generally accommodate the following facilities:

1. Private vehicle parking
2. Private vehicle drop-off and pick-up areas
3. Drop-off and pick-up areas for taxis
4. Bicycle parking
5. Access points for pedestrians
6. Drop-off, pick-up, and layover or parking areas for bus and coach passengers

This concentration of different mode types in the activity node demands operational safety and efficiency.

All bus parking areas serve large numbers of passengers. Hence, passengers' comfort, access, and safety demand special considerations. Parking surfaces are advised to be designed on a relatively level ground, without any abrupt grade changes. The presence of road humps and other vertical and horizontal traffic management devices should be avoided in the facilities providing bus parking. Safe walking routes for drivers and passengers are an important factor, along with the provision of adequate space for baggage handling.

15.1 Off-Street Bus Parking Layouts

Off-street bus parking are the areas where buses stay for longer durations. Off-street bus parking is adopted for stand-by buses to wait until called for service and are typically used for bus stations, schools, and parking for office staff buses. The following two unique parking layout configurations are adopted:

1. Drive-In Reverse-Out (DIRO)
2. Drive-In Drive-Out (DIDO)

Figure 15-2 shows the typical layouts for DIRO and DIDO configurations. Based on the angle of parking and vehicle maneuvering requirements, various layouts can be developed under DIRO and DIDO configurations. The appropriate configuration and layout should be selected based on the local considerations, which includes physical constraints related to site shape, size, orientation, access, and bus operating characteristics, thereon seeking the approval of the Overseeing Authority.

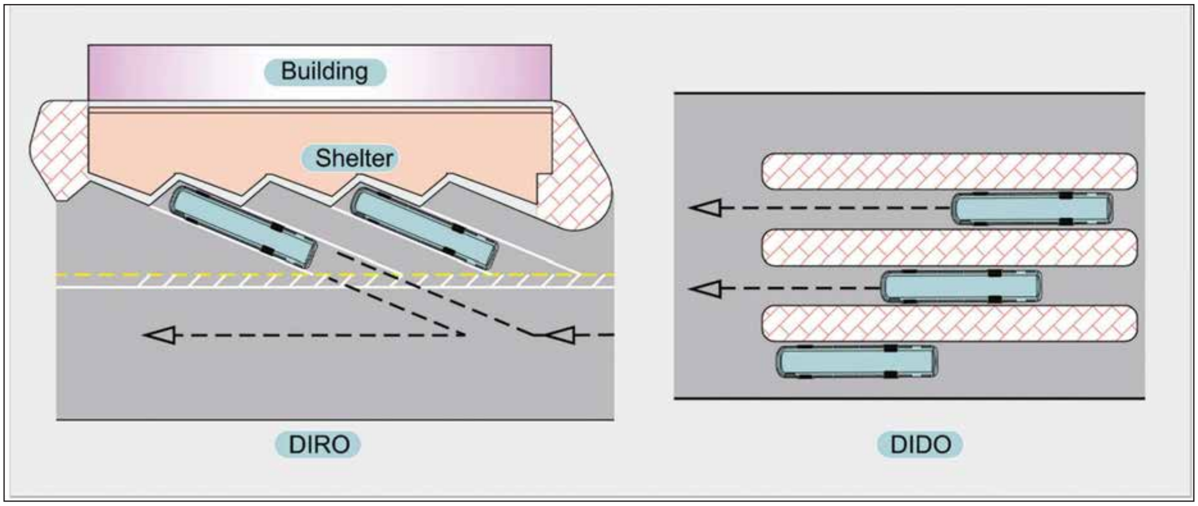


Figure 15-2 Bus and Coach Station Layout

15.1.1 DIRO Configuration

A DIRO configuration requires the bus to be driven into the bus bay on arrival and to reverse on departure. This layout helps passengers go directly to the shelter or concourse area, allows controlled pedestrian movements, and reduces the risk of pedestrian and vehicular conflicts. DIRO configuration requires smaller site area and provides a concentration of facilities and passengers in one securely managed concourse. With this layout, control measures must be implemented to prevent pedestrian access to the bus carriageway.

Figure 15-3 shows a typical layout of a bus station, with parking for both passenger drop-off or pick-up and bus driver layover for DIRO station arrangements. The final layout and angle of parking depends on the available space and operational characteristics of the facility, such as bus types and their size, service frequency, number of services, and passenger volumes.

Modern bus station designs separate passenger movements as much as possible from those of vehicle movements and are typically built according to the design standards of the metro rail and light rail facilities. This ensures safety of passengers while boarding and alighting the bus. Passenger movements to and from the platform to the bus are typically controlled by sliding glass panels or doors. This level of control has the added advantage of regulating the access to vehicle lanes, thereby improving safety and ensuring that pedestrians remain within a safe environment.

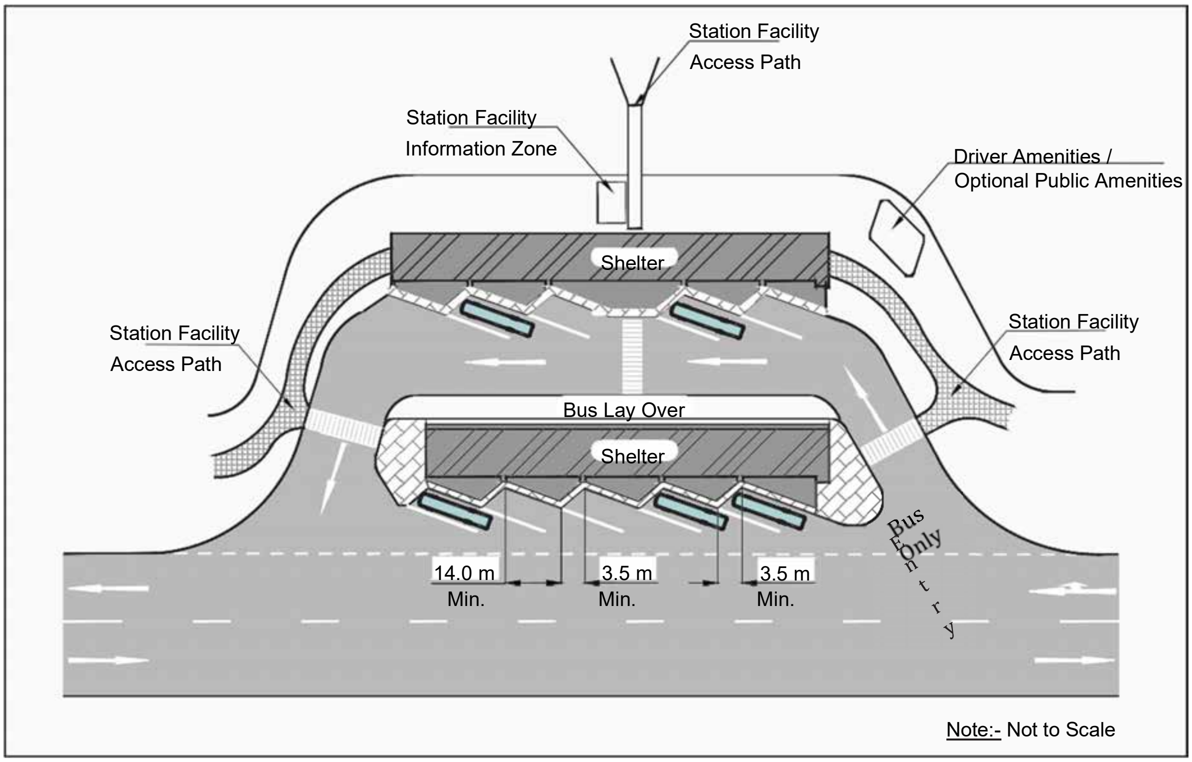


Figure 15-3 Bus Station Layout with DIRO Angular Layout for City Bus

The bus layover area is used for temporary holding of buses. These are generally devoid of any passenger movement and, hence, requires only a simplified angular layout. A sample layout, for illustrative purposes is included in **Figure 15-4**. The DIRO layout is also known as an angular layout. The respective parking angles and dimensions are included in **Section 15.1.3**.

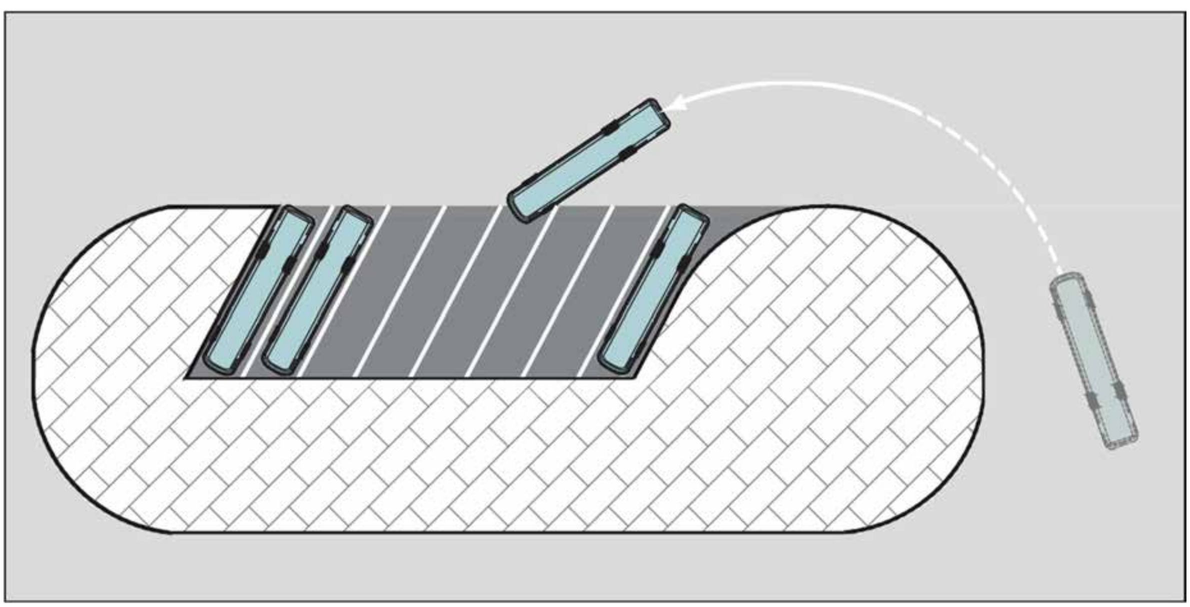


Figure 15-4 Bus Layover Layout without Public Access

Table 15-1 lists the advantages and disadvantages of DIRO station arrangements.

Table 15-1 DIRO Layout Advantages and Disadvantages

Advantages	Disadvantages
Smaller footprint layout allows a more efficient use of the available space.	Buses are required to reverse on departure, thus creating a safety hazard.
Pedestrians are separated from buses in a single enclosed concourse, providing full weather protection, accommodating all customer facilities.	If passengers alight and do not go into the concourse, they enter an apron with multiple buses reversing, thus increasing the risk of injury.
More efficient use of Closed-circuit television (CCTV) and Real Time Information (RTI) screens with a concourse layout.	
Improved security with a concourse through CCTV and ability to remotely lock facilities outside of operating hours.	
Enclosed concourses allow for retail units, cash points, telephones and vending/ticketing machines in a safe environment.	Procedural instructions need to be issued to operators on how to use facilities and avoid conflicts with other buses and pedestrians.
Greater control over desire lines by directing people from the bus into the concourse area and on to the designated exits.	
Bay doors linked to induction loops allow passengers access only to the maneuvering area, once a bus has arrived.	Increased dwell time for bus maneuvering on and off layover.
Covers passenger transfer between bays with no conflict with maneuvering buses.	Need for vehicle restraint barriers to reduce the risk of collisions with the infrastructure.

15.1.2 DIDO Configuration

DIDO configuration facilitates entry and exit to and from the parking stall without reversing. This configuration is suitable for larger bus stations or areas with high bus passenger volumes, large number of services, and high service frequency, for example, schools, stadiums, regional bus stations, etc. There are three types of layouts for DIDO configurations:

- **Sawtooth bus parking layout** is used for high-demand and high-frequency bus operations, with adequate space available to accommodate the design (e.g., stadiums). Typical sawtooth DIDO bus layout arrangements are shown **Figure 15-5** and **Figure 15-6**.

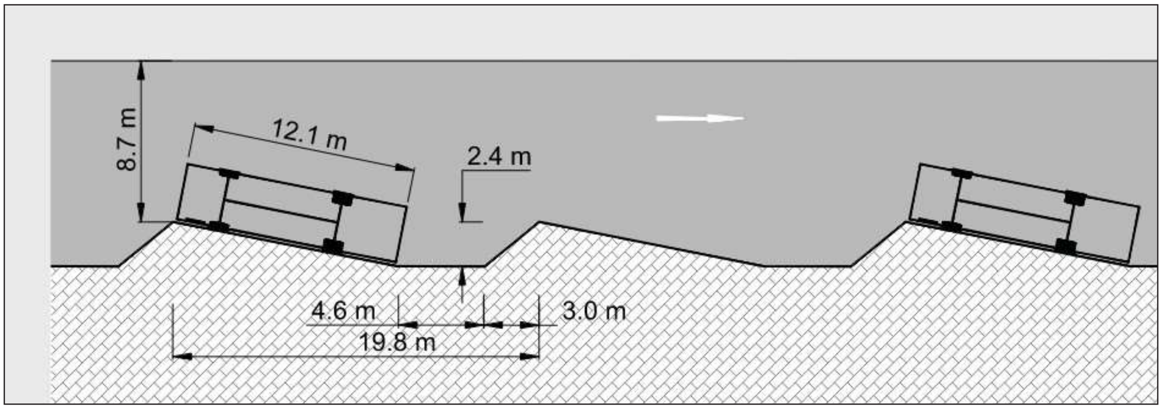


Figure 15-5 DIDO Sawtooth Bus Parking Layout for City Bus

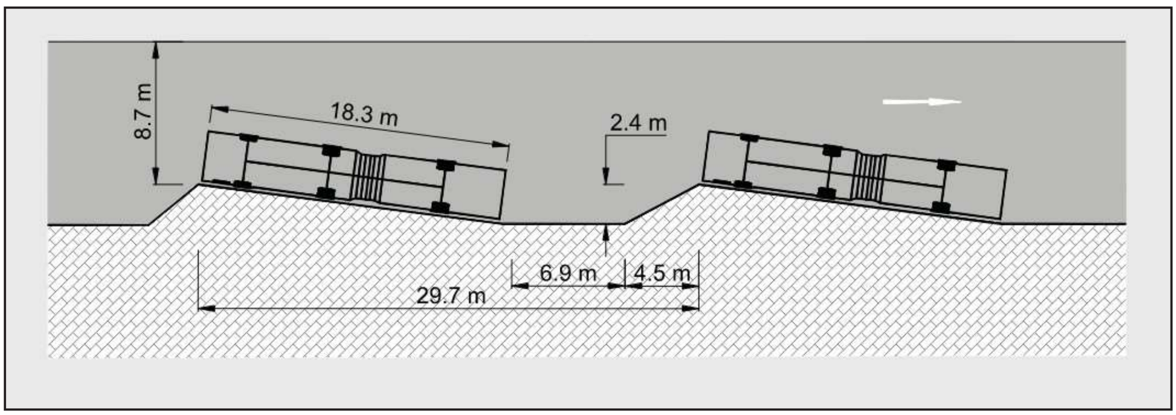


Figure 15-6 DIDO Sawtooth Bus Parking Layout for Articulated Bus

- **Parallel bus parking layout** is used for low-demand and low-frequency bus operations. **Figure 15-7** and **Figure 15-8** present the details of the recommended parallel bus parking layout for city buses and articulated buses, respectively.

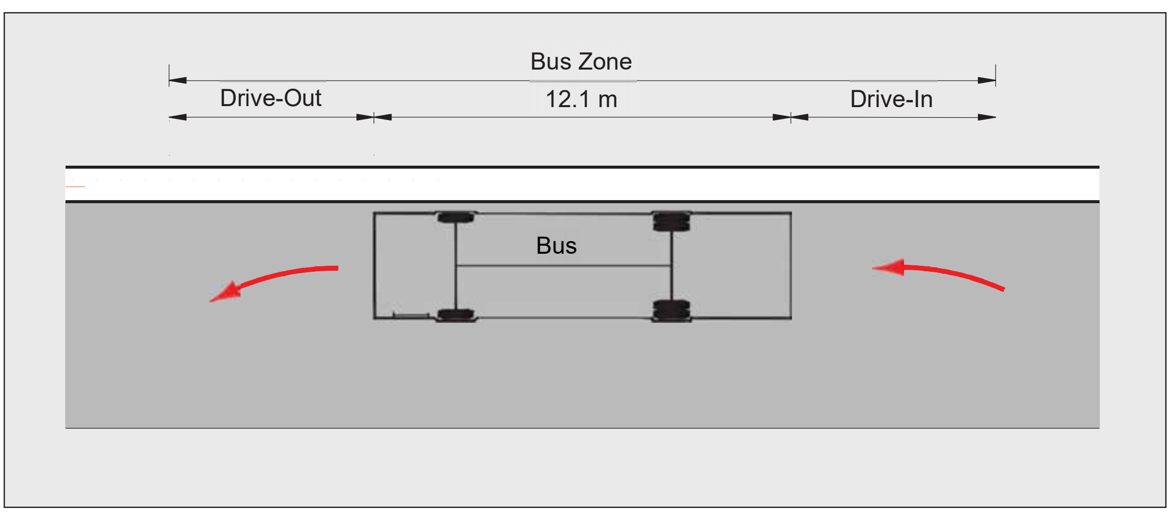


Figure 15-7 Parallel Bus Parking Layout for City Bus

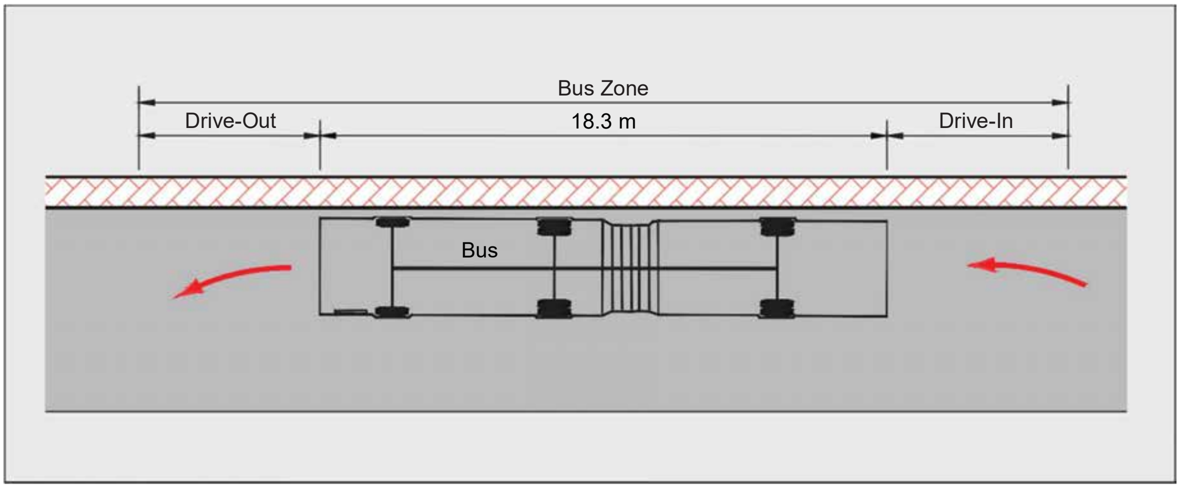


Figure 15-8 Parallel Bus Parking Layout for Articulated Bus

- **Parallel bus parking layout with islands** is used for high-demand bus operations with limited space available to accommodate the design (e.g., schools). **Figure 15-9** shows an illustrative diagram for this type of layout.

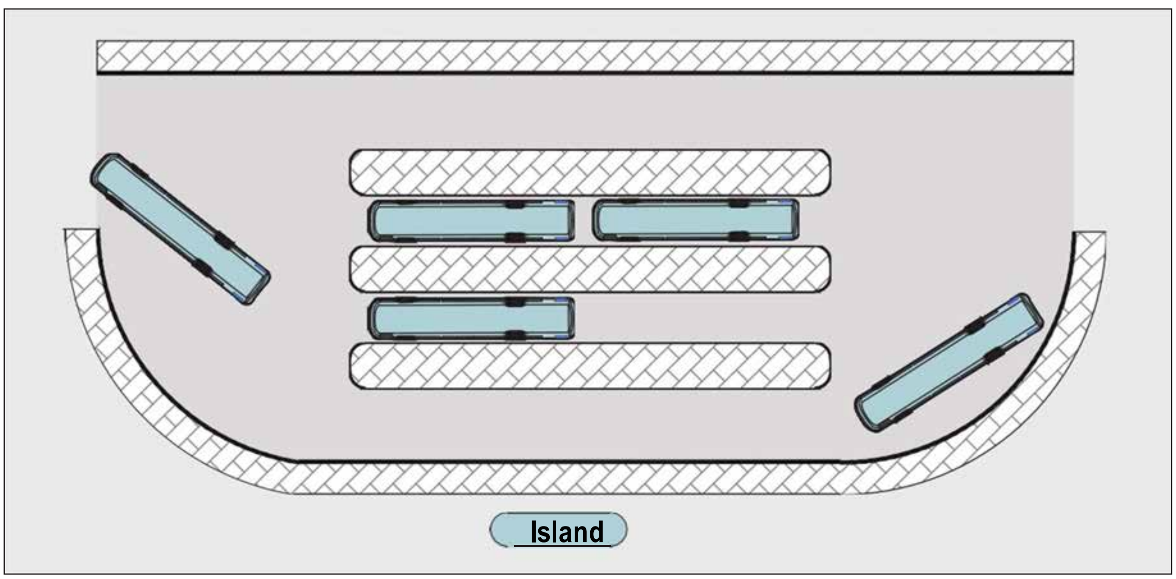


Figure 15-9 Island Parallel Bus Parking Layout for City Bus (for illustrative purposes only)

Perimeter parallel bus parking (Figure 15-10) and **concourse parallel bus parking** (**Figure 15-11**) are two different variants that can also be used depending upon the specific needs. The selection of the layout derived, based on the bus operational requirements and space constraints, should be agreed upon with the Overseeing Authority.

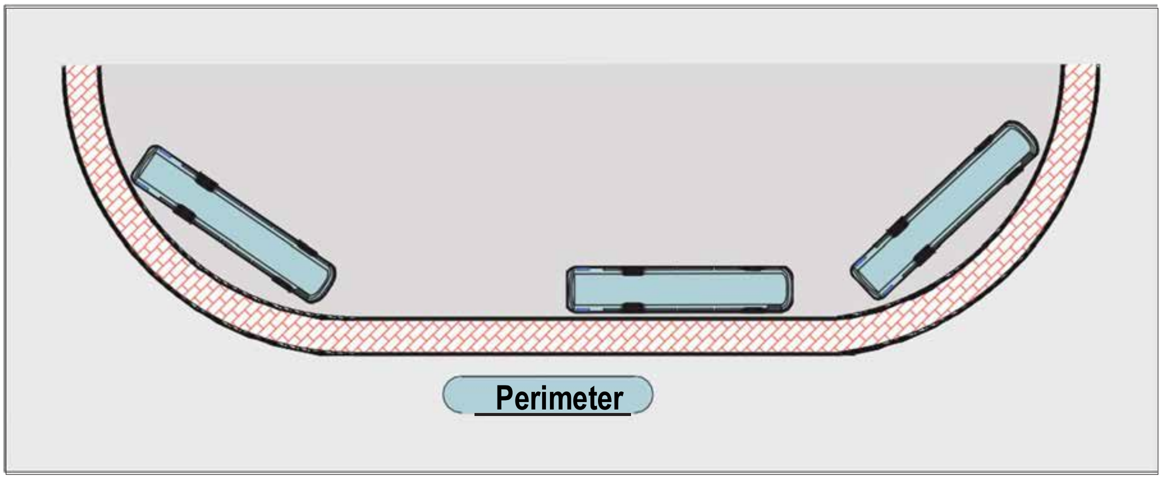


Figure 15-10 Perimeter Parallel Bus Parking Layout for City Bus (for illustrative purposes only)

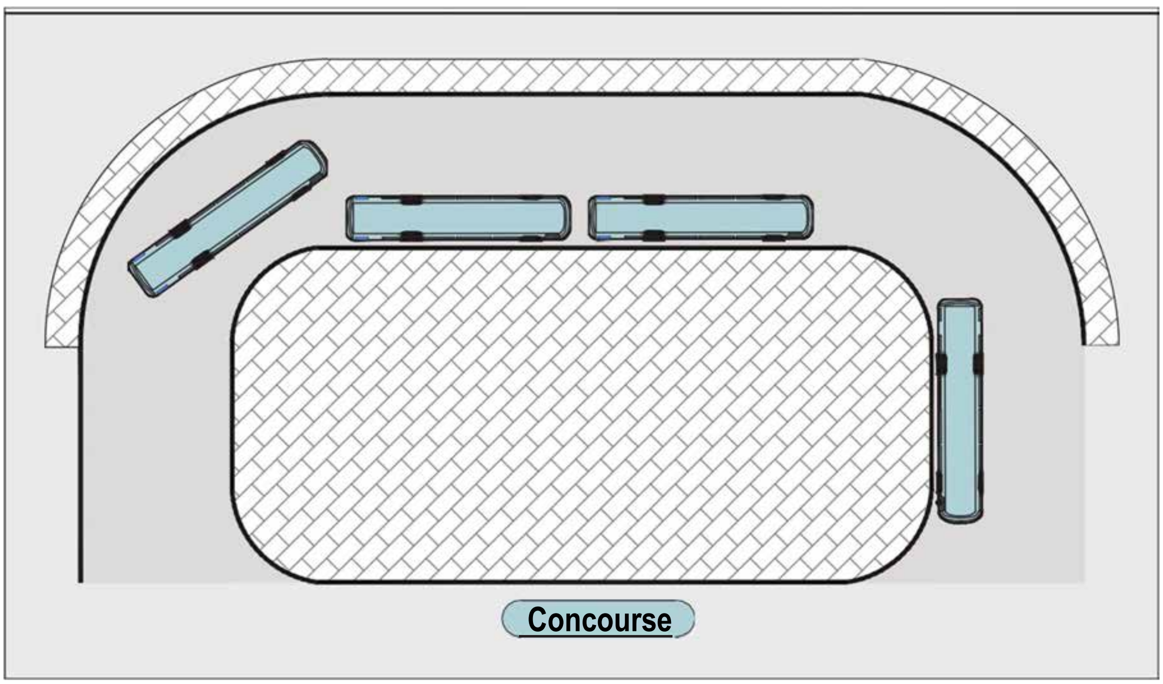


Figure 15-11 Concourse Parallel Bus Parking Layout for City Bus (for illustrative purposes only)

See **Table 15-2** for a list of the advantages and disadvantages of the DIDO parallel bus parking layouts.

Table 15-2 DIDO Parallel Layout Advantages and Disadvantages

Advantages	Disadvantages
Avoids reversing maneuver unless required in relation to layover	Less efficient use of space; may require separate islands
Reduced dwell time for maneuvering on/off layover	Shelter islands might feel less safe at night than concourse environments, if not properly designed and managed
Reduced risk of passengers walking in drivers' blind spots, as no reverse movement is required in a DIDO configuration	Impacts to mobility-impaired passengers associated with cross carriageways and crossing-dropped curbs
Reduced construction costs	CCTV coverage is very complex with more cameras and proportionately high number of RTI screens needed due to more passenger waiting areas
Reduced risk of infrastructure collision associated with parallel parking	Need for more pedestrian safety provisions to address increased passenger movements between islands, and potential conflicts with buses
	Passengers subject to inclement weather, while using uncovered crossings
	Islands create additional crossing points, each of which increases the risk of a bus colliding with a station user and multiple crossing points with pedestrian right of way can impede flow of buses through the station

15.1.3 Off-Street Parking Stall Dimensions

This section includes the relevant dimensions required for designing bus parking stalls and aisles. These have been derived by conducting swept path analysis using the appropriate design vehicles. For finalizing the parking stall dimensions and other parking design parameters, the designer is required to perform a detailed and site-specific swept path analysis and seek approval from the Overseeing Authority.

Parking stall dimensions are determined by the horizontal space needed for traffic, as well as the space needed to maneuver in and out of parking stalls. **Table 15-3** provides the minimum aisle widths and parking stall dimensions for straight-in and reverse-out maneuvers for a 45-degree angled stall and a reverse-in and straight-out maneuvers for a perpendicular stall. Dimensions are provided for three different types of buses, including conventional school bus, city transit bus, and articulated bus. The dimensions provided should only be considered as guidance. The designer should conduct a swept path analysis with the appropriate design vehicle (bus) to determine the exact dimensions of stalls and aisles. **Figure 15-12** shows the design components of bus parking.

Table 15-3 Minimum Dimensions for Off-Street Angular Bus Parking

Parking Angle (A)	Vehicle Type	B Minimum Stall Width (m)	C Depth of Parking Stall (m)	D Minimum Aisle Width (m)	E Stall Curb Length (m)	F Module Width (m)
45° Parking	Conventional School Bus (S-Bus 11)	3.50	10.00	8.00	5.00	28.00
	City Transit Bus (City Bus)	3.50	11.00	8.50	5.00	30.50
	Articulated Bus (A-Bus)	3.50	15.00	8.50	5.00	38.50
Perpendicular Parking	Conventional School Bus (S-Bus 11)	3.50	11.50	9.00	3.50	32.00
	City Transit Bus (City Bus)	3.50	12.70	11.50	3.50	36.90
	Articulated Bus (A-Bus)	3.50	18.80	14.00	3.50	51.80

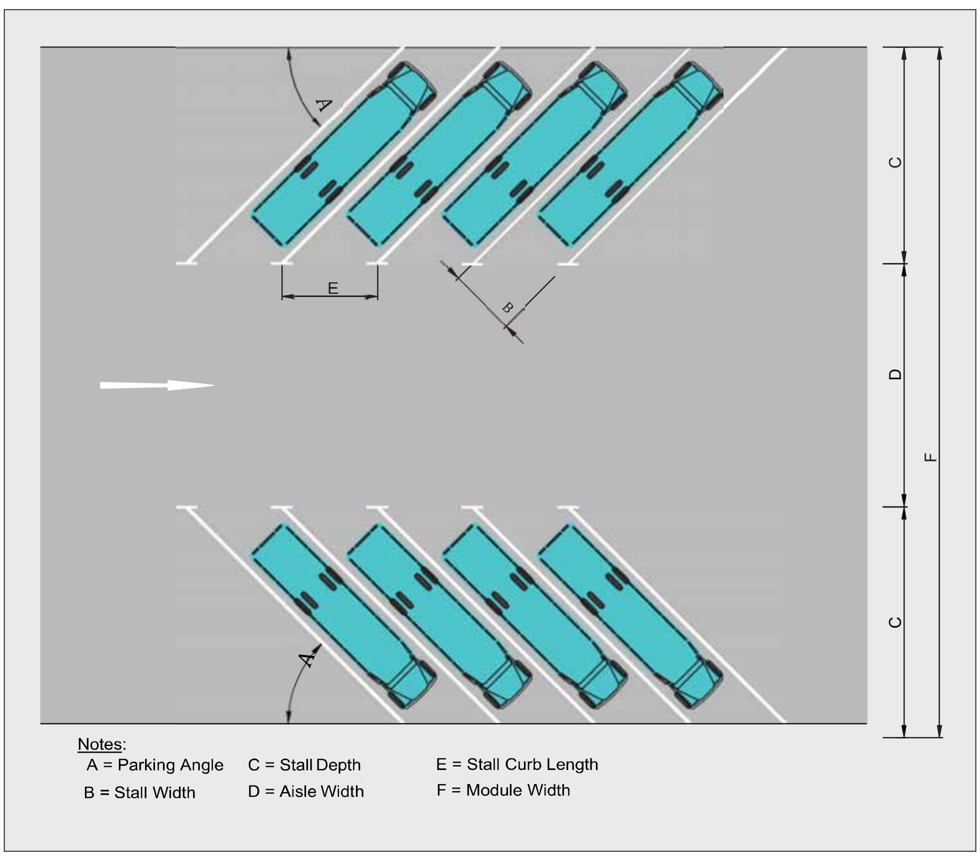


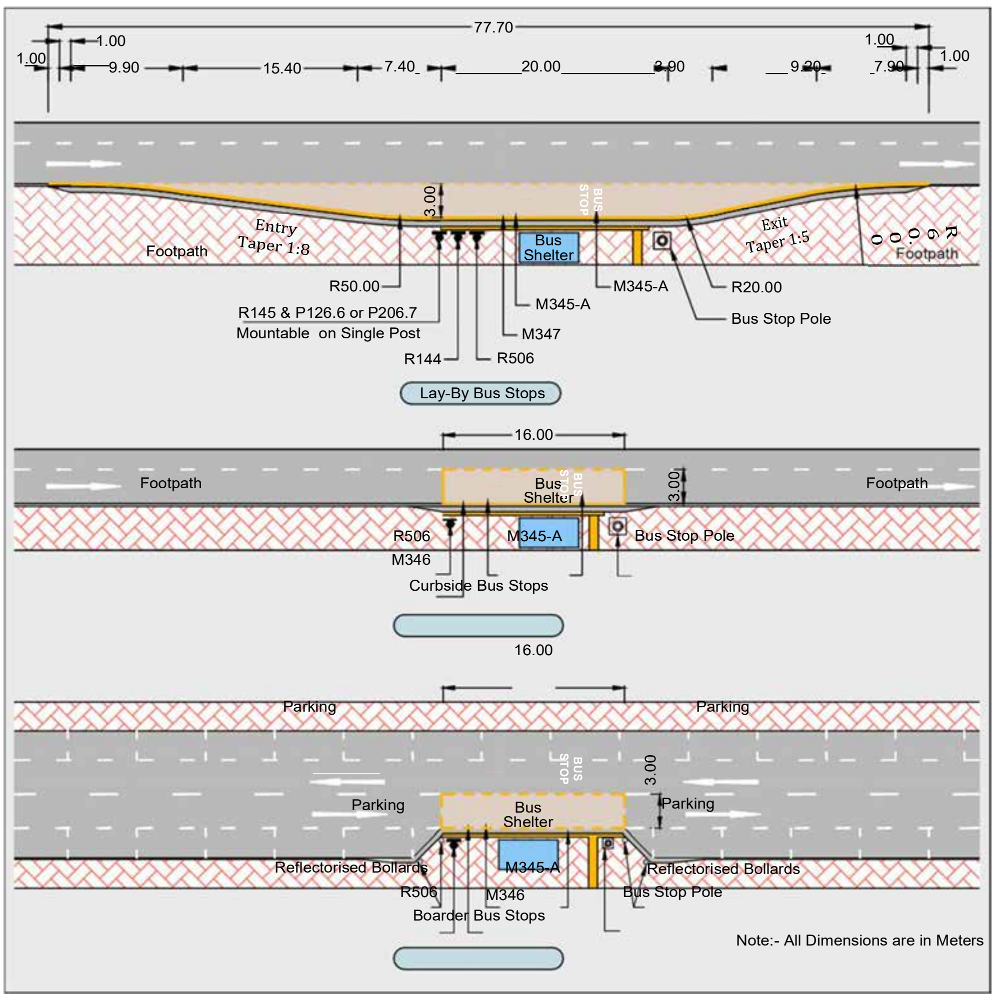
Figure 15-12 Design Elements for Off-Street Angular Bus Parking

15.2 On-Street Bus Stops and Lay-Bys

On-street bus parking mainly covers bus stops and layover bays (lay-bys). The design principles of bus stop bays are illustrated in **Figure 15-13**. There are three types of bus stops, as outlined below:

1. **Lay-by bus stops** are used on high-volume roads with higher speed limits (> 50 kph).
2. **Curbside bus stops** are located clear off through-traffic lanes or at sites where the disruption to traffic flows and parked cars are minimized. This is permitted on roads where the posted speed is 50 kph or less.
3. **Boarder bus stops** are an extended built-out area from the existing curb line. This facilitates a straight run-in to the curb and exit by buses, as well as boarding and alighting. This is permitted on roads where the posted speed is 50 kph or less, with low bus frequency.

The information presented in this section is for reference only and has been adopted from the QHDM (Volume 3, Part 26). It is recommended that the design is carried out following the QHDM recommendations.



SOURCE: Adapted from QHDM, Volume 3, Part 26, Appendix A, Appendix B and Appendix C.

Figure 15-13 On-Street Bus Stops

15.3 Park and Ride Facilities

Modern public transport facilities, multimodal or intermodal centers, are where individuals or carpools park to transfer to high-occupancy vehicles (HOVs). These park and ride facilities are designed to provide a common location for individuals to park their vehicle or bicycle and transfer to a HOV, such as a bus, train, or carpool, for the balance of their trip. Multimodal or intermodal centers are designed to provide convenient connections between personal vehicles, pedestrians, bicycle travel modes, and other forms of public transport, such as bus, rail, or ferry services. These facilities truly encourage public transport use by improving convenience and safety associated with the transfer from one mode to another.

Park and ride facilities can be located in the suburbs, city, or town center. This helps reduce traffic congestion by reducing the number of vehicles on the road. Park and ride areas provide transfer points between several modes. This heterogeneity of traffic mix has a potential to increase conflicts between cars, transits, and pedestrians. Design of park and ride facilities should minimize conflicts and facilitate easy transfer between the modes. Park and ride facilities should also provide a high degree of safety and security for users and vehicles.

Park and ride facility design should consider a range of design components, as mentioned below, to ensure a safe and efficient transport system:

1. Planning and design considerations for park and ride facilities (**Section 15**)
2. Requirements for pedestrian (**Section 12**) and bicycle facilities (**Section 13**)
3. Provisions for transit vehicles (**Section 16**)
4. Parking for private vehicles/cars (**Section 6)**
5. Parking for powered two-wheelers (**Section 14**)
6. Provisions for short-stay vehicles and taxis (**Section 5.5**)
7. Requirements for drainage and illumination (**Section 20**)
8. Safety and security (**Section 4**)
9. Signage (**Section 17**), access management (**Section 7**), and ITS (**Section 18**)

The final design upon consideration of the above-mentioned elements, should be presented to the Overseeing Authority for their approval.

The layout of a park and ride facility should be unique to the location of the facility. There are two critical design concepts associated with the idea of maximizing the use of park and ride facilities:

- Provision of separate access by mode, where possible, and separate space for transit operations, private vehicle access, carpools, bicycle access and storage, pedestrian circulation, and passenger drop-off facilities
- Prioritization of the pedestrian and transit modes in the design process

An example of the layout and design details of a typical park and ride facility is shown for illustrative purposes only in **Figure 15-14**. Design features that should be considered for any new park and ride facility include:

1. Ease of access/egress and efficient layout for maneuvering/parking
2. Presence of parking space near the bus/rail hub
3. Provision to handle peak vehicle arrival/departure rates in morning and evening peak periods
4. Installation of security/lighting/panic buttons, security cameras, and entrance/exit system to a secure area
5. Allocation of short-term (2 minutes) and long-term (15 minutes) waiting space for drop-off and pick-up near the entrance
6. Presence of an attractive landscape
7. Placing of shading structures or trees
8. Enabling bus or taxi drop-off or pick-up areas with approach slip roads separate from the park and ride facility
9. Provision of dedicated pedestrian and bicycle access to avoid conflict with vehicles
10. Provision for prioritized access for park and ride users and passenger drop-off during the peak periods
11. Availability of bicycle lockers
12. Presence of parking stalls adjacent to all the entrances for people with disabilities
13. Provision of stalls for motorcycle parking
14. Clear circulation for vehicular and pedestrian movements
15. Clear visibility of information signs at or near the facility
16. Planning of a good urban design
17. Provision for safe, attractive, and sheltered waiting areas
18. Availability of site amenities, such as newspapers and beverages
19. Furnishing of traffic calming measures and clear pavement markings

Figure 15-14 illustrates various elements of a park and ride layout, incorporating passenger drop-off, electric car charging, accessible spaces, pedestrian crossings, transit stops, height restriction, and recycling bins.

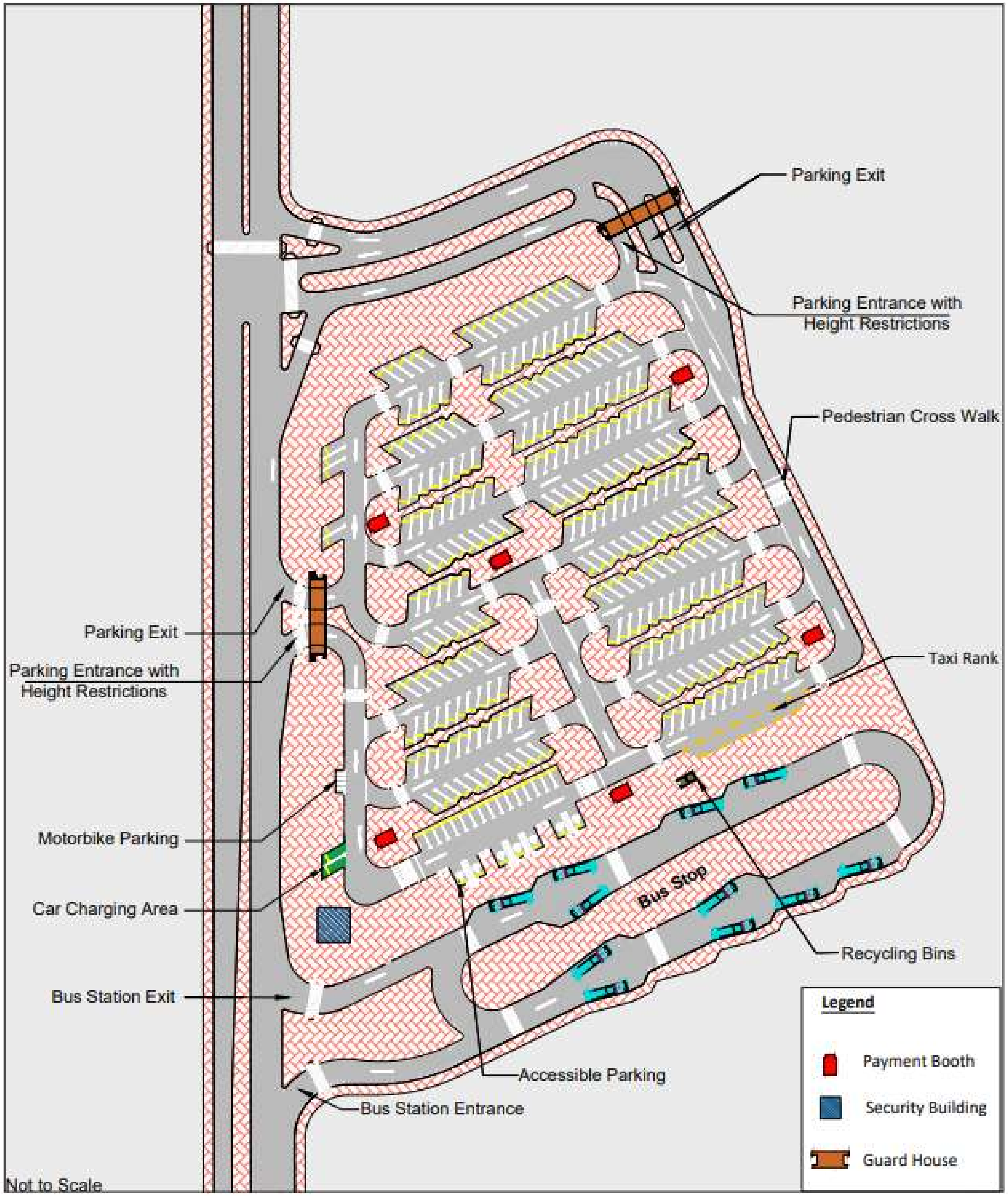


Figure 15-14 Park and Ride Facility Layout

Park and Ride facility layouts are generally categorized as small, medium, and large, based on the number of parking spaces planned and the area of development. A generic guideline for consideration of a small, medium, and large park and ride facility is presented in **Table 15-4**.

Table 15-4 Indicative Park and Ride Facility Size and Parking Spaces

Park and Ride Facility Size	Number of Parking Spaces	Area of Development (hectares)
Small	550	2.5
Medium	1,200	4.5
Large	2,000	8.5

Figure 15-15, **Figure 15-16**, and **Figure 15-17**, respectively, provides park and ride layouts for small-sized, medium-sized, and large-sized facilities for illustrative purposes only.

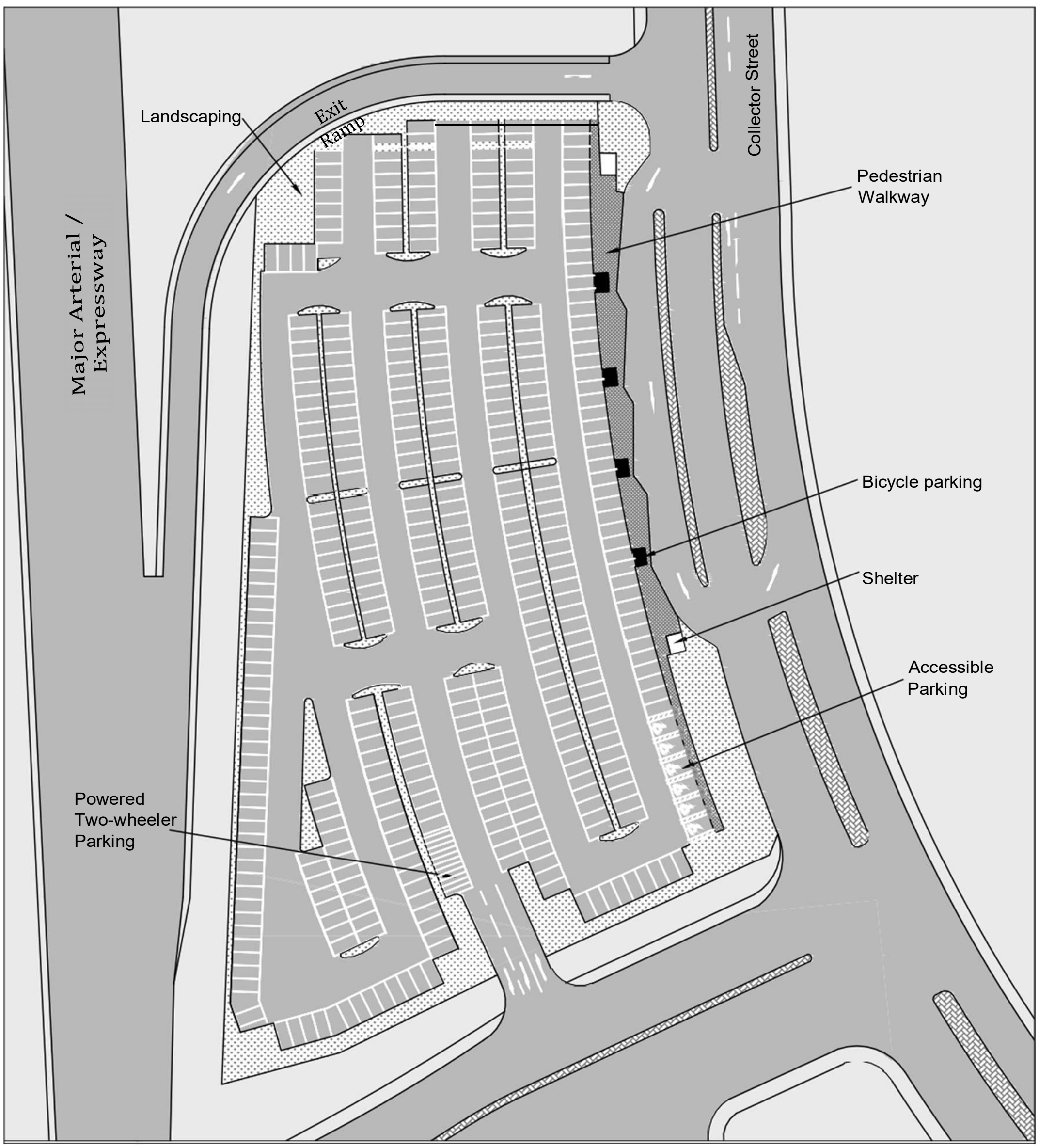


Figure 15-15 Illustrative Layout for a Small-Sized Park and Ride Facility

Figure 15-16 Illustrative Layout for a Medium-Sized Park and Ride Facility

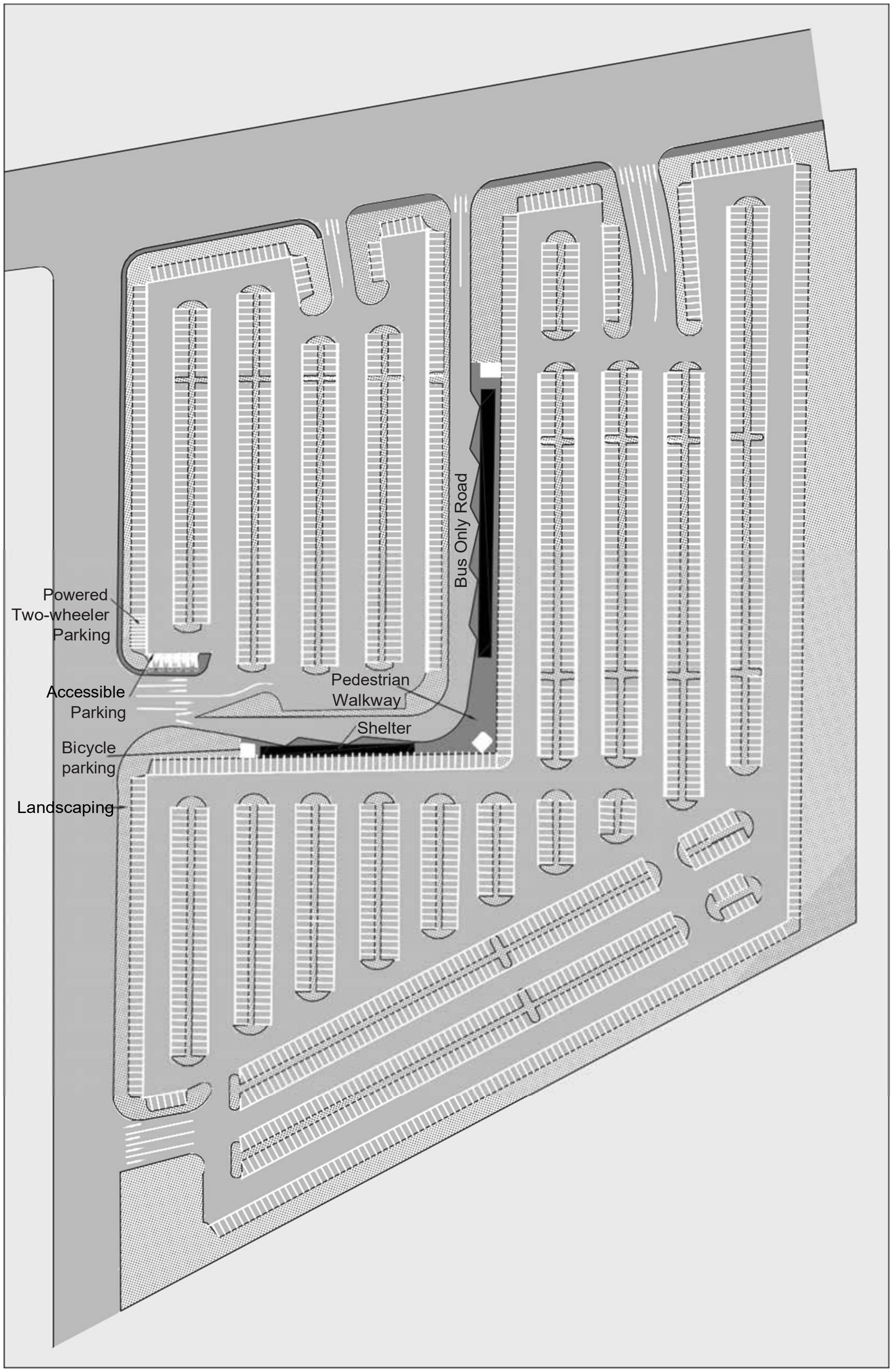


Figure 15-17 Illustrative Layout for a Large-Sized Park and Ride Facility

Section 16

Commercial Vehicle Parking

16: Commercial Vehicle Parking

This section of the Qatar Parking Design Manual (QPDM) includes the parking design guidelines for those commercial vehicles that are used exclusively for the transportation of goods. A broad range of fleets, inclusive of small delivery vehicles, service vehicles, and heavy industrial trucks, fall under this category. This section is applicable only for off-street parking design because on-street truck parking including loading/ unloading is not allowed.

The design of a parking facility for commercial vehicles depends on the type of vehicle that is expected to use that facility. It is impractical to develop guidelines for all commercial vehicles or to recommend a universal layout that fits all such vehicles. The guidelines included in this section are based on International Best Practices. It is recommended that their application is rendered on a case-by-case basis in consultation with the Overseeing Authority.

16.1 Basic Guidelines

Parking for delivery, service, and commercial vehicles should be designed in conjunction with a Traffic Impact Study (TIS). The TIS also helps to conclude that the parking design is suitable for the access road classification and that it is safe and operationally acceptable to the Overseeing Authority. Truck parking facilities should be designed to accommodate the vehicle class or classes that would frequently utilize the facility. **Figure 4-4** lists the design vehicles currently available and in use in the State of Qatar, or ones likely to be used in the near future, along with respective dimensions. If a vehicle class falls beyond these categories (e.g., oversized vehicles), the design should be subjected to special design provisions on a case-by-case basis.

16.2 Off-Street Truck Parking

The layout of a commercial vehicle parking facility depends on the dimensions of the vehicles using the facility. In general, the following elements should be considered in the planning and designing of any commercial vehicle parking facility:

A. Safe circulation and environment for all users

1. Entering, exiting, and internally circulating traffic should be studied to ensure that the vehicles of all sizes can move freely with utmost safety and efficiency. In addition, a similar study covering the impact on external traffic circulation should be conducted. Suitable measures should be identified to mitigate any impact, if observed, as a part of the study.

2. One-way circulation is preferred for commercial vehicles.

3. Special attention is to be given to all the entrances and exits, inclusive of:

   a. provisions for separate entrance and exit driveways, which is desirable. However, when entrance and exit driveways are together, adequate opening widths considering standard lanes and additional widths corresponding to the design turning radii should be provided.

   b. designing of entrance and exit with right-in and right-out arrangements, respectively.

   c. provision of access control systems.

4. Blind aisles are to be avoided.

5. Clear sight lines to and from the parking aisles to be ensured. Sight lines to be maintained by regular trimming of vegetation.

B. Topography, drainage, and pavement surface

1. Flat level is preferred for parking of trucks to enable stability against any inclement weather conditions.

2. Locate truck parking bays on flat-grades to maintain appropriate sight lines to other vehicles traveling on the adjacent road.

3. A surface water drainage plan should be developed, which includes a minimum slope of 0.6% and a preferred minimum of 2% slope on paved surfaces.

4. An impervious surface, such as cement concrete or asphalt concrete, is to be used for truck parking, and a uniform select material for sub-grade compacted to a consistent density is to be selected. If not available, a granular sub-base should be considered.

C. Accommodating features

1. Lighting

   a. Proper lighting of the parking area is to be ensured for vehicle and pedestrian safety and community relations.

   b. Initial lighting installation is to be planned so that it can be expanded easily in the future.

   c. Light poles are to be located in areas where lighting is likely to deter crime or prevent accidents.

2. Fencing and screening are to be provided.

3. Security cameras and systems are to be installed.

4. Landscape areas are to be created.

5. Garbage bins are to be provided.
6. Loading docks should be constructed.
7. Fuel and lubricant concentrations are to be provided.
8. Underground utilities are to be taken care of.
9. Serviced toilets are to be maintained.
10. Sleeping quarters are to be constructed.
11. Vending machines are to be installed.

D. Other considerations

1. Truck parking bays are to be identified by local name and/or number and/or by road to aid in identification and reporting of maintenance and emergency issues.
2. Private car traffic serving workers are to be reduced and usage of public transport should be encouraged.
3. Personal vehicle drivers should be discouraged from using truck parking bays.
4. Use of curb bumpers and curb stop as boundary barriers is to be avoided because they may cause problems with maintenance and street sweeping.
5. Use of steel poles, such as bollards set in concrete, are to be avoided, except for utility and other structure protection with the approval of the Overseeing Authority.

16.2.1 Parking Stall and Aisle Dimensions

The width of a parking aisle is determined by the horizontal space needed for circulating traffic, as well as the space needed to maneuver in and out of a parking stall. This is derived based on the swept path analysis. **Table 16-1** provides the minimum aisle width and parking stall dimensions for one-way reverse-in parking arrangement. Values for a single unit truck (SU-12) and intermediate semi-trailers (WB-15 and WB-20) with 45-degree and perpendicular parking are tabulated in **Table 16-1**. **Figure 16-1** provides a typical layout of angle parking. It is recommended to undertake swept path analysis using vehicle dimensions provided in **Section 4.8** and obtain approval from the Overseeing Authority.

Table 16-1 Standard Off-Street Angled Parking Dimensions (One-Way Circulation)

Parking Angle (A)	Vehicle Type	B Minimum Stall Width (m)	C Depth of Parking Stall (m)	D Minimum Aisle Width (m)	E Stall Curb Length (m)	F Module Width (m)
45-degree Parking	Single-Unit Truck SU-12	4.00	11.00	6.00	5.70	28.00
	Intermediate Semitrailer WB-15	4.00	14.50	8.00	5.70	37.00
	Intermediate Semitrailer WB-20	4.00	18.50	14.00	5.70	51.00
Perpendicular Parking	Single-Unit Truck SU-12	4.00	12.60	11.00	4.00	36.20
	Intermediate Semitrailer WB-15	4.00	17.50	13.00	4.00	48.00
	Intermediate Semitrailer WB-20	4.00	23.00	16.00	4.00	62.00

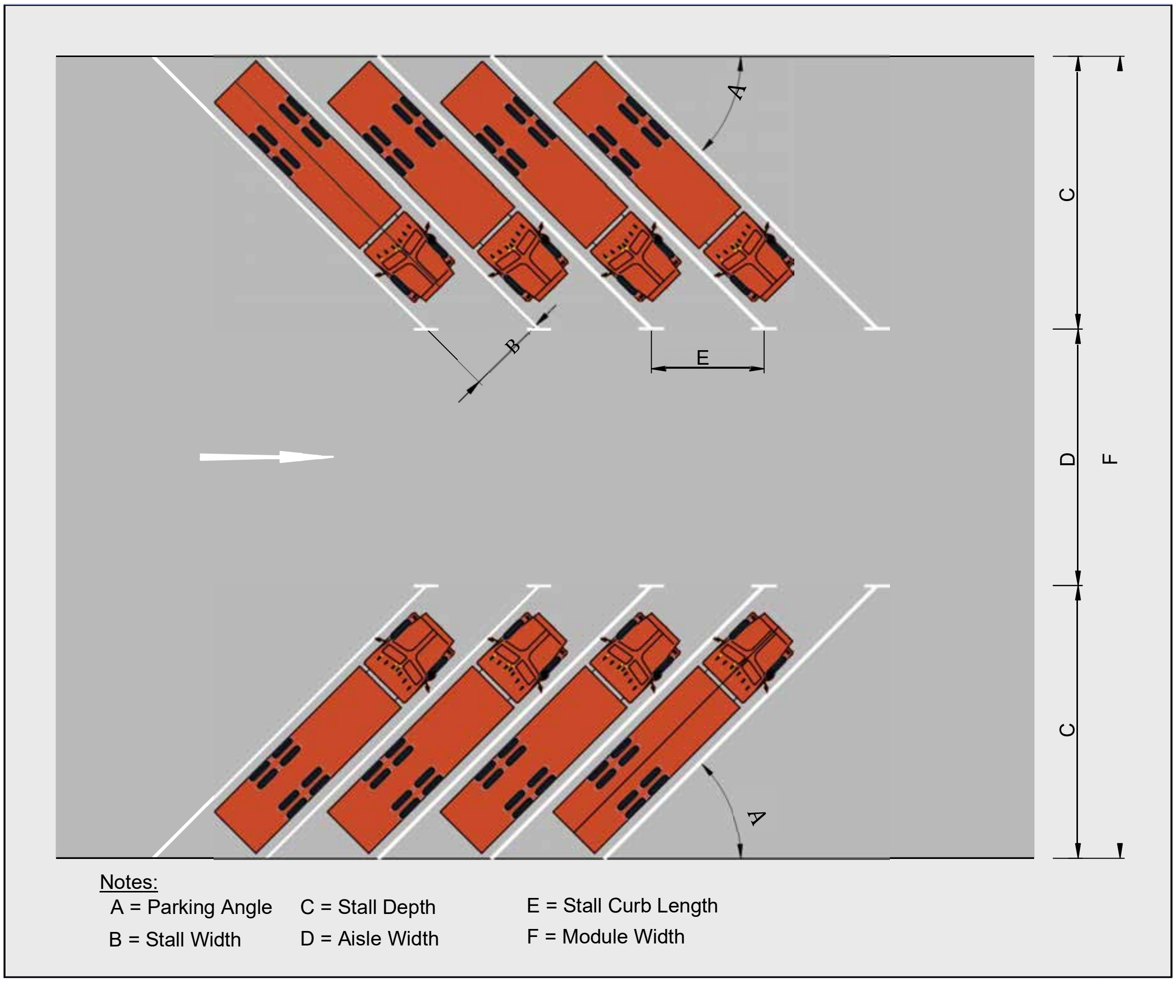


Figure 16-1 Angled Off-Street Commercial Vehicle Parking Layout

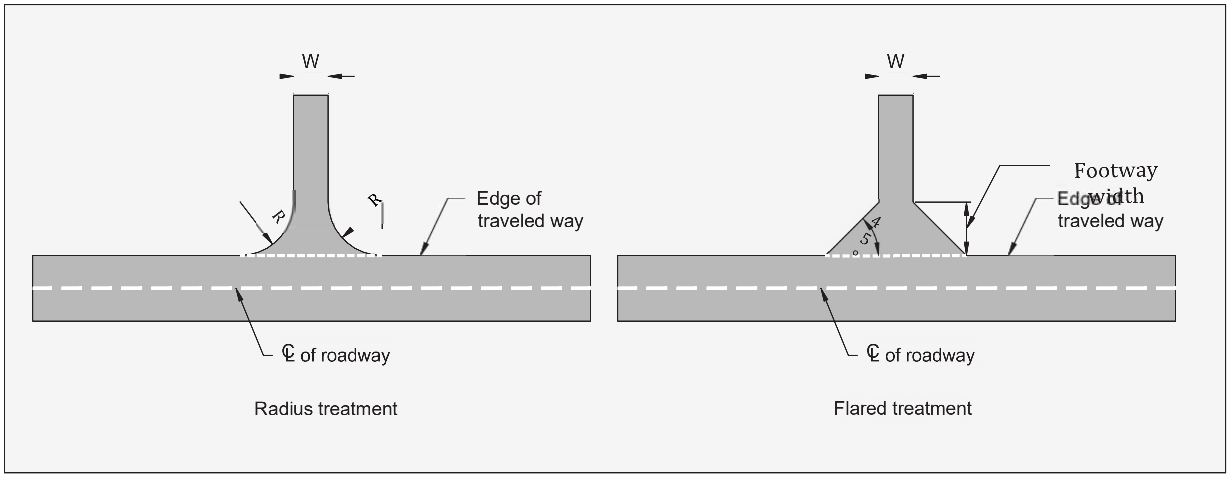
16.2.2 Access Driveways and Circulation

Access to a parking area of commercial vehicles should be provided with one-way circulation roadways that connect to the access driveways. Access design to a parking area depends on the following:

1. Maximum size of vehicle likely to use the facility
2. Frequency at which vehicles of different classifications use the facility
3. Classification of the public road (major or minor)

Circulation roadways must be designed to accommodate the swept path of the largest design vehicle using the facility and the relevant clearances. All access driveway designs must be checked using the swept path analysis.

Typical driveway return treatments are shown in **Figure 16-2. Table 16.2** provides recommended driveway parameters. This should be used appropriately in consultation with the Overseeing Authority on a case-by-case basis.



SOURCE: QHDM, Volume 1, Part 5, Section, 1.4.10 Driveways.

Figure 16-2 Driveway Return Treatments

Table 16-2 Recommended Driveway Elements for Commercial Vehicles

Design Vehicle	Width of Driveway, W (m)		Radius of Driveway, R (m)
	One-way	Two-way	
SU-12	5	8	7.5
WB 15	5	8	14.5
WB 20	5	8	21.5

Access driveways must be designed to minimize the interference between the maneuvering of vehicles in and out of the parking facility, or the service area, along with the vehicles traveling through the public roadway. For the access design, service areas can be treated similarly as those of a commercial vehicle parking facility. A service area or yard is an area that is utilized for the storage of materials, garbage containers, mechanical equipment etc. it is accessed by commercial vehicles for specific operations, like loading, unloading, servicing, inspection, and parking. The following design principles must be considered for design access driveways:

1. On a major public road, there should be no interaction with the opposing direction of travel when vehicles are crossing the centerline or median of the public roadway to access the service area. Access to a service area should be either through grade separation or turnarounds at intersections.

2. On a minor public road, vehicles should be able to enter and leave the access driveway without going beyond the boundaries of the road space.

3. Wherever practical, vehicles entering the access driveway should be able to turn inside the facility, while staying within the curb lane.

4. Major service areas, as well as parking lots connecting to major roads, should have separate entry and exit driveways. Wherever they connect to minor roads, a two-way driveway is adequate.

5. The maximum grade of an access driveway to the connecting circulation should be 5%.

6. Appropriate sight distance should be maintained.

7. Adequate area should be provided for truck maneuvering and turning.

8. Other services such as security, fueling, maintenance, cleaning, and sleeping areas can also be provided, as deemed appropriate.

16.2.3 Service Areas

Service areas are defined in **Section 16.2.2**. There are two types of vehicle maneuvering that may take place within a service area, which need to be considered for the appropriate design vehicle:

1. Turning path movement – It is used in checking the forward travel path of vehicles arriving and leaving service bays, as well as in the design of access driveways and circulation roadways.

2. Reverse entry movement – It is used in the design of service bays and service area aprons to allow maneuvers required to dock in the service bay.

The principles that need to be considered while designing a service area are as follows:

1. The largest design vehicle and other special vehicles likely to use the service area should be considered.

2. A service area can consist of a staging area for temporary parking, inspection bays, loading and unloading bays, etc. These dimensions are generally the same or specified based on the operational requirements. It is advised to agree to those dimensions with the Overseeing Authority.

3. Loading and unloading bay dimensions depend on the vehicle size. A loading bay (alternatively service bay) is an area of a building where commercial vehicles are loaded and unloaded. This is similar to the commercial vehicle parking and may be fitted with a docking platform outside the parking area.

4. There should be a sufficient number of parking stalls or service bays to accommodate peak service demand.

5. An off-street maneuvering area of adequate size and shape must be provided to allow movement into and out of service bays.

6. Provision of a roof and other service bay amenities should be made to ensure adequate storage and transfer capacity for incoming and outgoing goods.

7. Service areas should be designed to ensure adequate drainage.

8. Service areas should be separated from the car parking, pedestrian activity, and all entrances and exits.

9. To prevent height restrictions, it is recommended that service areas should not be planned in a structure with shared functions. Any gateway structure adjacent to the service area should be capable of accommodating the largest design vehicle.

10. The area should be entirely within the vicinity of the development that is being served.

11. Service areas should be located away from residential developments.

12. Service areas should be clear of any access driveways, aisles, ramps, columns, signs, or other similar obstructions.

13. Considering vehicle type, minimum dimensions are to be maintained for any parking stall or service bay meant for loading or unloading.

14. Typical service bays are supposed to be 1.0 m wider and 1.0 m longer than that of the design vehicle.

The layout design of a service area is typically developed using the reverse-in and straight-out maneuvering paths. It is recommended that movements to and from the service bay be checked independently using the appropriate vehicle or an appropriate computer simulation package. **Figure 16-3** presents an illustrative service area layout with the loading/unloading area and parking facility for different transportation modes.

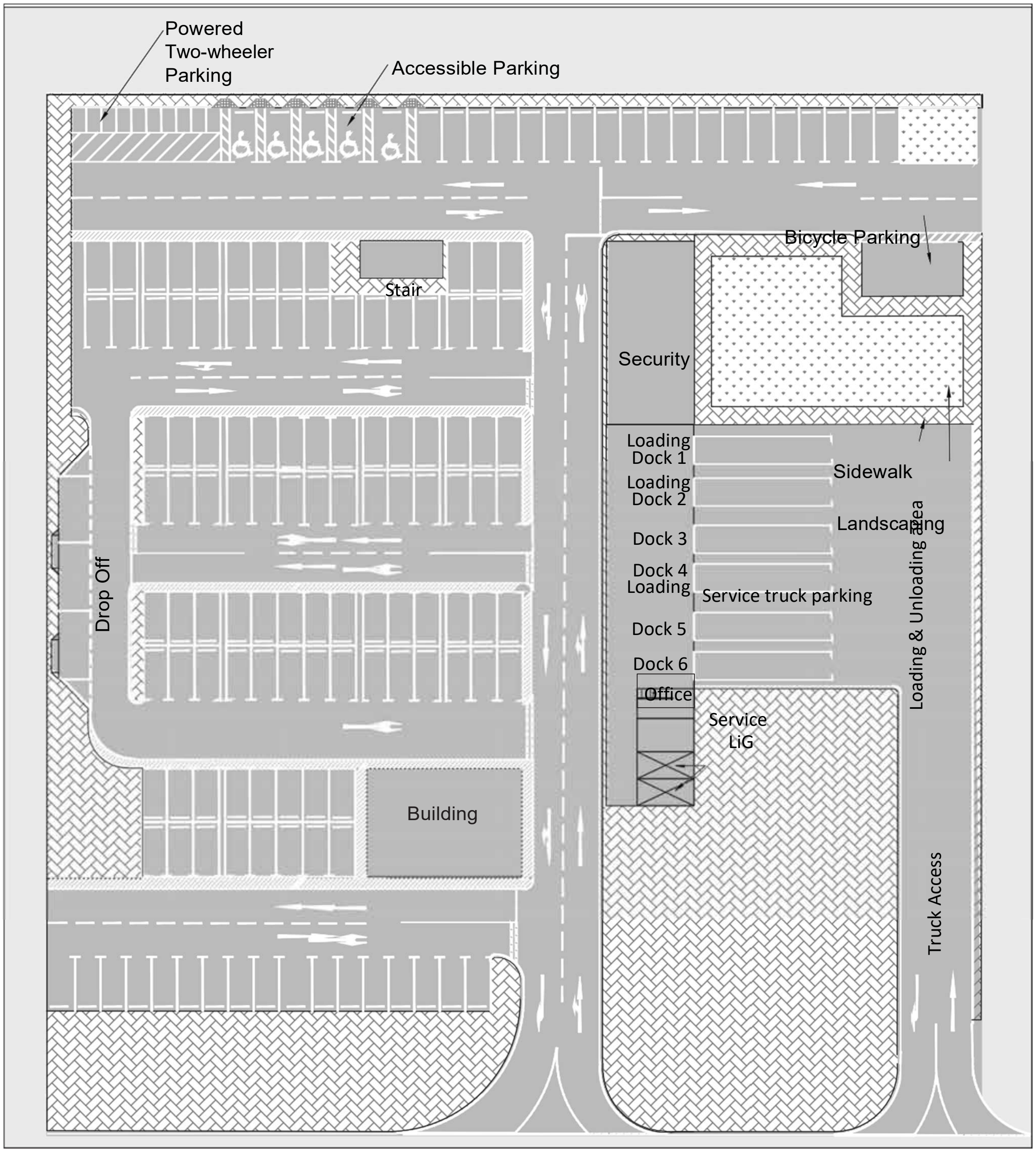


Figure 16-3 Typical Service Area Layout

Figure 16-4 shows a typical off-street truck parking area used in the State of Qatar. Based on the requirements, the truck parking area could serve for only a particular type of truck or different types of trucks within the same parking facility. Where the facility is planned to serve different types of trucks, it is recommended to have dedicated parking areas and access for each type to enhance the efficiency of the facility. Other services, such as security, fueling, maintenance, cleaning, and sleeping areas, can also be included by the designer according to the operational requirements.

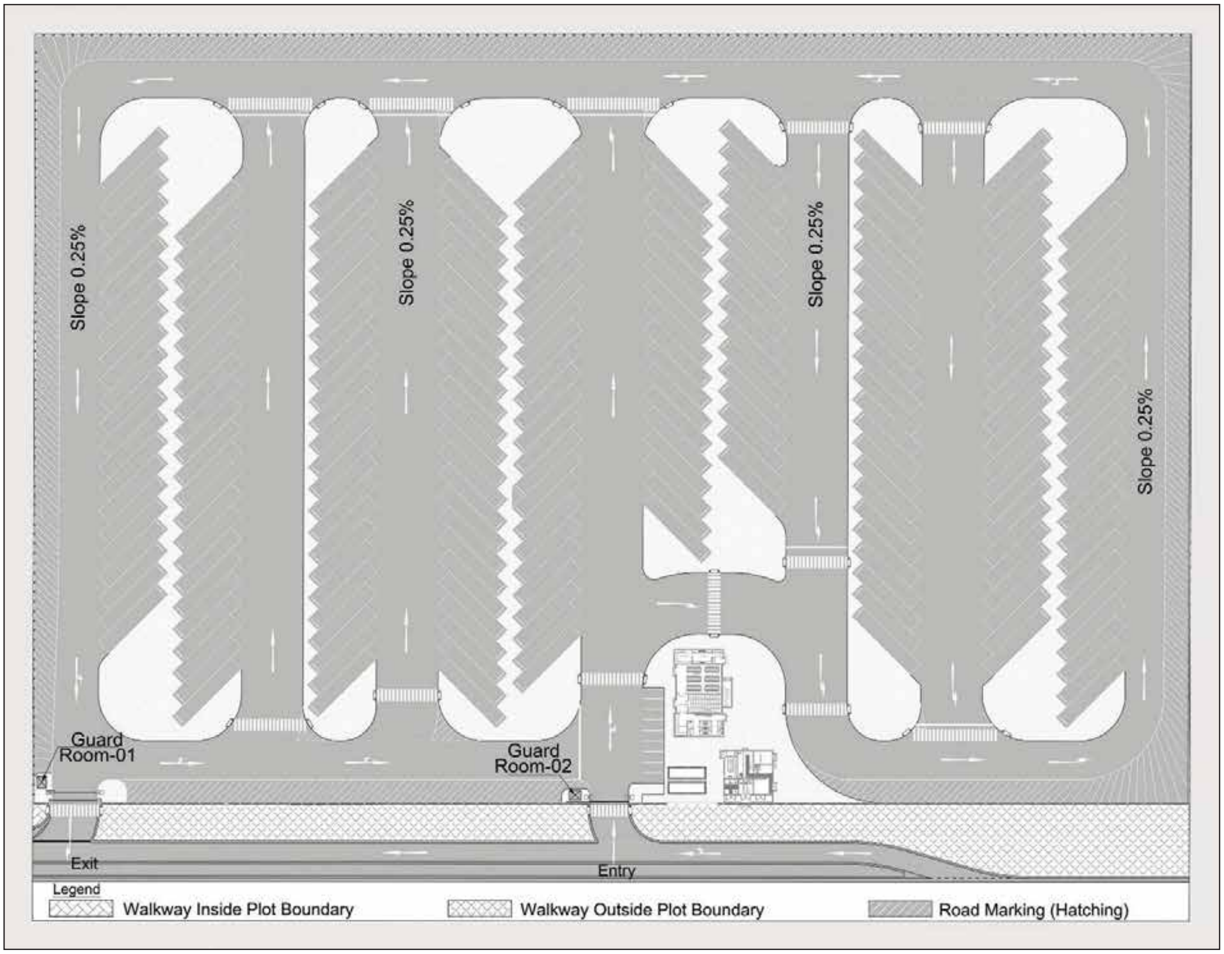
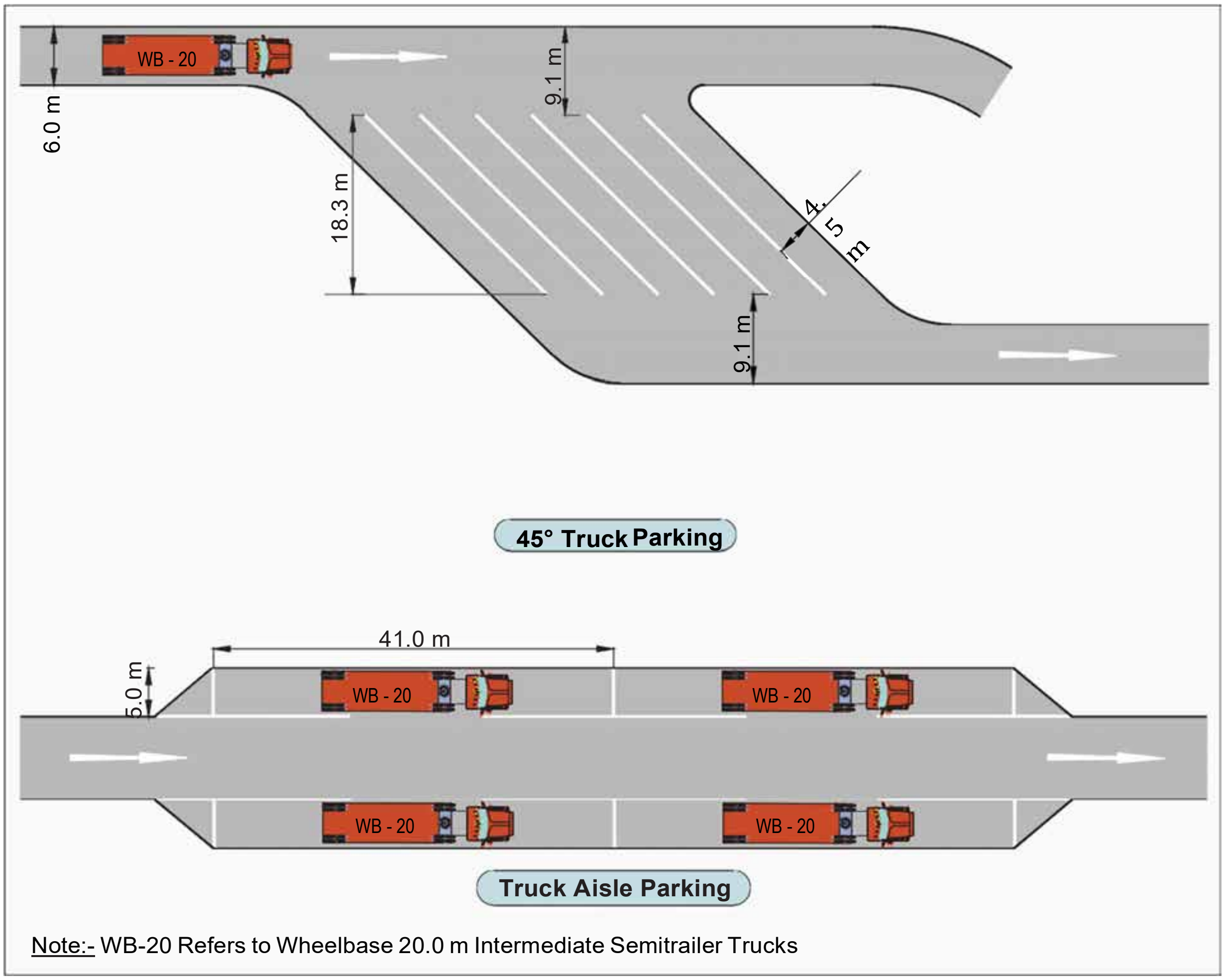


Figure 16-4 Typical Off-Street Truck Parking in Qatar

16.2.4 Rest Areas

The examples of off-street commercial vehicle parking for a WB-20 truck trailer at a rest area is shown in **Figure 16-5.** Dimensions can change based on the type of trucks expected to park in the truck parking facility. Procedures provided in **Section 4** should be followed to determine the required parking area dimensions through swept path analyses using computer-aided design (CAD) software. Refer to **Section 4.8**.

Rest areas may also include parking for other vehicles (e.g., cars, bicycles, and powered two-wheelers) and accessible parking. Parking stall dimensions of cars, bicycles, and powered two-wheelers are shown in **Section 6**, **Section 13**, and **Section 14**. The layout, circulation, and access should be developed based on the TIS, and in consultation with the Overseeing Authority.



SOURCE: QHDM, Volume 1, Part 3, Section, 8.2.3.2 Parking Layout

Figure 16-5 Typical Commercial Vehicle Parking Layout for Rest Areas

Section 17

Signage and Pavement Markings

17: Signage and Pavement Markings

This section of the Qatar Parking Design Manual (QPDM) describes the traffic control devices applicable for parking facilities, both on-street and off-street, in the State of Qatar. The Qatar Traffic Control Manual (QTCM) establishes the overall guidelines and principles that dictate the design and application of the traffic control devices. The traffic control devices covered under this section include signage and pavement markings (alternatively road markings), which are placed on, over, or adjacent to a parking facility, and act to regulate, warn, or guide the multimodal traffic flow (including pedestrians) in that particular facility. For the purpose of the QPDM, signage is used to describe the design or use of single or multiple signs to communicate a message.

Traffic control devices must meet a few basic requirements to fulfill their effectiveness such as:

- Satisfy an important need
- Command attention
- Convey a clear and simple message
- Command the respect of all users of the parking facility
- Be positioned to give adequate time for proper response

The purpose of traffic control devices is to improve the safety by providing orderly movement of vehicles, pedestrians, and other conveyances throughout the parking facilities, and to provide users with visual information. The visual information is conveyed to drivers as:

- Regulations
- Warnings
- Guidance

The requirements and purpose of traffic control devices can be achieved through the correct design, application, placement, and uniformity, as specified in this manual. It is generally expected that the signs are visible to users, are properly located, and are simple and clear in meaning. Standard sizes, shapes, lettering, color, and messages should be used. The signs must be well-maintained, actively enforced, and supported by legally enacted regulations. This section provides guidelines for the use of different signage, electronic parking information, and pavement markings. New signage and pavement markings related to parking complying with the recommendations made in Qatar Parking Master Plan (QPMP) is also included in this section. The new signs have been developed in addition to the signs already included in the QTCM. As required, signs may be depicted in both Arabic and English. The QTCM which provides guidelines for the design and use of various signage and markings should be referred appropriately.

17.1 Signage

There are three primary and one supplementary group of signs recommended as part of the QPDM. They are:

1. **Regulatory Signs** (depicted with prefix "R") – these are primary signs through which the traffic laws are put into effect. These signs can either be mandatory or prohibitory.

2. **Warning Signs** (depicted with prefix "W") – these are primary signs that alert users towards potential hazards on the way ahead.

3. **Guiding Signs** (depicted with prefix "G") – these are primary signs that give route designations to road users, destinations, directions, distances, or other information regarding their location or facilities. They are also referred as information signs.

4. **Supplementary Signs** (depicted with prefix "P") – these are signs that support primary sign types with further clarity, additional information, etc.

Regulatory and warning signs are generally static by nature. These signs should only be used where they are practically required; otherwise, they may tend to lose their credibility and effectiveness.

Guiding signs for a parking facility are divided into two major groups, depending on the physical characteristics and type of information displayed on them. These groups are:

- Static Signs – direct traffic to permanent parking areas
- Electronic Signs:
  - Fully Dynamic Signs or Variable Message Signs (VMS) – electronic signs to direct traffic to temporary or special event parking
  - Partial VMS – electronic signs that are used to provide real-time parking space availability and price information

Some information signs, i.e., directional guide signs, should be used frequently to keep drivers informed of their location. However, general information guide signs, such as signs providing tourist information and maps, can be overused leading to signs clutter. Such signs when located in close vicinity of regulatory and warning signs, can result in drivers missing critical safety information shown on these particular signs. Periodic inspections should be conducted for the brown tourist information guide signs to check if the facility they are assigned is still applicable or not; if not, they should be removed.

A set of existing signs included in the QTCM has been adapted for the QPDM. These signs are described in **Section 17.2**. New signs pertaining to parking have also been introduced and included in **Section 17.6**, which aim to promote road safety within and around the parking facilities. Electronic signs are presented in **Section 17.3**.

17.2 Key Signs for Parking Design

17.2.1 No Entry

Sign R117 prohibits entry to a roadway by all vehicles, unless used in combination with an exempting supplementary plate. Sign R117 should be located on both the left and right sides of a one-way roadway. Care should be taken in placing the sign to avoid the possibility of drivers misunderstanding the application of the roadway sign.

R117

17.2.2 No Waiting, Loading, and Unloading

Waiting, loading and unloading prohibitions on the side of a roadway generally apply from the center of the pavement to the roadway edge. The prohibitions should therefore apply to any shoulder, bicycle path, or verge (location for ground-mounted signs).

Waiting, loading, and stopping activities are defined as follows:

- Waiting – A vehicle is stationary to pick up or drop off passengers.
- Loading – A commercial vehicle is stationary to load objects that are too heavy or too bulky to be carried by hand. This does not include time for purchasing goods.
- Stopping – A vehicle is stationary on the roadway for purposes other than waiting or loading.

Sign R138 prohibits waiting at specific locations on the roadway. Sign R138 should be 200 mm in size. Sign R138 is used in combination with sign R139 or R139.1 at locations where waiting is prohibited.

R138

“At any time” legend should be shown on sign R139, along with sign R138 above it, in locations where the waiting is prohibited at all times.

R139

The time restriction is displayed on sign R139.1, along with sign R138 above it, in areas where waiting is prohibited only during certain hours of the day, days of the week, or for consecutive months.

Signs R138, R139, and R139.1 must be provided at the end points of the waiting restriction, with the sign displaying a single arrow to indicate the direction in which the restriction is applicable.

R139.1

Sign R140 is used where loading is prohibited for a 24-hour restriction. If the restriction is only applicable for part of the day, in an off-street parking facility, the legend includes the time for which the loading restriction is applicable (variant R140.1). Where the loading restriction extends for a distance greater than 50 m, the sign must be repeated at intervals not more than 25 m.

R140

17.2.3 Prohibition of Waiting on Verge or Footway

Sign R141 is used in combination with Sign R138 in certain situations where it is required to prohibit waiting on the verge or footway. This sign may indicate verge, or footway, or both.

Sign R141 must be provided at end points of the waiting restriction area, with signs mounted parallel to the curb. Repeater signs should be provided at every 60 m.

R141

17.2.4 No Waiting Except Taxis, Ambulances, or Police Vehicles

Sign R142 is used in combination with sign R138 where the exception for taxis is applicable for only part of the period in which waiting is prohibited. The time shown on the sign may be varied or omitted.

The word “taxis” shown on the sign may change for ambulances or police vehicles. Sign R142 must be provided at the end points of the waiting restriction area and be mounted parallel to the curb. Repeater signs should be provided at every 60 m.

R142

17.2.5 No Waiting by Trucks and Buses

Sign R143 is used to prohibit waiting by any truck with a maximum gross weight as shown on the sign (e.g., 5 ton). For trucks, sign R143 is used in combination with sign R138 and P400 for trucks (see **Section 17.2.28**). Time periods shown on the sign may be varied.

For buses, P401 (see **Section 17.2.28**) must be added to or substituted for P400 for trucks wherever the restriction is applicable to buses.

Sign R143 must be provided at the end of the waiting restriction area and signs should be mounted parallel to the curb. Repeater signs should be provided at every 60 m.

R143

17.2.6 Tow-Away Zone

Sign R144 is used to indicate a tow-away zone; for example, places where waiting or loading is prohibited, or on a clearway where drivers are not permitted to stop vehicles. Sign R144 should be located on the right side of the roadway, close to the beginning of the tow-away zone.

R144

17.2.7 Police Vehicles

Sign R146 restricts access at specific locations to police vehicles only. It may be used in both permanent and temporary situations. Sign R146 should be placed at an appropriate location on the right side of the roadway.

R146

17.2.8 Accessible Parking

These signs should be sufficiently visible to attract the attention of the drivers from an appropriate distance. Sign R200, used in combination with G100, may be used to designate accessible parking reserved for disabled badge holders only.

When a single parking place for disabled people is required, sign R200 should be located on the shoulder, approximately centered on the length or width of the stall.

R200

17.2.9 Limited Waiting

Sign R201, used in combination with sign G100, indicates a parking space where certain restrictions are applicable. These restrictions may include:

- time of operation
- limited waiting period
- class of vehicle (i.e., car, motorcycle, or bus)

R201

A directional arrow may be included at the bottom of Sign R201 to show the place where the restriction is applicable. There are no restrictions on parking outside the time of operation, unless there are signs and road markings to indicate otherwise.

17.2.10 Permit Parking

Sign R202, in combination with sign G100, is used where a parking space is reserved for permit holders. Permits may be issued for residents, employees, students, faculty/staff, doctors, or business personnel.

R202

17.2.11 Pay-and-Display Parking

Sign R203, in combination with Sign G100, is used in conjunction with on-street parking facilities with pay and display parking fee payment machines. Sign R203 includes a directional arrow to show the direction to the nearest parking pay station. The sign may be located between two parking machines, with arrows pointing in both directions. When sign R203 is placed close to the pay machine, the directional arrow is removed.

R203

Pay and display sign R203 should be installed at each end of a row of parking stalls served by a pay and display parking machine, with the sign face parallel to the curb line or edge of the roadway.

17.2.12 Shared Use Parking

Shared use parking signs are for permit parking bays that may be used for other vehicles, either at the same time or during specified times.

Sign R204, in combination with sign G100, should be used where there is time-limited parking. The example shown here is time-limited parking on Sundays to Thursdays from 7:30 am to 6:30 pm for permit holders only, and 20-minute parking for non-permit holders, with no return for 40 minutes.

Sign R204 is used for shared use parking bays. It should be located at each end of a row of shared use parking stalls with the sign face parallel to the curb line or edge of the roadway.

R204

17.2.13 Loading Bay

Sign R205 should be used to indicate a loading bay, in conjunction with bay marking M126 or M128. Sign R205, if used, should be located at each end of a row of loading bays with the sign face parallel to the curb line or edge of the roadway.

R205

17.2.14 Drop-Off and Pick-Up

Sign R206 should be used to indicate a drop-off and pick-up zone. This sign should be provided in loading bays to permit short-term waiting, while actively dropping off or picking up passengers.

R206

17.2.15 Prohibited Parking

Sign R207 should be used to prohibit parking at specific locations along a roadway or parking area. Supplemental message plates may be mounted below sign R207 to indicate specific restrictions.

R207

17.2.16 Clearway and No Stopping

Sign R145 prohibits drivers from stopping their vehicles, unless in an emergency or directed by traffic police. It is provided at the beginning of the clearway, supplemented by plate P211, and repeated at intervals not greater than 700 m until the end of the clearway (segment of curbside where no parking or stopping is allowed). It is supplemented by plate P208. These signs are installed on both sides of the roadway.

R145

P211

P208

17.2.17 Low Clearance

Low clearance signs should be used at all locations where vehicles first enter a covered area or encounter an overhead obstruction where the clearance is 2.5 m or less. This is applicable only for cars or light vans that are likely to use the facility.

Sign W404 is used to indicate the maximum height of a vehicle that may pass. The figure quoted on the sign must be at least 100 mm less than the measured minimum clearance, to allow a margin for driver error. It should be expressed to the next lowest multiple of 100 mm.

W404

17.2.18 Steep Grade Warning

Sign W423 should be used in public parking facilities at the beginning of steep ramps and up- or down-ramps that drivers may find unexpectedly steep. Grades in the order of 1:6 (16.6%) or steeper may require such signs.

W423

17.2.19 Circulation Direction

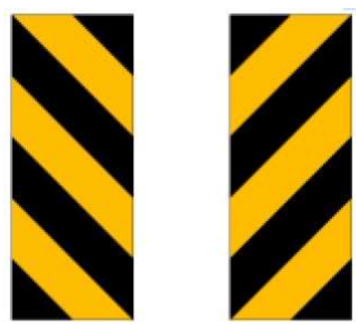
This sign indicates the route a driver must take while searching for a vacant space. It is located at each point where a driver is confronted with a choice of routes or must make a turn.

W300 -R

W300 -L

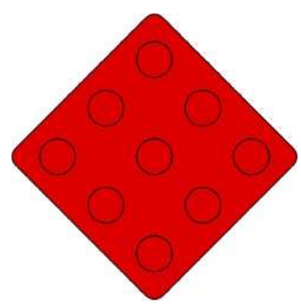
17.2.20 Hazard Warning Markers

Hazard warning markers or object markers are used to mark obstructions adjacent to the lane. Sign W440 is used where a parapet of ramps or other obstruction is adjacent to a traffic lane. Any other objects protruding into or near the lane should have a marker sign.



W440

Sign W441 alerts drivers of a roadway ending. This sign should be used when there are no alternative vehicle paths to use, such as dead ends or blind aisles. Sign W441 should be located at the center of the end of lane. When required, additional W441 marker signs may be provided adjacent to the center marker or the center marker may be supplemented with a barricade.



W441

17.2.21 General Parking without Time Limit

Sign G100 should be used to indicate a parking facility for vehicles, for both on-street and off-street parking. The sign plate may be extended to include the distance or a directional arrow below the text. Parking facilities that are open to the public should be with a blue parking sign, G100.

Sign G100 (plus supplementary plates P400 or P401 to P403 inclusive), when used in on-street parking bays, should be located at each end of a row of parking stalls with the sign-face parallel to the curb line or edge of the roadway.

G100

17.2.22 Entrance and Exit

Signs G129 and G132 guide the drivers toward any action required at the point of entry or exit from the parking facility. These signs are normally erected back-to-back in pairs: signs G129 and G130 for entry and signs G131 and G132 for exit. Parking facilities should be provided with directional guide sign, as deemed appropriate. For paid parking facilities with access control, parking tariff must be displayed at the entrance to the parking facility to enable drivers to decide whether to opt for entry into the facility or not.

Paid on-street parking must be clearly identified with supplementary signs showing information on maximum allowable hours and other relevant information.

G129

G130

G131

G132

17.2.23 Abnormal Loads Parking Point

Sign G126 is used to inform drivers hauling abnormal loads that they must wait at the point indicated by the sign.

G126

17.2.24 Truck Parking

Sign G136 is used to direct truck drivers to a designated parking area for trucks. Sign G136 should be located on the right side of the roadway. The distance shown on the sign may be varied.

G136

17.2.25 Park and Ride

Sign G213, variant G213.1, and sign G214 are used to inform road users of nearby park and ride facilities. Park and ride signs must be located on all access routes to a park and ride facility.

G213

G213.1

G214

17.2.26 Stop and Give Way

These signs are normally required at the unsignalized intersection of a parking access driveway and a frontage road. They may also be required in parking facilities at any intersection or where right of way must be assigned and approach speed controlled. Stop or give-way lines alone may be adequate in many cases. Where practical, layouts should be designed to avoid such situations.

R100

P200

R101

17.2.27 Speed Management

A parking facility should be designed so that it does not encourage excessive speed. If excessive speed is a problem, traffic management devices, such as speed humps should be used. Speed limit in parking aisles must be lower than the speed at the access, egress, and circulation roadways. Speed limit signs may be used to indicate the general speed limit desired in a parking facility. The limit should not be unrealistically low, and as a guide should approximate the average speed of drivers using the parking facility. Sign P305 should be used where a speed hump may not be visible at a time when the driver has to slow down to negotiate it. Sign W410 warns the presence of a speed hump or a series of speed humps. The location of signs must follow the QTCM standards and be clearly visible.

R148

W410

P305

17.2.28 Buses, Trucks, Bicycles, and Motorcycles

Sign G100 may be used in combination with a supplemental plate mounted below to indicate reserved parking for:

- Trucks (P400)
- Buses (P401)
- Bicycles (P402)
- Motorcycles (P403)

P400

P401

P402

P403

17.2.29 Repeated Signs

The repetition of signs depends on the type of signs, and their usage needs to be in line with the QTCM guidance and requirements. Directional and other wayfinding signs should be provided at all places where there are changes in direction to inform users about the travel way and parking information.

The factors that determine the repeated sign requirement are the legible distance at which a user is able to view and understand the information displayed on the sign and the time needed to react to it. The type of parking layout and the speed of the vehicle determines the spacing between the signs. Pedestrian signs must be placed at all the pedestrian crossings and advance warning signs should be provided at regular intervals.

17.3 Electronic Parking Information

Electronic parking information displayed as dynamic or variable message signs are typically provided at public parking facilities for the following purposes:

- Provide parking facility and parking space availability information in a town center or central business district (CBD)
- Guide drivers toward vacant spaces
- Indicate the number of vacant spaces in real time
- Provide other information about the facility
- Provide parking fee information

These signs provide electronic display of messages, such as parking availability information. For details of signs that provide electronic parking information, refer to the Ashghal ITS Deployment Manual (2013) and relevant specifications. Reference must be made to QTCM Volume 3, Drawing (drawing E104 – Electronic Parking Information) for a schematic layout that provides parking facility location and space availability information.

The following requirements relate to the use of variable message signs:

1. Symbols other than arrows should not be used unless they meet minimum public comprehension requirements.
2. Signs with words only should be limited to a maximum of four words per screen.
3. Scrolling of messages should be limited to only parking facilities and on no more than two screens. Running messages should not be used.

Changing messages should not be displayed to drivers within or approaching a vehicle or pedestrian conflict area. Sample electronic parking information is shown in **Figure 17-1**.

1

2

3

SOURCE: www.parkassist.com

Figure 17-1 Electronic Parking Information

17.4 Signage and Pavement Markings for Emergency Vehicles

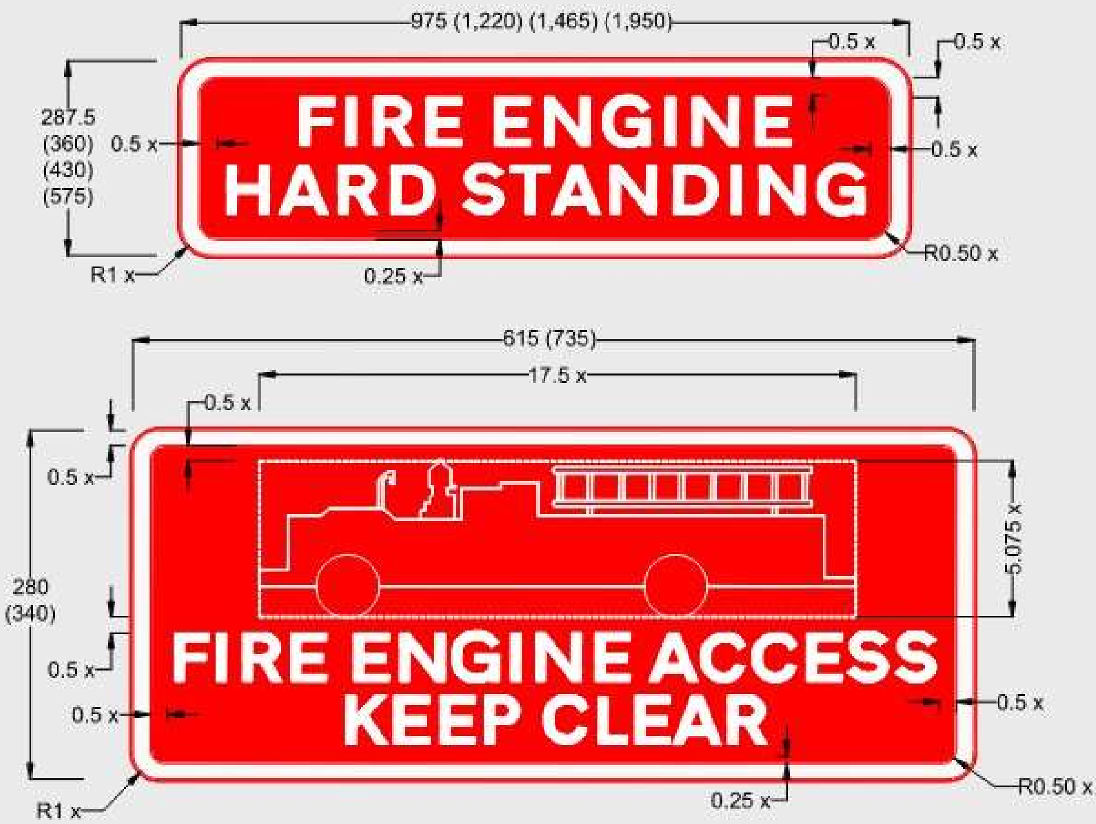
All corners of a fire engine hard standing should be marked. Signage guidance is shown in **Figure 17-2**. Hard standing pavement markings are shown in **Figure 17-3**. Marking of corners should be in a contrasting color to the ground surfaces or finishes. Fire engine hard standing provided on a turfed area must be marked with contrasting objects (preferably reflective) that are visible at night. The markings are to be at an interval no more than 2.0 m apart and should be provided on both sides of the fire engine hard standing.

1 SOURCE: www.ampron.eu

2 SOURCE: www.electroautomation.com

3 SOURCE: www.transportxtra.com

Side post displaying "Fire Engine Access – Keep Clear" sign should be provided at the entrance of the fire engine hard standing. Sign lettering height must be 50 mm or more.



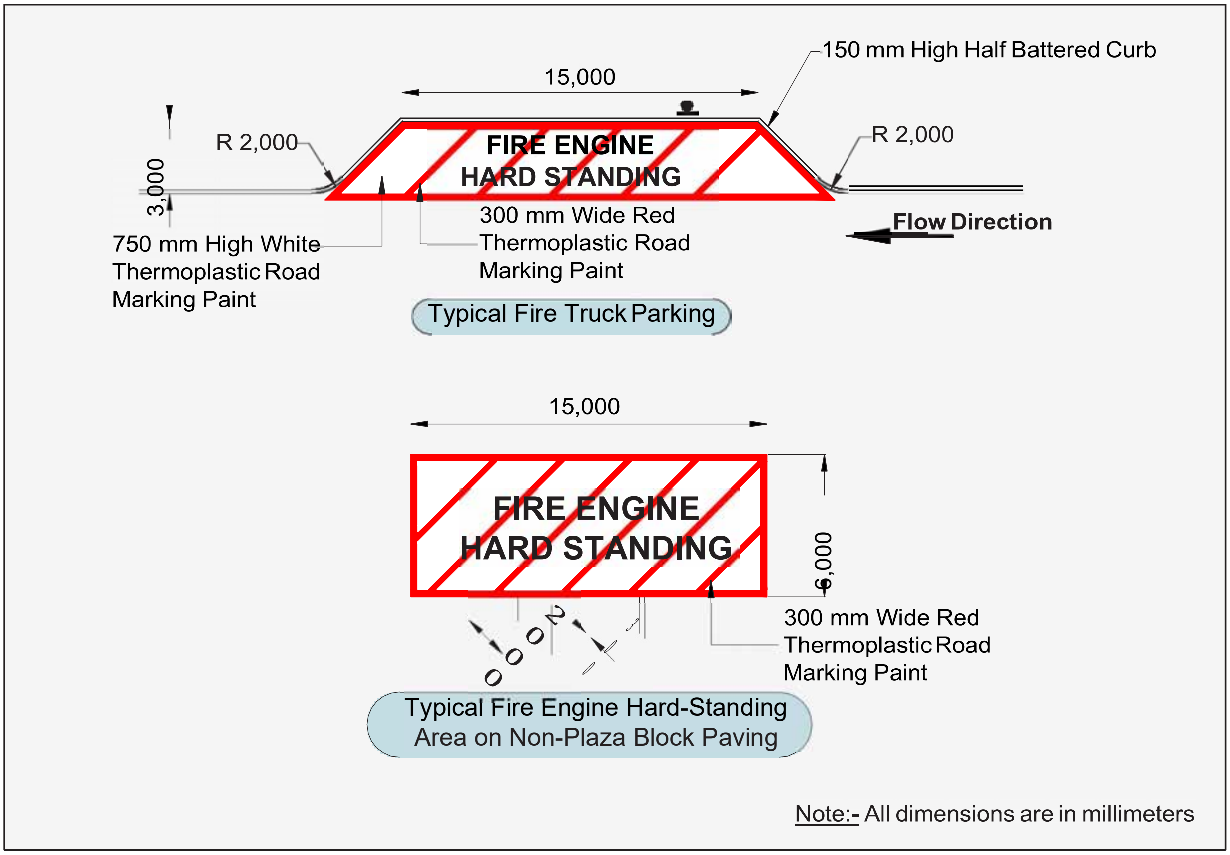
Aleph Height (mm) (Arabic Letter)	X - Height (mm) (Latin Letter)
85	50
106.25	62.5
127.5	75
170	100

Note:-

- The legend is from the Transport Medium alphabet at the X- heights specified
- The Tile outlines do not form part of the design
- Dimensions - Overall sign height and width in millimeters,Other dimensions in X - height
- Colors:-
  - Background - Red
  - Legend and border - White

SOURCE: QTCM, Volume 3, Drawings (Drawings G124 and G125)

Figure 17-2 Fire Engine Signage Requirements



SOURCE: Station area planning, Phase, 1 Qatar Metro Projects (IA 14/15D 003 G).

Figure 17-3 Hard Standing Pavement Marking

17.5 Pavement Markings

Reference may be made to QTCM Vol. 2 for additional guidance on pavement markings.

17.5.1 Parking Stalls

Parking stalls other than those for people with disabilities should be delineated by means of white lines that are 80 to 100 mm wide. Yellow lines should be used for parking which are designated for taxis, ambulance, fire engine, and police vehicles. In case of angled or parallel parking, white or yellow pavement markers should be used appropriately. Pavement markers, if used, must be substantially flushed (not higher than 3 mm). Raised pavement markers, more than 3 mm in height, may cause a tripping hazard for pedestrians. Pavement markings for parallel parking should be according to M128, mentioned in this section. In a parking area, all parking spaces of the same type should be marked in the same way.

Pavement markings for angled parking should be according to M129, which is mentioned later in this section. For off-street parking, parking stall dimensions must be according to **Table 6-1**. For on-street parking stall dimensions, refer to Qatar Highway Design Manual (QHDM).

Parking bays can be marked on the curb or adjacent to the roadway to delineate areas set aside for parking. There are various types of parking bay markings, and the type depends on the proposed use of the parking area. Parking bays may be marked parallel to the curb or at an angle to the curb. The different markings are M125, M126, M127, M128, and M129.

The markings depicted in the subsequent paragraphs are from the QTCM and should be considered only for the details and type of marking. However, the stall dimensions, depth, and buffer areas should be in line with the details explained in various sections of this manual.

Table 17-1 details the various types of parking space markings, their intended use, and any restrictions and signs required for each type of parking space.

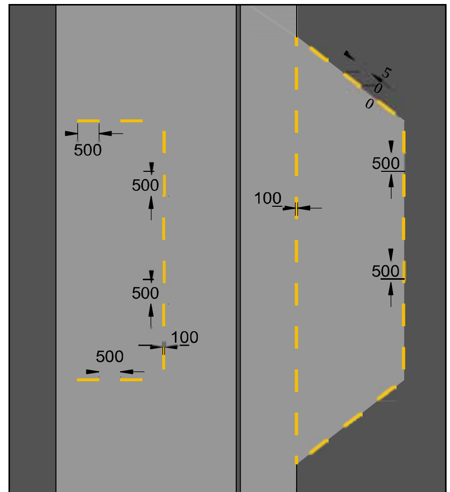
Table 17-1 Parking Stall Markings

<table>
<tr><th>Marking</th><th>Type of Parking</th><th>Relevant Signs</th><th>Width (in mm)</th><th>Color of Marking</th></tr>
<tr><td>M125</td><td>Taxis only
Ambulances only
Fire Engine only
Police only</td><td>R142</td><td rowspan="6">Parking stall width will be according to the design and the details provided in the earlier sections of the QPDM.</td><td>Yellow</td></tr>
<tr><td>M126</td><td>Accessible parking
Buses only
Loading only
Large vehicles</td><td>R200
R201 or
G100/P401 R205
G100/P400</td><td>White</td></tr>
<tr><td>M127</td><td>Doctors' parking
Motorcycle parking
Permit holders
Limited waiting or no specific class of vehicle</td><td>R202 G100/P403
R202
R201</td><td>White</td></tr>
<tr><td>M128</td><td>Limited waiting
Unlimited parking
Accessible parking
Loading only
Permit holders</td><td>R201 or R203
G100 or none
R200 R205
R202</td><td>White</td></tr>
<tr><td rowspan="2">M129</td><td>Limited waiting/
Paid parking
Unlimited parking
Doctors' parking
Permit holders</td><td>R201/R203
G100 or none
R202</td><td>White</td></tr>
<tr><td>Accessible parking</td><td>R200</td><td>White</td></tr>
</table>

SOURCE: Adapted from QTCM, Volume 2, Part 6, Section 2.11, Parking Bays.

Marking M125 Continuous Bay

Marking M125 forms a continuous bay which could include space for more than one vehicle at the edge of the roadway. It must be colored yellow in order to inform drivers that the bays are enforceable. The bay can be extended to any length, but in most instances, it is long enough to accommodate only a small number of vehicles within it. The permitted sign for use with marking M125 is R142, with the legend varied to denote whether the parking is for taxis, ambulances, or police vehicles.



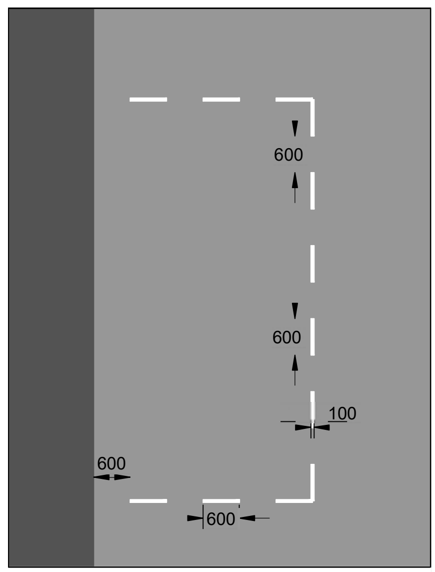
Note:- All dimensions are in millimeters

M125

M126 Wide Vehicle Parking

Marking M126 is used to define parking areas for wide vehicles. This could be for vehicles displaying permits for the disabled people, buses, or large vehicles.

The bay markings are white and must be accompanied by the appropriate sign. This can be either R200 for accessible parking, in conjunction with marking M130; R201 when altered for buses or the combination of G100 and P401 for buses; and the combination of G100 and P400 for large vehicles.



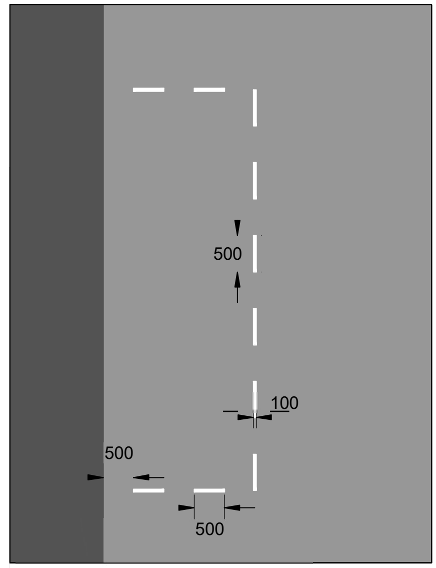
Note:- All dimensions are in millimeters

M126

Marking M127 Single Designated Parking

Marking M127 is used to define a single designated parking stall for limited waiting, permit holders, class of vehicle, or paid parking. The markings should be located at the edge of the roadway and the stall markings must be in white.

The parking stall is a space for only one vehicle and must be accompanied by the upright signs for the following purposes: R202 for doctors' parking, a combination of G100 and P403 for motorcycle parking, R202 for permit parking, and R201 for limited parking.



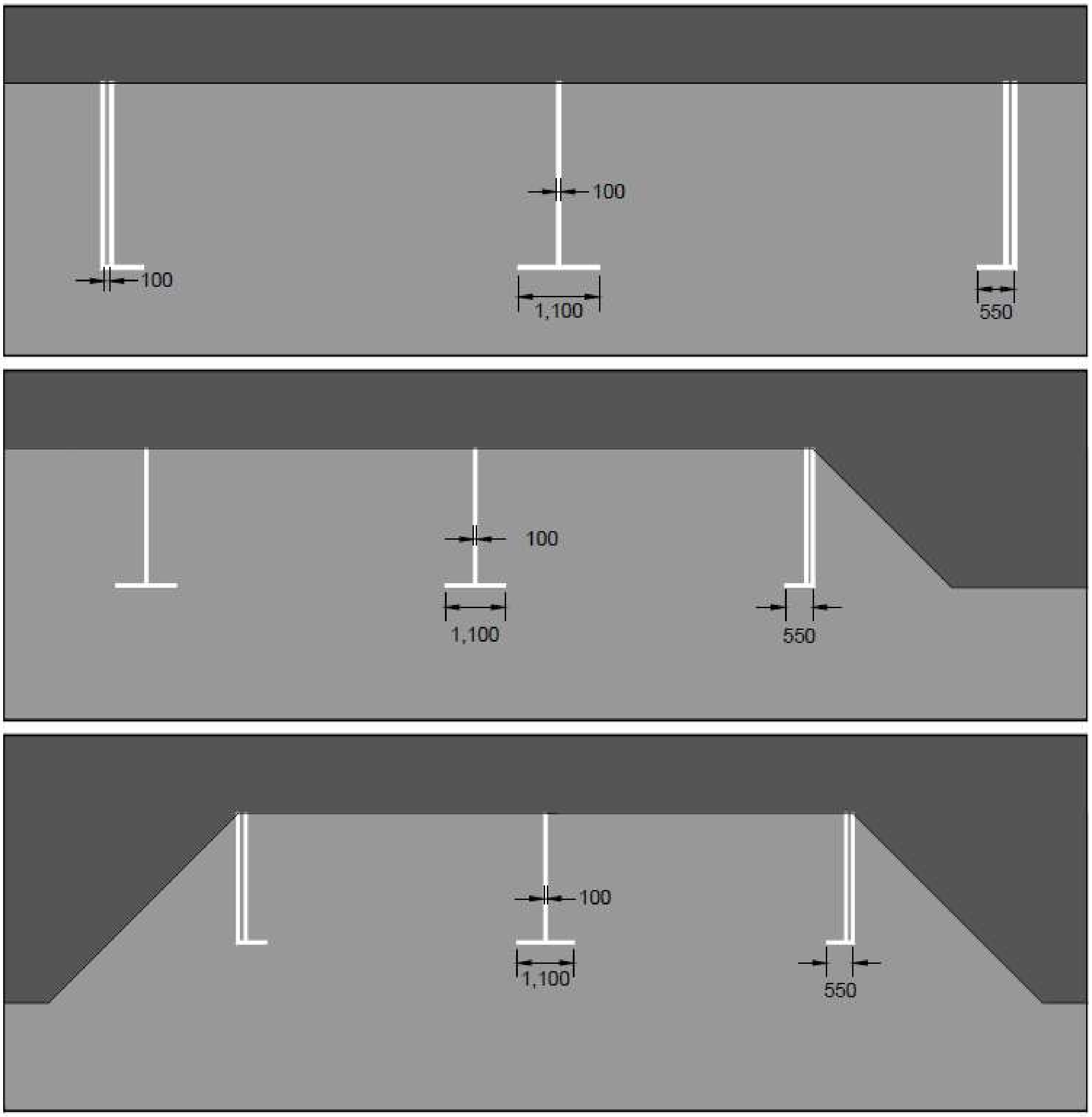
Note:- All dimensions are in millimeters

M127

Marking M128 On-Street Parallel Parking

Marking M128 is used to divide a length of the roadway into individual parking stalls with each end of a bay marked as a double line, except where the bay limit is delineated by a raised curb. The marking can be used where parking is free or where a fee is applicable. The length and width of parking stall depends on the design. Longer stalls are generally required where:

1. Forward-in parking is required
2. Automatic parking is allowed (if reverse parking is permitted)
3. Longer vehicles, such as vans, are expected to park



Note:- All dimensions are in millimeters

M128

Dimensions must be according to QPDM.
SOURCE: Adapted from QTCM, Volume 2, Part 6, Section 2.11, Parking Bays.

Figure 17-4 Pavement Marking Details for M128

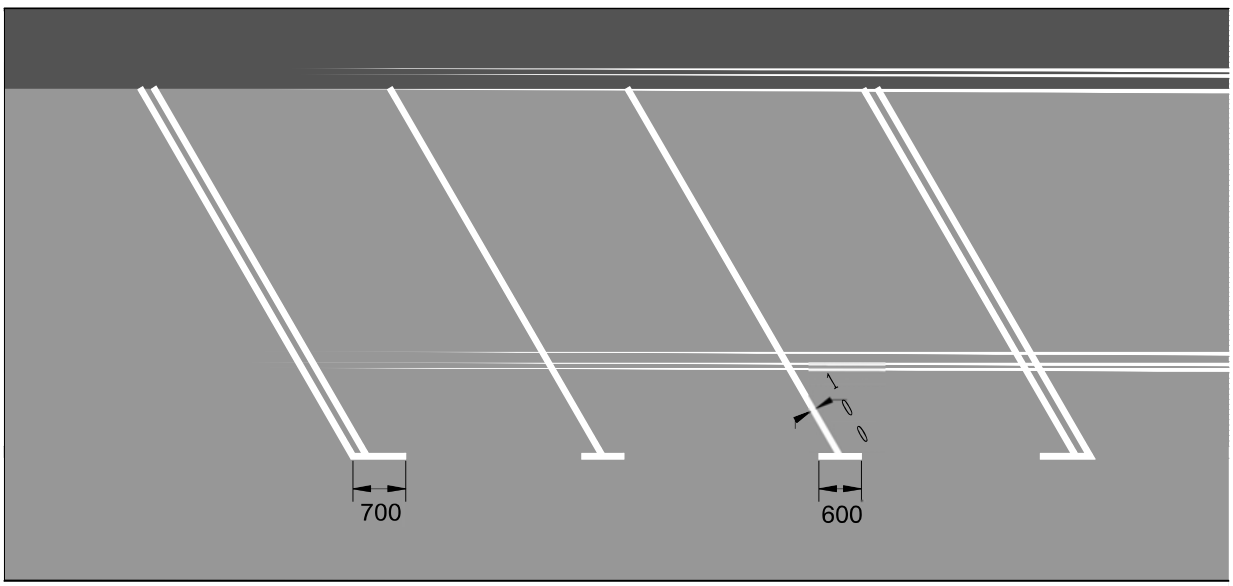
The bay should be placed at the edge of the roadway, and the bay marking must be in white. Upright signs must be used to denote a specific class of parking, which can be R200 for accessible parking (with marking M130) or R205 for loading only.

In areas where there are parking fees, signs R201 or R203 are to be used. Sign R202 is to be used for permit holders. Sign G100 or no sign can be used if there is no charge or limitation.

Marking M129 Angled Parking

Marking M129 is used to indicate angled parking bays and may be used where parking is either free or a charge is applicable. The angle between the markings and the roadway edge may be varied to suit the available roadway width at angles of 45 and 90 degrees, or as agreed with the Overseeing Authority. Several angled stalls may be reserved for use by accessible (disabled) badge holders. The stall width should be 3,500 mm, excluding the access aisle, and sign R200 must be provided along with marking M130. Standard width stalls for accessible parking may be used for doctors' parking. They must be accompanied by sign R202.

Signs R201 or R203 must be used for paid parking and sign R202 for permit parking. Sign G100 or no sign should be used if there is no charge or limitation.
Each end length of parking bays should be marked with a double line, unless the stall is limited by a raised curb.



Note:- All dimensions are in millimeters

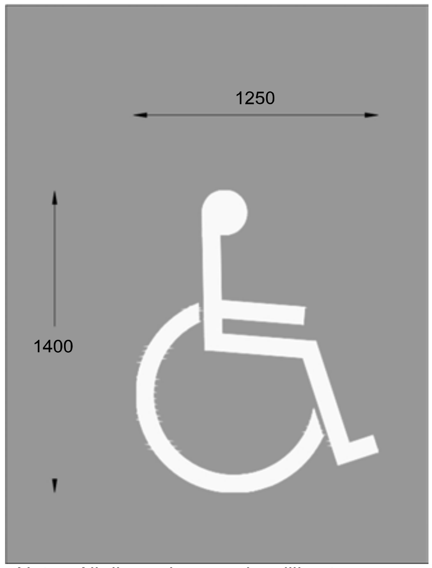
M129

Dimensions must be according to QPDM.
SOURCE: Adopted from QTCM, Volume 2, Part 6, Section 2.11, Parking Bays.

Figure 17-5 Pavement Marking Details for M129

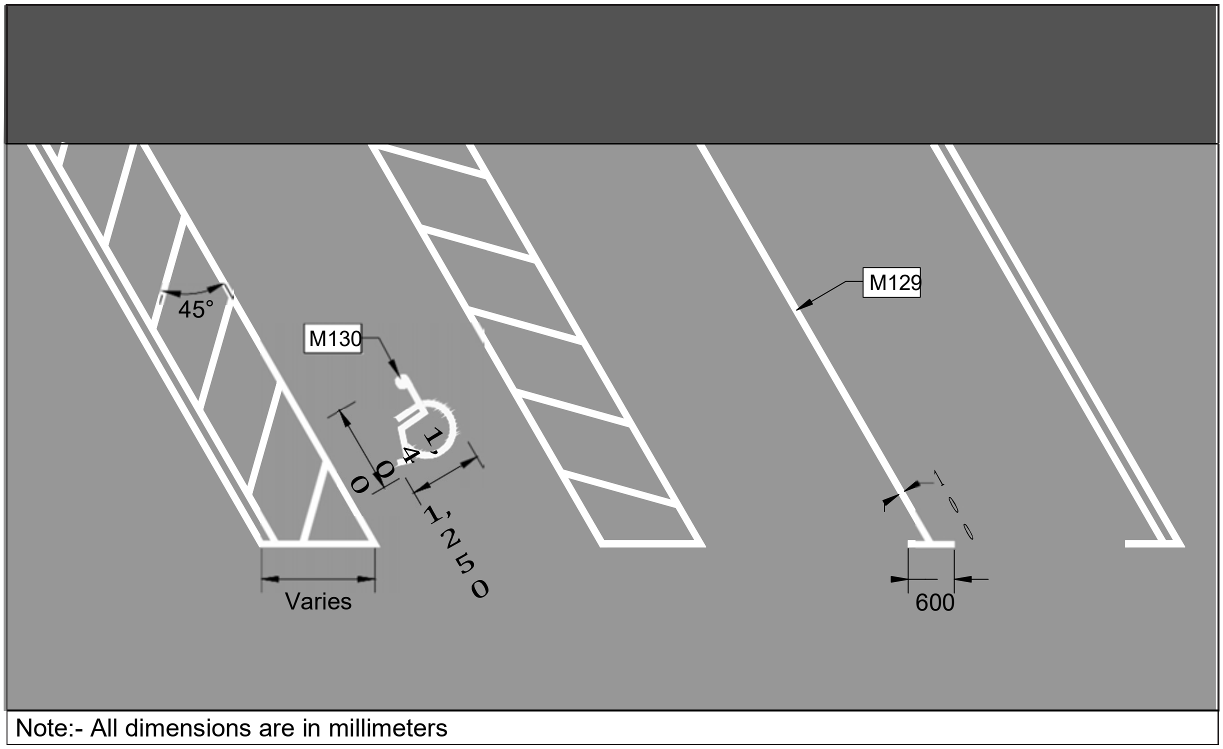
17.5.2 Accessible Parking Stall Symbol

Marking M130, in conjunction with sign R200, should be used where parking is assigned as an accessible parking stall. Marking M130 is located centrally within the bay, oriented to appear upright to approach traffic. The pavement marking is shown in **Figure 17-6**.



Note:- All dimensions are in millimeters

M130



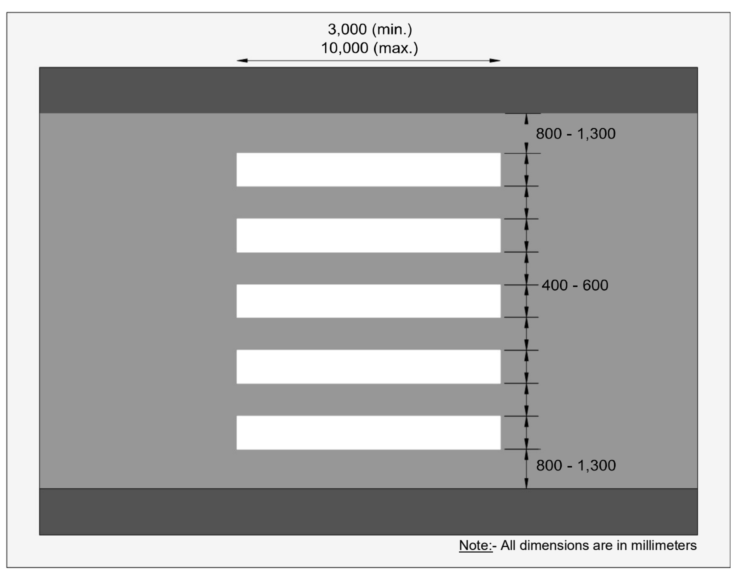
Dimensions must be according to QPDM.
SOURCE: Adapted from QTCM, Volume 2, Part 6, Section 2.11, Parking Bays.

Figure 17-6 Pavement Markings for Accessible Parking

17.5.3 Pedestrian Crossings

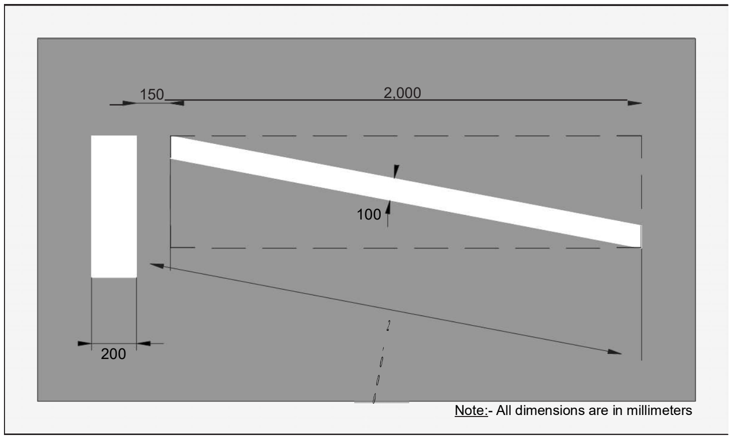
Marking M311 High Intensity Marking

The width of a pedestrian crossing is determined by the pedestrian flow. An extra 500 mm should be added to the minimum width of 3,000 mm for every 125 pedestrians per hour above 600, averaged over the 4 peak hours, up to a maximum width of 10,000 mm. The black-and-white stripes should be laid across the full width of the roadway, and the stripes immediately adjacent to the edge of the roadway must be black and not more than 1,300 mm wide. All other stripes, both black and white, must be of equal width and not less than 400 mm or more than 600 mm wide.



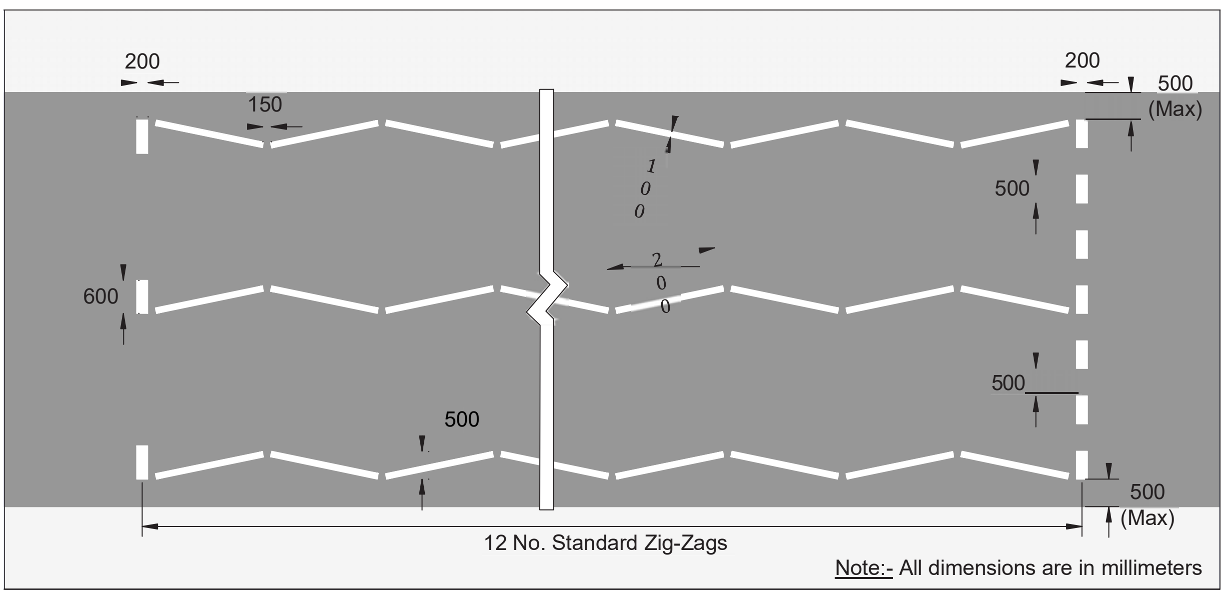
Marking M312 Zigzag Marking

Marking M312 may be provided in advance of marking M310 where the crossing is not at a signalized intersection and in advance of marking M311. It warns motorists of the presence of the crossing and prohibits the vehicles from stopping within the length of the zigzag marking, except to permit a pedestrian to cross the roadway. The individual marking is 2000 mm long and angled between two guidelines that are 500 mm apart, with each mark separated by 15 mm.



The end of a set of zigzag markings should be provided with a terminal bar, which is 200 mm wide and 600 mm long.

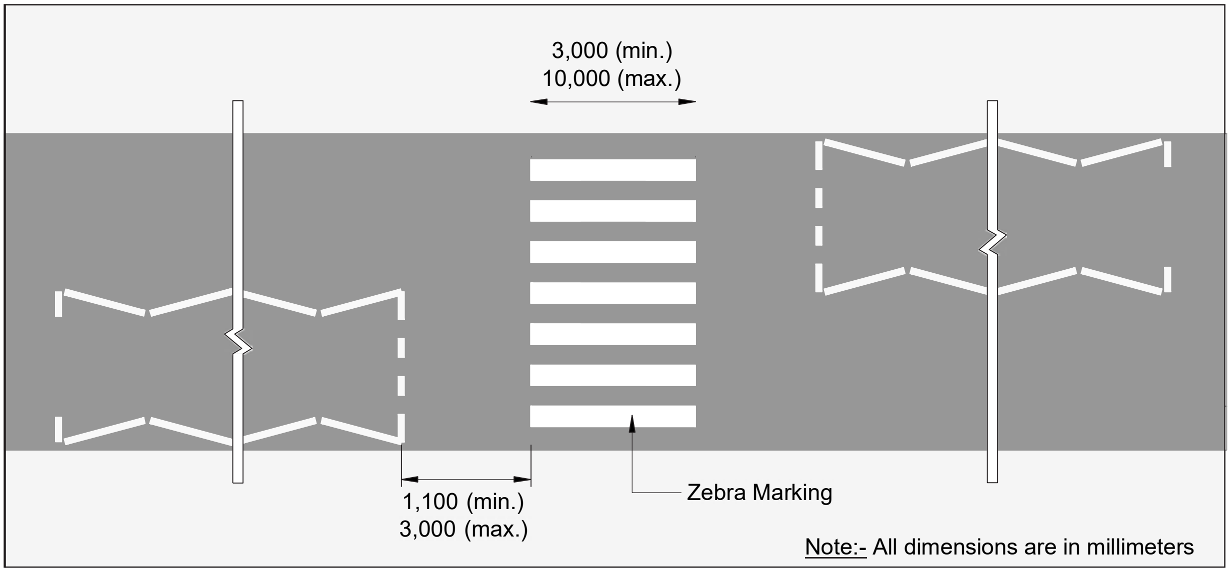
The standard pattern of zigzag markings consists of twelve 2000 mm marks and a terminal bar. A layout of marking M312 is depicted in **Figure 17-7**. The “GIVE WAY” line consists of a single broken line which is composed of 500 mm marks and 500 mm gaps; the line is 200 mm wide and extends across the roadway for the number of lanes on approach.



SOURCE: QTCM, Volume 2, Part 6, Section 4.2.3, Zigzag Markings.

Figure 17-7 Zigzag Pavement Markings for Pedestrian Crossing

At unsignalized pedestrian crossings, markings M311 and M312 should be positioned as illustrated in **Figure 17-8**. The "GIVE WAY" line is normally placed between 1100 mm and 3000 mm from the edge of the stripes on the crossing.

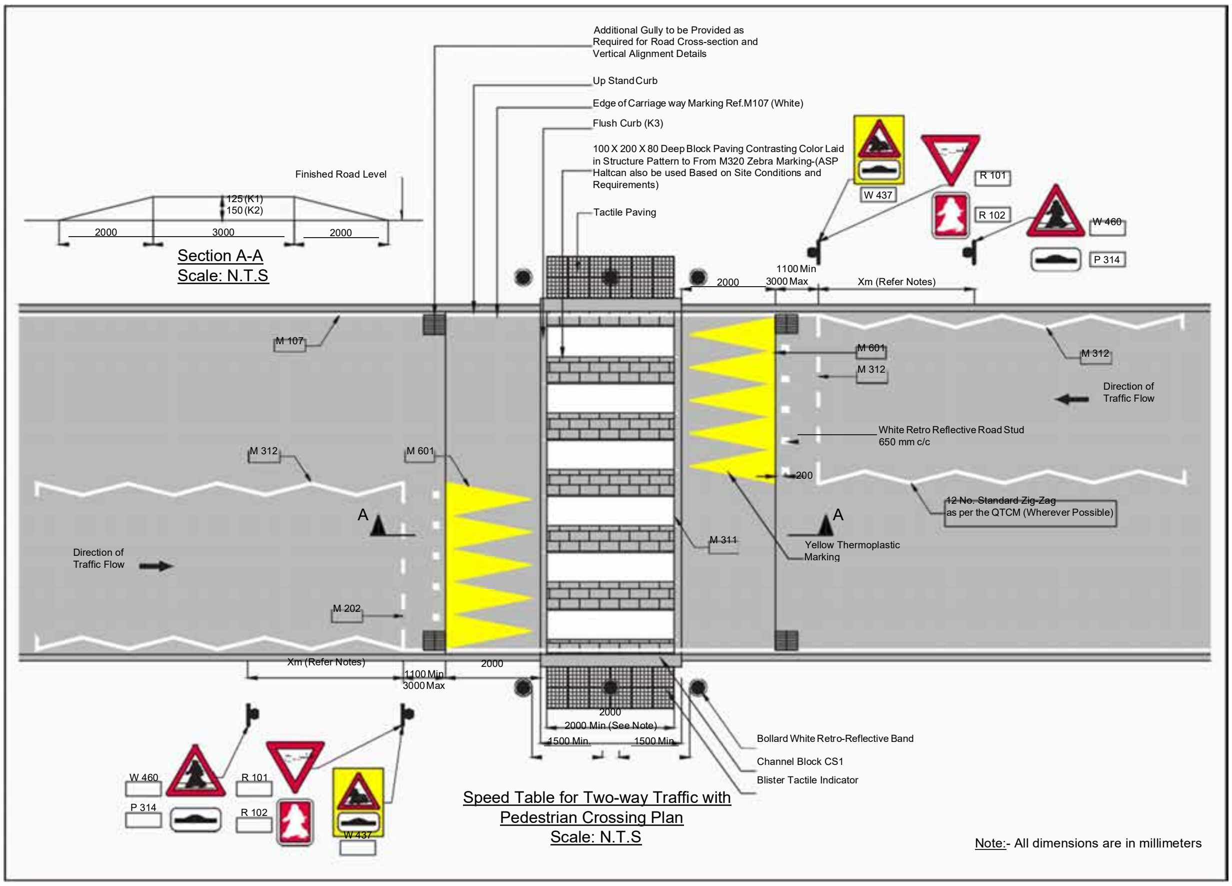


SOURCE: QTCM, Volume 2, Part 6, Section 4.2.3, Zigzag Markings.

Figure 17-8 Pavement Markings for Unsignalized Pedestrian Crossing

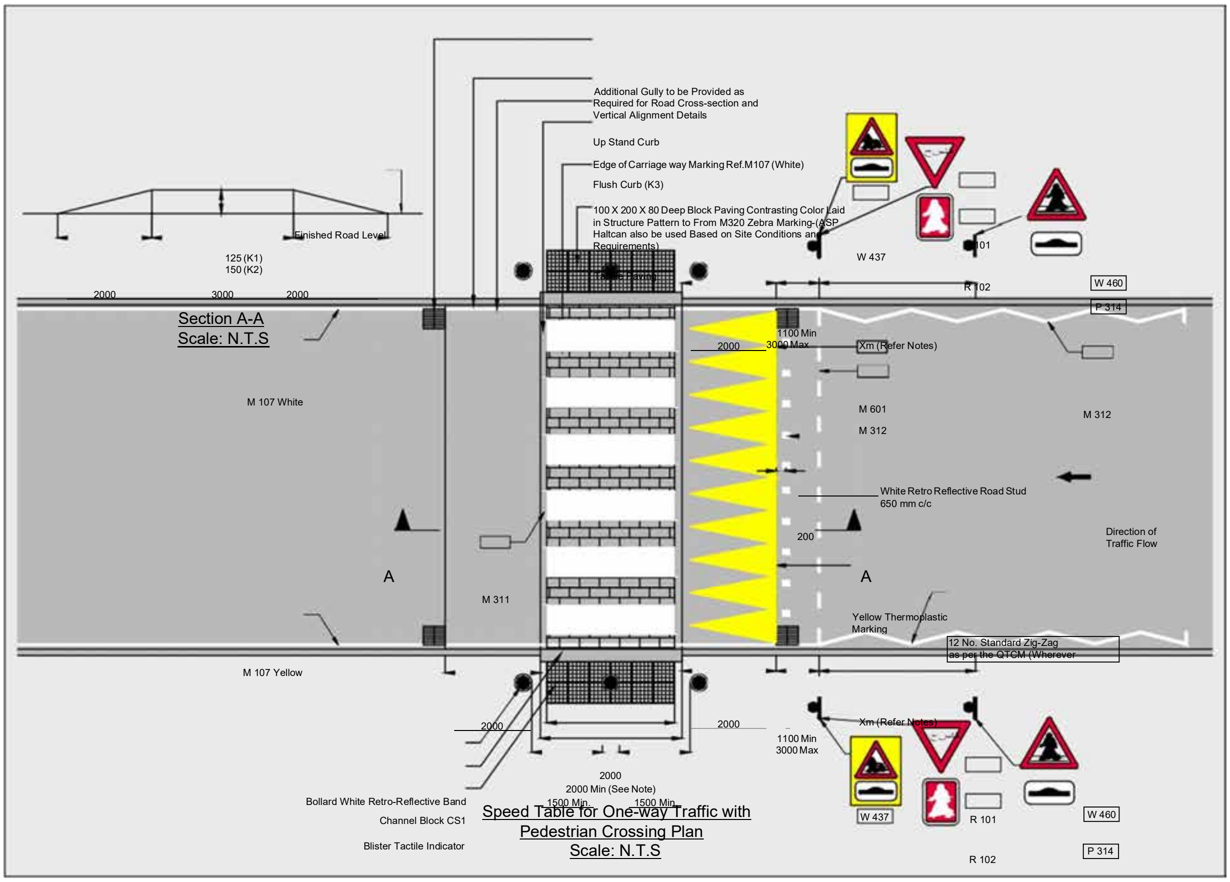
Tactile paving should be installed as a guide to visually impaired pedestrians according to the latest QTCM. This should be present at all the signal-controlled pedestrian crossings, whether midblock or at intersections.

The signs and marking for raised pedestrian crossings are shown in **Figure 17-9** and **Figure 17-10**.



SOURCE: Public Works Authority (PWA) Standard Drawings.

Figure 17-9 Speed Table for One-Way Traffic with Pedestrian Crossing Plan



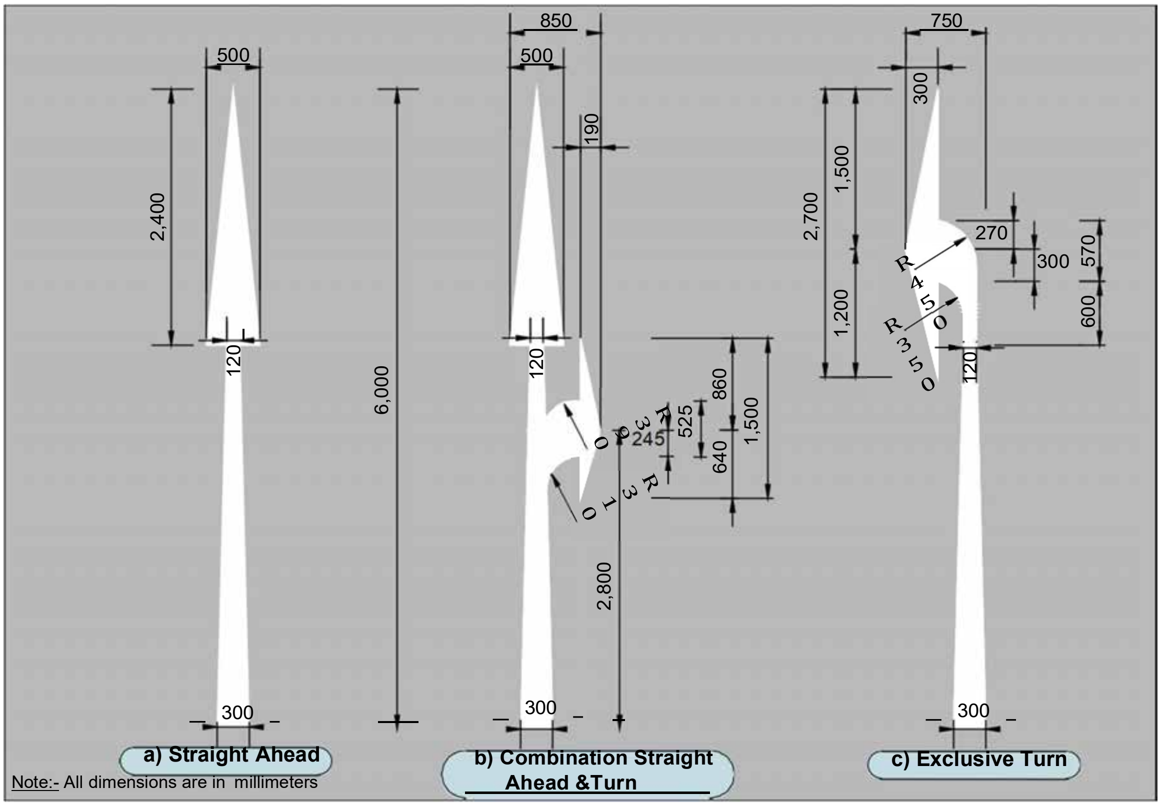
Note:- All dimensions are in millimeters

SOURCE: Public Works Authority (PWA) Standard Drawings.

Figure 17-10 Speed Table for Two-Way Traffic with Pedestrian Crossing Plan

17.5.4 Pavement Arrows

Recommended shapes and sizes for pavement arrows to control and direct circulating traffic within a parking facility and associated circulating roadways are illustrated in **Figure 17-11**.

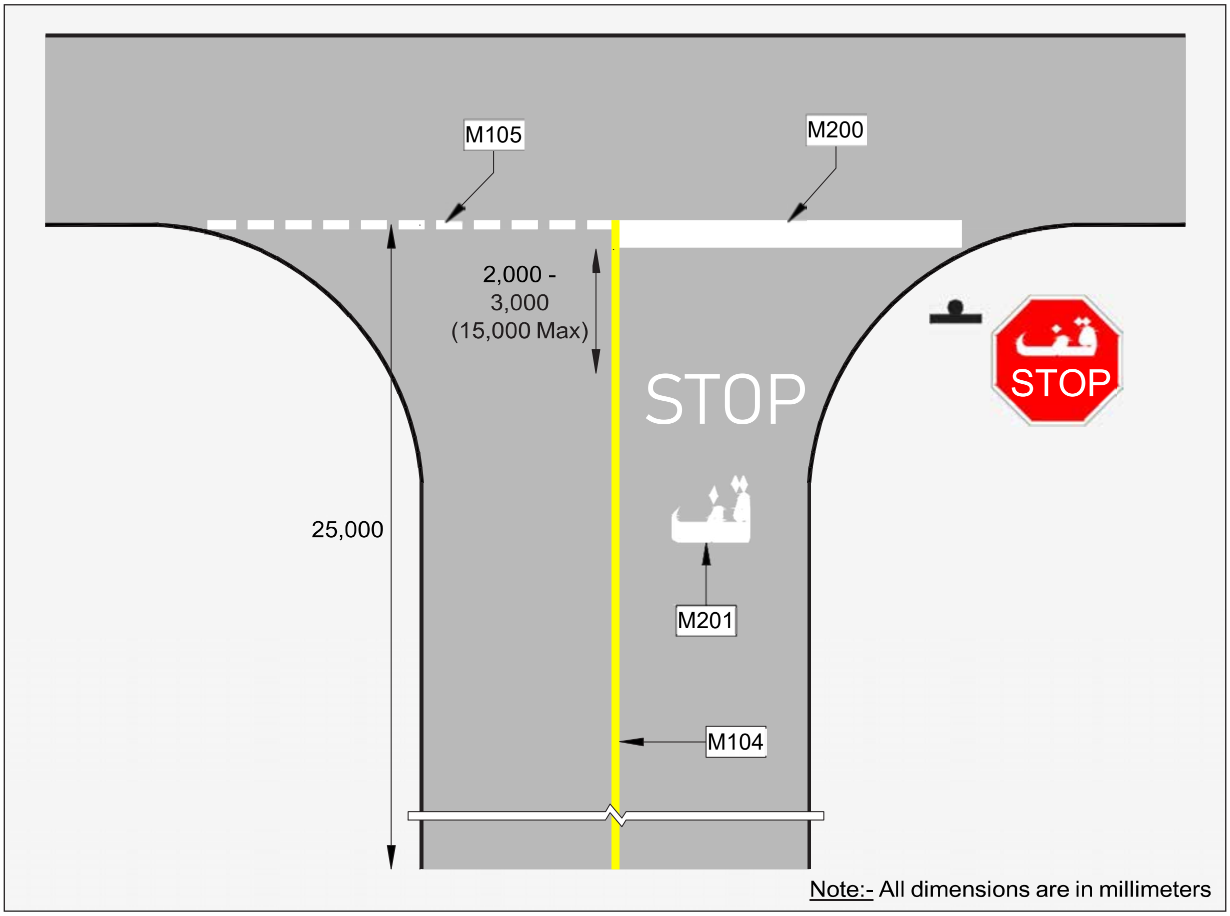


SOURCE: QTCM, Volume 3, Drawings (M402 (sheet 2 of 4)).

Figure 17-11 Parking Facility Pavement Arrows

17.5.5 Intersection STOP Lines

Marking M200 should be used at priority intersections controlled by sign R100 (STOP) to indicate the place where drivers should stop. The marking consists of a single continuous line: 500 mm wide with the accompanying STOP legend (marking M201). The STOP legend should be located so that the top edge of the symbol is between 2 m and 3 m from the nearest part of the STOP line, as detailed in **Figure 17-12**.

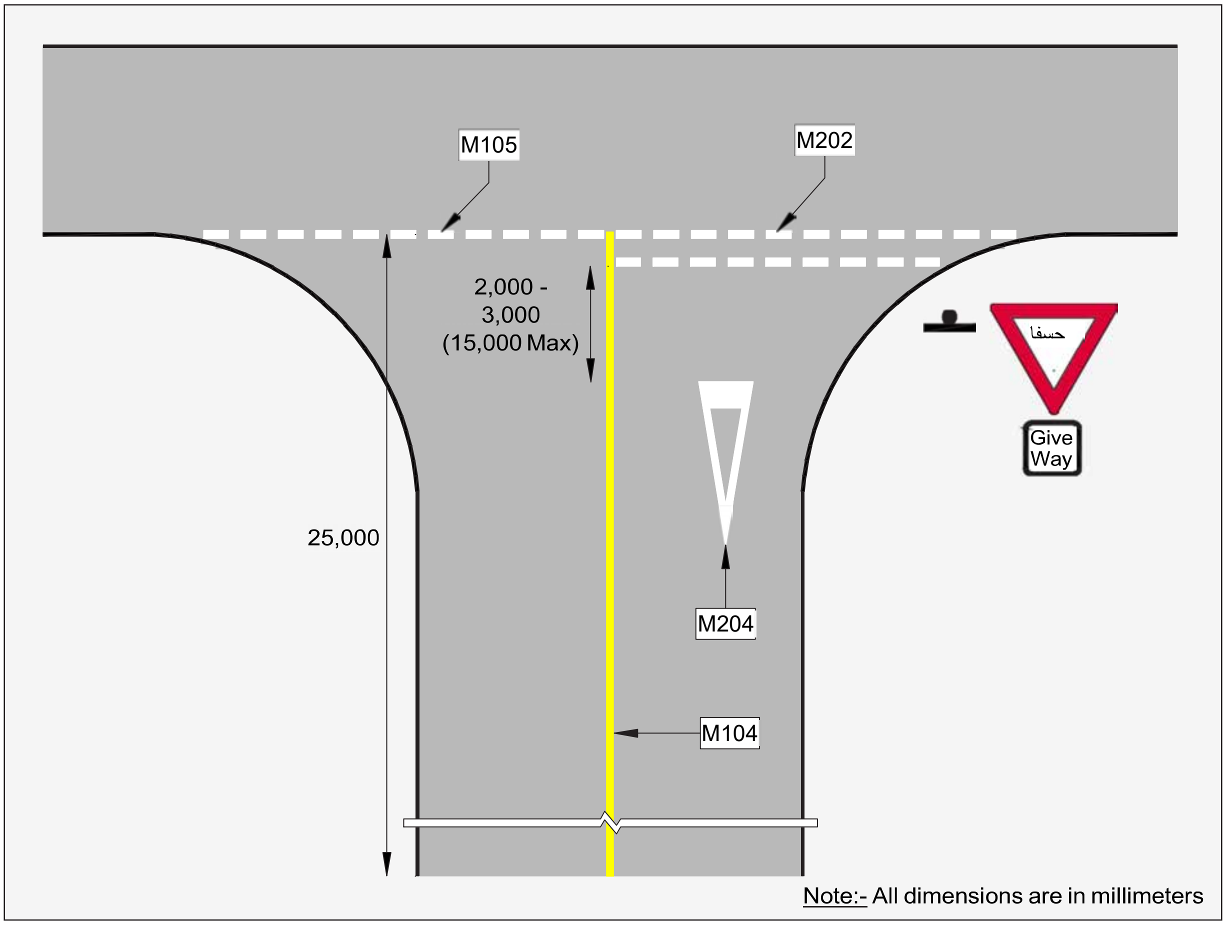


SOURCE: QTCM, Volume 2, Part 6, Section 3.1.1, Intersection STOP Lines.

Figure 17-12 Typical Priority STOP Intersection Layout

17.5.6 GIVE WAY/Yield Lines

Marking M202 should be used at priority intersections controlled by sign R101 (GIVE WAY) to indicate where drivers should yield to vehicles on the major roadway. Marking M202 should be accompanied by marking M204 (GIVE WAY triangle). Marking M202 consists of two parallel broken lines, each comprising 600 mm marks and 300 mm gaps. The lines are 200 mm wide and are spaced 300 mm apart. Marking M202 is used at the junction of the minor roadway; its position in relation to the edge of the major roadway is shown in **Figure 17-13**.

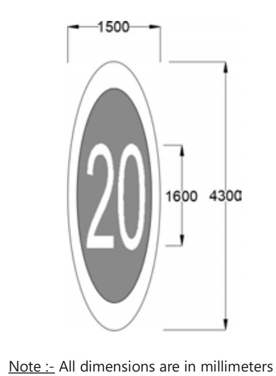


SOURCE: QTCM, Volume 2, Part 6, Section 3.1.3, GIVE WAY/Yield Lines.

Figure 17-13 Typical GIVE WAY Layout

17.5.7 Marking M600

An indication of the posted speed may be placed on the roadway using marking M600. Marking M600 may be used either at a change in posted speed or as a repeater. Marking M600 must only be used in conjunction with Sign R148. Marking M600 may be varied to show the posted speed in force and elongated in the direction of travel to compensate for the foreshortening effect.



M600

17.6 New Signs and Pavement Markings

Parking guidelines require the usage of several signage and pavement markings that are related to parking. The QTCM includes most of the required signs and pavement markings. The combination of some individual signs in the QTCM applies to several specific requirements. To address additional parking signage and marking requirements, new signs and markings are proposed. International Best Practices have been used in the development of new signs and markings. The layout of proposed new signs are presented in **Table 17-2** and proposed new markings are presented in **Table 17-3**. The specification of each sign and marking (type, size, and color), type of arrow, background color, and borders should align with the latest QTCM. Variable information, time, fee, and day are shown in the signs in **Table 17-2** and are only placeholders. These must be appropriately edited according to the specific requirements.

Table 17-2 New Signs Proposed

Sign Name	Information Sign	Mandatory / Regulatory Sign	Remarks
No Parking at Mosques			These signs are to be used at the parking spaces near the mosques.
Reserved Parking for VIP			These signs are to be used for different occasions of reserved parking. The signs provided are typical and should be used for reserved parking for senior citizens, visitors and carpools.
Family Parking			This sign indicates that the parking stall(s) is reserved for parking vehicles containing family. These shall be suitably located and easily visible in a parking aisle, circulation aisle, or roadway, and easy to reach.
Ladies' Parking			This sign indicates that the parking stall(s) is reserved for ladies only. These must be suitably located and easily visible in a parking aisle, circulation aisle, or roadway, and easy to reach.

(table continued in next page)

Table 17-2 New Signs Proposed (continued)

Sign Name	Information Sign	Mandatory / Regulatory Sign	Remarks
Expectant Mothers' Parking			This sign indicates that the parking stall(s) is reserved for parking for expectant mothers' vehicles. These must be suitably located and easily visible in a parking aisle, circulation aisle, or roadway, and easy to reach.
Electric Vehicle Parking			These signs are reserved for parking electric vehicles. The sign in green denotes the charging point. The sign on the top reserves parking for electric vehicles. The bottom sign in green background denotes availability of a charging point.

(table continued in next page)

Table 17-2 New Signs Proposed (continued)

Sign Name	Information Sign	Mandatory / Regulatory Sign	Remarks
Direction to Elevator and Escalators			These signs are for providing information on elevator and escalator. These signs are used to indicate elevators, stairs, directions to facilities being served by the parking facility, disabled user facilities, and the like. Where there are no standard symbols for the message to be conveyed, words must be used.
Parking bay identification	 		These signs are used to mark parking bays or modules, which act as a reminder of parking location. The numbering of modules must be arranged in a logical progression and visible to users walking or driving through the parking facility. Follow a parking zoning system and align the numbering system accordingly. It is helpful to use color coding or symbol location signs to indicate the different levels or areas in a parking structure or large parking lot to assist drivers with locating vehicles.

(table continued in next page)

Table 17-2 New Signs Proposed (continued)

Sign Name	Information Sign	Mandatory / Regulatory Sign	Remarks
Parking bay identification direction	 		These signs provide information to the driver on the location of particular parking bays, modules, or zones. This enables the driver to reach the exact location for retrieval of the parked vehicle.
Way out			This sign indicates the route the driver must take to exit the parking facility. A direction name is added at any location where there is a choice of routes leading to different exits. Way-out signs must be located so that they are readily visible to a driver in a parking aisle, circulation aisle or roadway.
Wayfinding sign			A combined sign for multiple uses. This sign is to be used only under specific situations where wayfinding for multiple users are to be accommodated in a single sign.

(table continued in next page)

Table 17-2 New Signs Proposed (continued)

Sign Name	Information Sign	Mandatory / Regulatory Sign	Remarks
Signs related to payment at parking lot	  		This sign provides information on the location of a parking fee payment machine. The two bottom signs provide information regarding payment at a parking lot. • The sign "payment at exit" is to be used where payment is possible at the exit. • The sign "no payment at exit" is to alert the user that payment cannot be made at the exit and should be done at the machine.
Parking Durations			These signs are related to permit parking. The signs provide information on the time and day for restricted parking, as well as the zone for which the exception is permitted.

(table continued in next page)

Table 17-2 New Signs Proposed (continued)

Sign Name	Information Sign	Mandatory / Regulatory Sign	Remarks
Parking Rates			This sign provides information on the parking fee.
Parking and Pay Zone			This sign specifies the applicability of the parking fee at an identified time.
Resident Permit Zone			This sign is for permit parking.

(table continued in next page)

Table 17-2 New Signs Proposed (continued)

Sign Name	Information Sign	Mandatory / Regulatory Sign	Remarks
Buffer Zone			This sign is for the parking of residents with parking permit license and it provides information on restricted parking to non-residents.
Paid Parking			This sign presents information related to paid parking including time restrictions and mode of payment. This sign can be customized based on the specific needs.
Restricted Parking for special/specified use			This sign is for restricted parking. The sign shown can also be used for situations such as valet parking and taxis.

(table continued in next page)

Table 17-2 New Signs Proposed (continued)

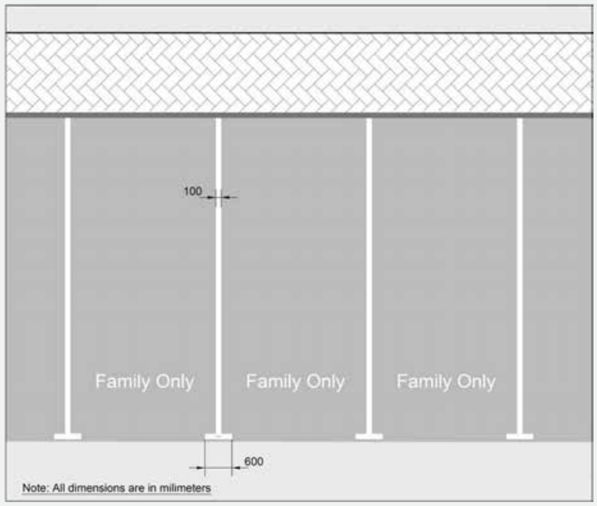
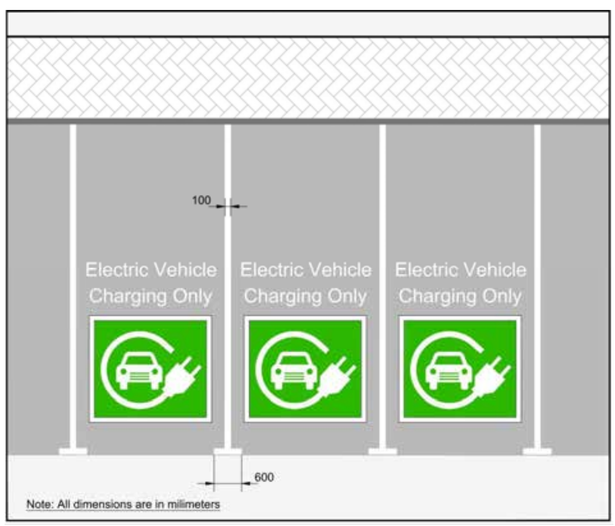
Sign Name	Information Sign	Mandatory / Regulatory Sign	Remarks
Controlled Zone Parking			This sign denotes the controlled parking zone.
Controlled Zone Ends			This sign denotes the end of controlled parking zone.
Parking for Resident Permit			This sign combination provides information on tow away and its applicability.

(table continued in next page)

Table 17-2 New Signs Proposed (continued)

Sign Name	Information Sign	Mandatory / Regulatory Sign	Remarks
CCTV Surveillance			This sign alerts the user about CCTV monitoring.
Fire Extinguisher			This sign is to be used at the location where a fire extinguisher is placed. This sign must be clearly visible. The fire extinguisher must be placed at easily accessible locations.
Fire Exit			This sign is to direct the pedestrians to the escape route in the event of fire.
Emergency Intercom			This sign is for locating the emergency intercom in a facility.
Pedestrian Escape Route			This sign directs the pedestrian to the escape route in an emergency situation.

Table 17-3 New Pavement Markings Proposed

Additional Marking	Marking Details	Remarks
Reserved parking		This marking is for parking stalls reserved for family parking. Similar markings must be used for other reserved parking such as VIP, elderly, ladies only, expectant mothers and carpools.
Parking for Electric Vehicle - Marking		The marking is for parking stalls reserved for electric vehicles.

(table continued in next page)

Table 17-3 New Pavement Markings Proposed (continued)

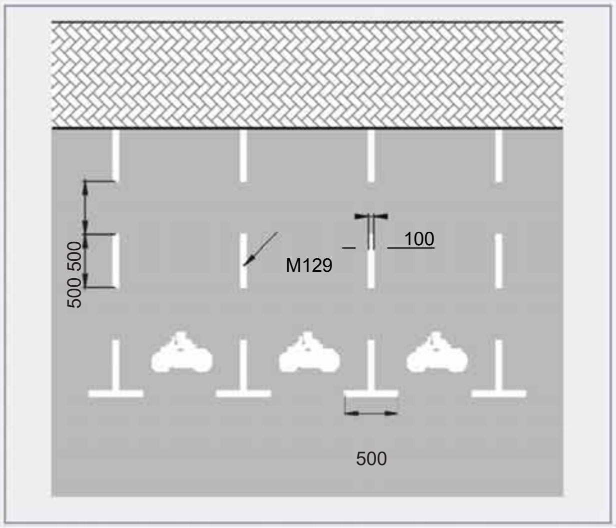
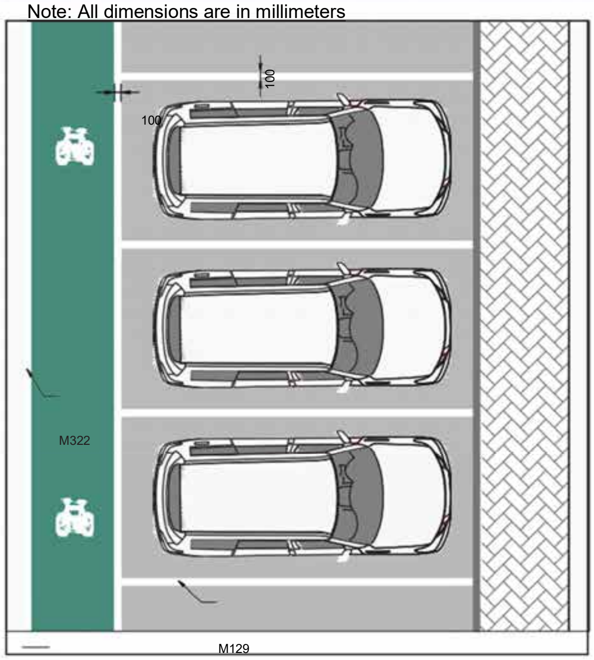
Additional Marking	Marking Details	Remarks
Powered Two-Wheeler Parking	 Note: All dimensions are in millimeters	This marking is for dedicated powered two-wheeler parking.
Bicycle Path	 Note:- All dimensions are in millimeters	This marking defines the bicycle path within the parking facility.

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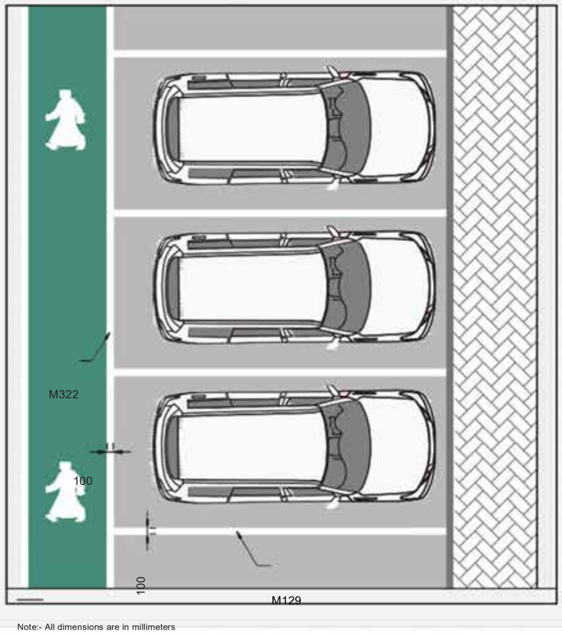
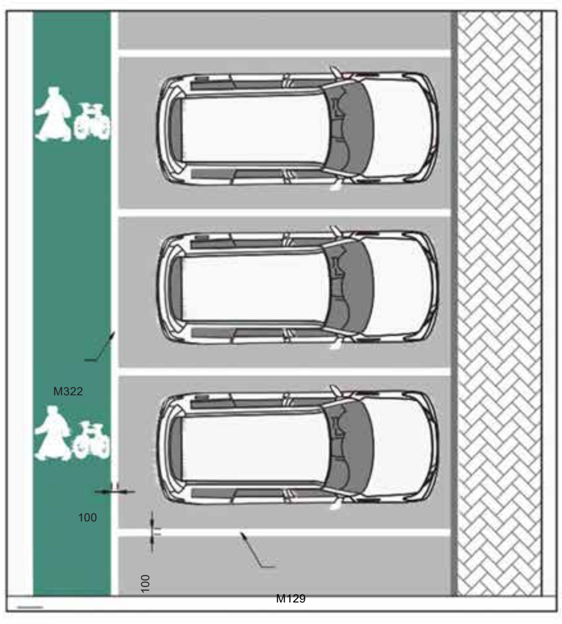
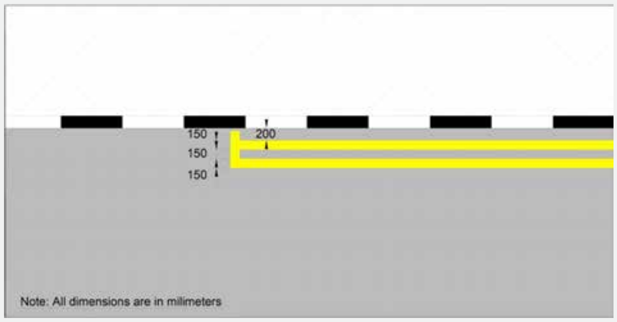
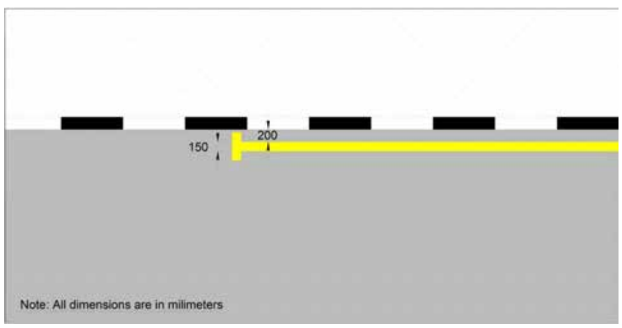
Table 17-3 New Pavement Markings Proposed (continued)

Additional Marking	Marking Details	Remarks
Pedestrian Paths in Parking Layout		This marking defines the pedestrian path within the parking facility.
Shared use paths in Parking Layout		This marking defines the path shared by bicycles and pedestrians within the parking facility.

(table continued in next page)

Table 17-3 New Pavement Markings Proposed (continued)

Additional Marking	Marking Details	Remarks
Double Yellow line at the pavement edge.		Double yellow continuous lines at pavement edge should be adopted to notify no parking and no stopping at any point in time. These lines should be adopted at on-street locations where parking and stopping is prohibited at all times and should be accompanied by supporting signage.
Single Yellow line at the pavement edge.		Single yellow continuous lines at the pavement edge should be adopted at all locations where time restrictions of less than 24 hours apply on parking such as drop off limits. This should be accompanied by supporting signage.

17.7 Additional Guidance

Refer to the QTCM, which provides guidelines for the design and use of appropriate signage and pavement markings.

Section 18

Intelligent Parking Management Systems

18: Intelligent Parking Management Systems

Intelligent Parking Management Systems (IPMS), or smart parking solutions, are advanced and innovative applications of integrated computer technology that enables parking operators to manage parking more efficiently and results in a better user experience. An IPMS is typically a combination of the following:

1. An access control system and security system
2. Vehicle detection, identification, and guidance systems that may include intelligent transportation systems (ITS) components, such as dynamic message signs (DMS) and license plate recognition (LPR)
3. Parking management software that integrates all parking systems and provides front- and back-office operations support inclusive of, but not limited, to revenue management and statistical information

While designing the IPMS for specific parking zones, parking lots, garages, or parking facilities, the designer should specify the combination of parking systems included in the design. The number, size, and strategic location of parking system devices should follow a holistic approach, achieving seamless integration between all components or systems of the IPMS.

Based on the ITS Master Plan 2014–2020, prepared by Ashghal in 2013–2014 (but not published officially), the following are the high-level goals of an IPMS:

- **Informative:** easy to use, user-friendly, and providing a better view of the transportation network and parking conditions to service providers and operators
- **Intelligent:** provides rapid, accurate, and efficient use of the available data, enabling improved functionality and performance of the transportation network for operators and users as well as business intelligence for continuous improvement
- **Integrated:** offers transportation choices for users across all modes and furnishes scalable and sustainable solutions to operators and service providers

The IPMS helps drivers locate and navigate to a vacant parking space as well as find a parked car in a timely manner. It also reduces the time spent searching for a parking space, resulting in a reduction in carbon emissions and traffic congestion. Parking space booking and payment process is also a functionality in many applications. Reliable smart parking combined with real-time data and local turn-by-turn guidance reduces search traffic and vehicle emissions. The IPMS uses technology and innovation in an effort to use as few resources as possible such as fuel, time, and space to achieve faster, easier and denser parking of vehicles.

The designer should follow the standard systems engineering process (flow-staged approach) to design an IPMS for a new parking facility. The design may vary based on the specific requirements of the parking facility.

A project-specific concept of operations, setting the objectives, functions, and key performance indicators (including financial performance) are recommended to be followed by a preliminary design (device selection, size, and location) and simulated under various scenarios anticipated in the concept of the operations. If the key performance indicators are achieved, the design can advance toward the detailed design and implementation stages.

18.1 Design Considerations

The designer should, at a minimum, consider hardware and software requirements, as mentioned in the following sections, during the design stage of the IPMS for on-street and off-street parking. The following principles should be considered:

- **Modular design:** Parking facility systems, wherever practicably possible, should have a modular design (subdividing the system into smaller parts called modules based on their functional and non-functional requirements), so that they can be expanded and configured to suit the needs of the Overseeing Authority and that of the parking owner and/or service provider.
- **Upgrade capability:** Parking facility systems should be designed such that continual upgrades can be implemented to replace components that reach end-of-life and/or update with technology, such as “chip and PIN” and “wave and pay.”
- **Standardized integration:** The facility systems should respect the defined demarcation and follow the standard communication protocol to allow seamless connectivity between parking facilities and the Parking Management Information System.

The following should be considered while incorporating the ITS technology in a parking design:

1. Technology should maximize user convenience and offer an enhanced experience to achieve higher occupancy, while minimizing and/or preventing congestion and queuing to support increased revenue.
2. Technology should improve the manner of reporting to reduce revenue loss and also help in the prevention of fraudulent activities.
3. Automating revenue collection should reduce or eliminate human handling of cash to minimize loss and fraud.
4. Technology should help in the increase of occupancy. Computerized signage is a powerful marketing tool, especially for variable pricing information.

Parking facility technology integration with other systems should enhance security, safety, and performance through technological advancements, such as access control, CCTV, intercom help points, and public road ITS.

18.2 Parking Management

Technology should be considered in relation to the overall goals of a parking management strategy. **Table 18-1** summarizes the methods by which technology can be used to meet the parking management goals.

Table 18-1 Technology Parking Management Goals

Technology	Parking Management Goals	Main Desired Outcomes	Supported Strategy
Detection and Monitoring	ITS devices for on-road detection and monitoring: Sensor-based: • Magnetometers • Inductive Loops • Radar, laser Video-based: • CCTV • LPR • Automatic Incident Detection (AID) Sound parking design should include a selection of devices that best suit the parking site conditions and are located strategically to enable successful real-time assessment of traffic conditions at street access/exit points. It should enable the ITS operator to detect traffic situations and assess them with remote video. LPR and AID may be used as potential enhancements to traffic management as needed, providing enhanced support to violations and incident management, as well as, in evidence collection.	• Parking ITS systems are to be provided for new facilities compatible with the city-wide ITS strategy to manage spaces. • Implementation of the ITS components of a roadway traffic regulation enforcement program is required. • Real-time traffic conditions assessment. • Enhanced support of violations and incident management to be provided.	**Strategy No. 111/ITS-1** Ensure that parking ITS systems are provided for new facilities compatible with the citywide ITS strategy and to manage spaces. **Strategy No. 114/ITS-4** Implement ITS components of a roadway operations program. **Strategy No. 118/ITS-8** Develop and implement the ITS components of a Parking Management Program. **Strategy No. 122/ITS-12** Implement the ITS components of a Roadway Traffic Regulation Enforcement program. **Strategy No. 127/ITS-17** Implement an integrated parking management and technology program. **Strategy No. 129/ITS-19** Adopt an automatic number plate recognition (ANPR) system.

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Table 18-1 Technology Parking Management Goals (continued)

Technology	Parking Management Goals	Main Desired Outcomes	Supported Strategy
Parking Information and Driver Guidance	• Driver information and navigation systems include: • Citywide signs directing drivers to the nearest available parking • Variable message signs providing drivers with parking information • Parking applications and software solutions supported by telecommunications and parking occupancy detection systems that provide guidance to the driver to the nearest parking lot with available space via a navigation or a mobile device • Parking for connected autonomous vehicles (CAV) and autonomous valet parking or assisted parking system (APS) • Parking design should include the deployment of parking guidance signs and variable message signs at strategic locations to minimize congestion and allow for standardized navigation information to be shared with CAVs.	• Implement an integrated multimodal traveler and parking information system • Support the connected vehicle program • Implement an integrated parking management and telematics-parking guidance system • Minimize congestion • Standardize navigation information	**Strategy No. 116/ITS-6** Develop and implement an Integrated Multimodal Traveler and Parking Information system **Strategy No. 121/ITS-11** Develop and implement a Connected Vehicle Program **Strategy No. 123/ITS-13** Implement an integrated Parking Management and Telematics-Parking Guidance System **Strategy No. 128/ITS-18** Use of technology to manage public parking provision for private developments

(table continued in next page)

Table 18-1 Technology Parking Management Goals (continued)

Technology	Parking Management Goals	Main Desired Outcomes	Supported Strategy
Integration and Traffic Control (see **Figure 18-1** for reference)	• Connectivity to the wider traffic management systems (traffic control center) • Traffic control through DMS and Lane Control Signs (LCS) 》 DMS provides the driver with traffic information before exiting the road and entering the parking facility. 》 LCS redirects drivers to the appropriate exit to avoid roadway congestion after exiting the facility. • DMS and LCS should be operated in conjunction with the parking occupancy and urban roads congestion information via a parking application and CCTV to determine the appropriate settings and messages that maximize safety and eliminate or mitigate congestion. • DMS and LCS should be strategically located to maximize support of efficient mobility.	• Integrates with National Transportation Management Center • Supports the Connected Vehicle Program • Supports an integrated parking management and telematics-strategic road control • Reduces congestion • Standardizes navigation information	**Strategy No. 113/ITS-3** Develop, implement, and operate a National Transportation Management Center **Strategy No. 118/ITS-8** Develop and implement the ITS components of a Parking Management Program **Strategy No. 121/ITS-11** Develop and implement a Connected Vehicle Program **Strategy No. 124/ITS-14** Implement an integrated Parking Management and Telematics-Strategic Road Control **Strategy No. 125/ITS-15** Implement an Integrated Parking Management and Telematics-Management of the Available Space in a Specific Zone **Strategy No. 127/ITS-17** Implement an integrated parking management and technology program

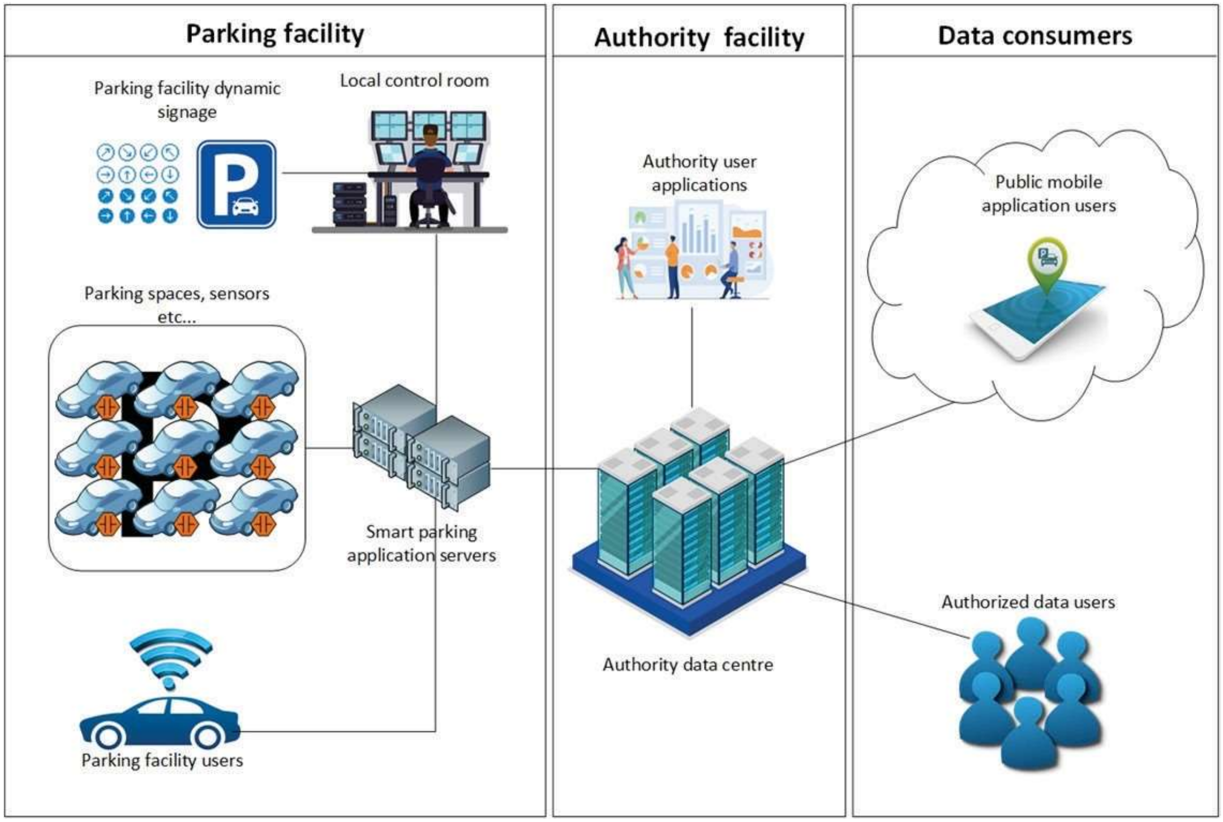


Figure 18-1 Typical Parking Control System

18.3 Integration

There is an interconnection between the standard ITS and parking facility management functional modules. Both systems share modules related to sensing and measuring traffic volume, volume data processing, archiving control (payment system), and user information.

The integration should consider the key elements summarized in **Table 18-2**.

Table 18-2 Integrating IPMS with Other Systems

Key Elements		Supported Strategy
Demarcation	• Parking management systems design should manage traffic inside the parking area only. • Parking management systems design should only deliver driver information and traffic monitoring in their area of influence. Management of traffic operations outside the parking area is covered by ITS and managed by the road traffic authority.	**Strategy No. 111/ITS-1** Ensure parking ITS systems are provided for new facilities compatible with the citywide ITS strategy and to manage parking spaces **Strategy No. 113/ITS-3** Develop, implement, and operate a National Transportation Management Center **Strategy No. 114/ITS-4** Implement ITS components of a Roadway Operations Program **Strategy No. 118/ITS-8** Develop and implement the ITS components of a Parking Management Program **Strategy No. 123/ITS-13** Implement an Integrated Parking Management and Telematics-Parking Guidance System **Strategy No. 124/ITS-14** Implement an Integrated Parking Management and Telematics-Strategic Road Control **Strategy No. 125/ITS-15** Implement an Integrated Parking Management and Telematics-Management of the Available Space in a Specific Zone **Strategy No. 126/ITS-16** Implement an Integrated Parking Management and Telematics-Operational Control of Parking Facilities **Strategy No. 127/ITS-17** Implement an Integrated Parking Management and Technology Program **Strategy No. 128/ITS-18** Use of technology to manage public parking provision for private developments

(table continued in next page)

Table 18-2 Integrating IPMS with Other Systems (continued)

Key Elements		Supported Strategy
Data Exchange and Communication	• Parking design should address all connectivity needs to manage parking operations and use all equipment deployed for such purpose within the parking area/ facility. Parking design should also address potential future communication needs for CAVs. • Parking design for facilities with autonomous valet parking or APS should address specific connectivity needs for such systems. • The designer should refer to ISO 16787:2017(International Organization for Standardization) to better understand what is required for a parking facility for CAVs. This standard includes rules for the general information strategy and does not restrict the information type or display system. • The designer should coordinate with the Overseeing Authority to define the appropriate design approach to interconnect the parking management system with external services like the parking application. Strict network security policies should be observed at all times. • The communications protocol should support all features that are desired for the operation of the equipment. Compliance with the National Communications Protocol for ITS (NTCIP) is required where practical.	**Strategy No. 111/ITS-1** Ensure parking ITS systems are provided for new facilities compatible with the citywide ITS strategy and to manage spaces **Strategy No. 113/ITS-3** Develop, implement, and operate a National Transportation Management Center **Strategy No. 114/ITS-4** Implement ITS components of a Roadway Operations Program **Strategy No. 116/ITS-6** Develop and implement an Integrated Multimodal Traveler and Parking Information System **Strategy No. 117/ITS-7** Implement an integrated payment mechanism for the transportation network **Strategy No. 121/ITS-11** Develop and implement a Connected Vehicle Program **Strategy No. 122/ITS-12** Implement the ITS components of a Roadway Traffic Regulation Enforcement Program **Strategy No. 123/ITS-13** Implement an integrated Parking Management and Telematics-Parking Guidance System **Strategy No. 124/ITS-14** Implement an integrated Parking Management and Telematics-Strategic Road Control **Strategy No. 125/ITS-15** Implement an Integrated Parking Management and Telematics-Management of the Available Space in a Specific Zone **Strategy No. 126/ITS-16** Implement an Integrated Parking Management and Telematics-Operational Control of Parking Facilities **Strategy No. 127/ITS-17** Implement an integrated parking management and technology program

The interface between the IPMS and smart parking application is an open-source application programming interface (API). The API is available to parking owners to program the interface and allow the exchange of information between their parking management system software and parking application software, as illustrated in **Figure 18-2**.

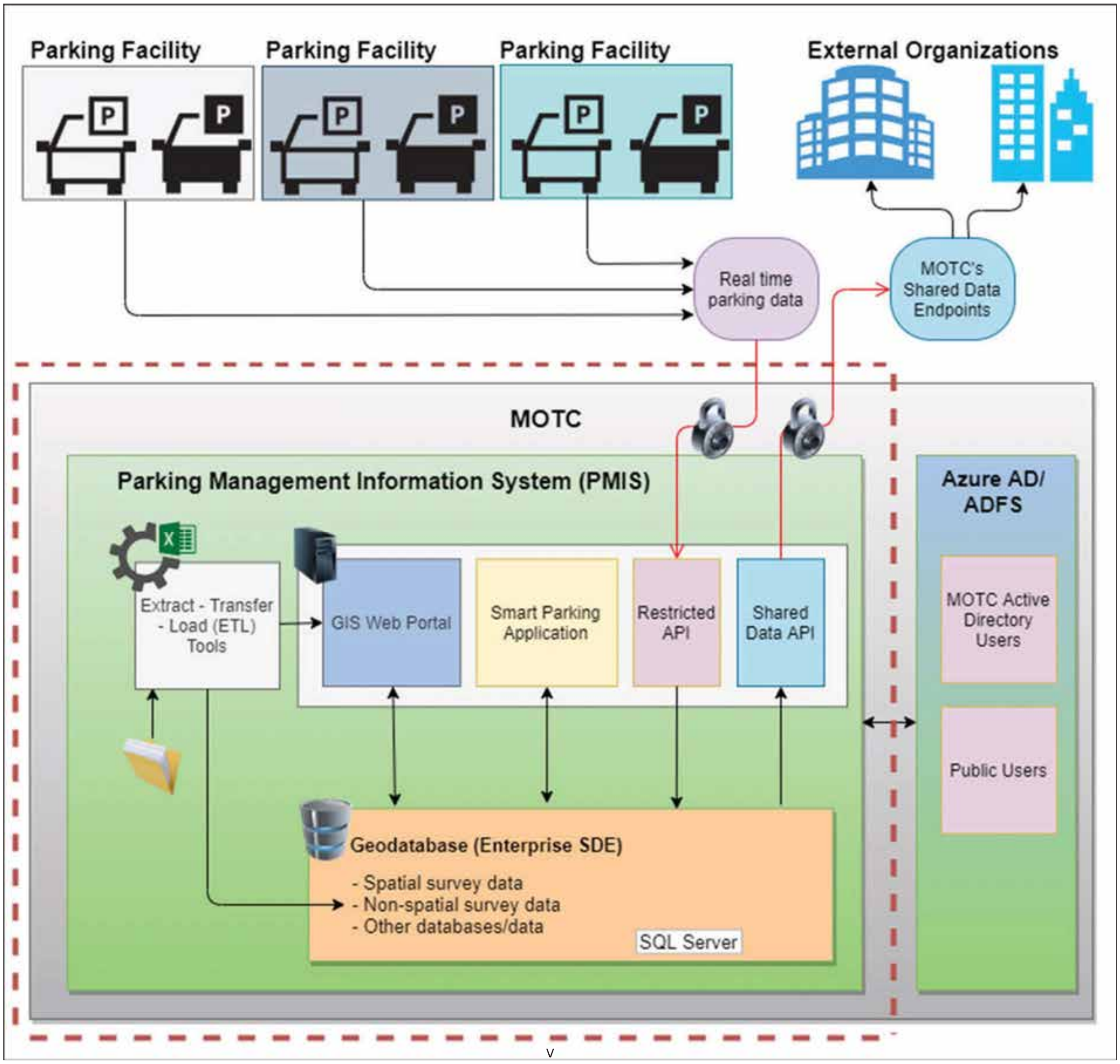


Figure 18-2 IPMS and API Interface

The API has been designed to meet the minimum requirements for parking information exchange. The minimal attribute requirements associated with parking space include, but are not limited to, the following:

1. Number of parking slots (available and occupied)
2. Available parking slots (free and booked/reserved)
3. Free parking slots (available and not booked/reserved)
4. Occupied parking slots (opposite of available)

The parking owner and/or the API programmer selected by the parking owner should consult with the Overseeing Authority regarding any up-to-date requirements, before starting the integration preparation work.

18.4 Design Requirements

The requirements listed herein are provided for a generic design guidance. The type of system used should be project-specific and identified in the design project drawings. Additional information on each system can be found in Ashghal's ITS Specifications, ITS Deployment Manual, Civil and Structural Standards for ITS, and ITS Telecommunications Strategy. Designers and contractors are responsible for achieving full compliance with the above standards in their latest editions at the time of design.

The designer should observe the recommendations in Ashghal's ITS Deployment Manual regarding detector technology options and detector-type advantages and disadvantages.

18.4.1 Detection and Monitoring

The requirements and considerations for detection and monitoring equipment are listed in **Table 18-3**.

Table 18-3 Detection and Monitoring Equipment Requirements

Equipment	Requirements
Sensor-based Detection and Monitoring	The criteria contained in this manual should be considered while designing a new Traffic Detection and Monitoring Systems (TDMS). It is important to note/clarify that there may be instances where all the criteria in these guidelines cannot be met. Justification for installation, despite not being able to meet all criteria, should be outlined by the designer and presented to the Overseeing Authority for review or approval. The goal of this process is to provide practitioners with overall guidance as well as consistency with respect to the TDMS installations. Primary considerations for the placement of suitable detection technologies are: • Spacing and Lane Coverage: In some instances, the interval spacing may be larger or smaller depending on the roadway layout and location. The quantity and frequency of detectors determine the spatial granularity with which data can be captured for incident detection, congestion measurement, etc. It is important that detector spacing remain consistent on a given roadway segment to maintain the same granularity. In general terms, all travel lanes should be covered by the detector(s) at each detection point. • Cost: Choose detection extent based on requirements for accurate information, including detector types, locations, and communication methods that optimize the overall cost of the system. Co-location of detectors on existing structures (e.g., CCTV poles), where possible, can help minimize the need for new structures, provided the detector spacing remains consistent for that section of road. • Accessibility: The device for maintenance and repair purposes is important, especially when many devices are required for a system. Inaccessible devices or devices embedded in pavement lead to higher costs and the potential need to close lanes to perform maintenance, increasing the potential for traffic operations disruption.

(table continued in next page)

Table 18-3 Detection and Monitoring Equipment Requirements (continued)

Equipment	Requirements
Sensor-Based Detection and Monitoring (continued)	• Comprehensive Data Capabilities: For incident detection and congestion, measurement speed, volume, and occupancy are typically required. • Accuracy: Speed data (where collected) must be accurate within a range of approximately 5 kph. Expected minimum aggregated accuracy levels should be approximately 90% for volume, 90% for occupancy, and 90% for speed for all lanes within a defined detection area or extent. • Location Precision: It is secondary to detector spacing, provided the integrity of the detector spacing, remains intact. For example, detection position variations of 1 to 2 m are irrelevant in terms of detector overall position in a 6 km scheme. Exact detector spacing is a function of the scheme and data collection technology to be used. The result of the design process should positively answer the following questions: • Predesign Planning › Is this deployment consistent with the needs outlined in the concept of operations? › Is this deployment consistent with the ITS architecture? › Does this deployment fit within the context of either an expressway, a local road, or a parking project? • System Requirements › Does the detector deployment satisfy the precision, spacing, and accessibility considerations established in the system needs? › Is the detector the correct type for the situation (e.g., do not use intrusive detectors on bridge decks)? • Detector Technology Selection • Deployment Guidelines › Does the detector technology satisfy the safety, accuracy, accessibility, and constructability established in the system needs? › Does the detector installation minimize new structures and co-locate devices, where possible? › Does the detector installation include sufficient detector coverage to satisfy functional needs? › Is the detection installed to ensure correct lane identification and spaced within a reasonable distance for an expressway network and on each relevant entry and exit ramp? › Is detection on a managed roadway installed at regular intervals in every lane for incident and speed/volume detection purposes? › Does the installation ensure that detection for every approach at signalized intersections is in place? › Has detection been designed for every entry or exit to major traffic-generating venues and public car parking facilities?

(table continued in next page)

Table 18-3 Detection and Monitoring Equipment Requirements (continued)

Equipment	Requirements
Sensor-Based Detection and Monitoring (continued)	• Communication 〉 Have the communication requirements for the detector type and subsystem been determined? 〉 Has an appropriate communication source been located and confirmed within reasonable proximity to the site? 〉 If there are multiple communication options, have the pros or cons been studied? 〉 While using public communications infrastructure, has service been coordinated with Ashghal? 〉 Is the communication protocol consistent with what can be supported by the Road Management Centre (RMC) Master Software? • Environmental 〉 Have all the necessary environmental, community, and cultural impact studies, processes, and concerns been addressed? 〉 Are the enclosures or any other infrastructure within or located next to any form of irrigation or watering system? 〉 What seasonal issues would impact performance (e.g., summer or higher than usual temperatures impact on material expansion)?

(table continued in next page)

Table 18-3 Detection and Monitoring Equipment Requirements (continued)

Equipment	Requirements
Video-Based Detection and Monitoring	When designing a video-based detection and monitoring system, the designer for parking projects should make every effort to follow the guidelines described above, as well as, the following: • The preference for the use of Fixed Point of View (FPOV) CCTV cameras for Video Image Video Detection Systems (VIVDS) is based on international experience, where the use of pan–tilt–zoom cameras (PTZ cameras) resulted in incorrect readings and or usage. PTZ cameras do not return to the exact home position following use either automatically or manually, given that the stepper motors are unable to track the exact previous position. This results in image drift, which can be a significant problem for VIVDS and is the reason for most mainstream manufacturers to specify FPOV. • Black and white camera systems for function detector structure: The designer should consider the availability of structures and the geographical location, when determining camera placement. The recommendation is that they should be located on existing structures; if co-location is not possible because of spacing or other system needs, new overhead structures must be constructed. Traffic signal mast arms are not a preferred structure for mounting video-based image detection system cameras in the State of Qatar due to excessive movement under windy conditions. • Detector vertical clearance and quantity should determine the number of lanes that a video image video detection system camera can monitor simultaneously. • Configure detection zones: Each detection zone must be defined, such that only vehicles within the detected lane, cross the zone.
LPR and AID	When designing LPR and AID detection and monitoring systems, the designer for parking projects should try to follow the guidelines described above and the following: • Conduct an Optical Character Recognition (OCR) engine training. • Hard shoulders should be considered by designers and incorporated into gantry design at the time of design or for future use.

18.4.2 Driver Information

The main requirements for driver information equipment are listed in **Table 18-4**.

Table 18-4 Driver Information Equipment Requirements

Equipment	Requirements
DMS	The primary function of a DMS is to provide information to driver/traveler. The nature of this information is varied, but the goal is to disseminate roadway condition information to travelers, so that they can make informed decisions, regarding their trip and/or route. The following list is intended to be a high-level guide to assist ITS practitioners with the many criteria associated with DMS design. The criteria contained in this manual should be followed during DMS design. It is important to note/clarify that there may be instances where all criteria cannot be met. Justification for deciding to proceed with the installation, despite not being able to meet all criteria, should be detailed by the designer and approved by the Overseeing Authority. The goal of this process is to provide practitioners with guidance, as well as to provide consistency with respect to the DMS installations. • Predesign Planning › Is this deployment consistent with the needs outlined in a concept of operations? › Is this deployment consistent with the ITS architecture? • Longitudinal Placement › Is the DMS visible and unobscured? › Is the DMS placed sufficiently in advance of any interchanges that would be used for diversion? › Is the DMS properly spaced away from existing guide signs? › Is the DMS placed to reduce glare/visibility issues from rising/setting sun? • Lateral Placement › Is the DMS structure located beyond the clear zone or protected by a suitable safety barrier? › Has the lateral offset of the DMS been accounted for while calculating the length of the reading and decision zone? › Is the DMS structure outside the horizontal clearance for roads and parking defined by QPDM/QHDM? • Vertical Placement › Is the approaching segment of roadway relatively flat (between 0 to 4% vertical grade)? › Is the DMS structure outside the vertical clearance for roads and parking defined by QPDM/QHDM? • Sign Matrix Type › Has a sign matrix type that is consistent with the visibility and message requirements of the roadway been selected? • Sign Viewing Angle › Has a sign viewing angle that complements the roadway alignment and the DMS structure been chosen? • Sign Access › Are there any traffic, environmental, or safety factors that warrant a specific type of sign access?

Table 18-4 Driver Information Equipment Requirements (continued)

Equipment	Requirements
DMS (continued)	• Structure ❩ Have visibility, road speed/volume, right-of-way, and maintenance been considered when selecting the type of sign structure? ❩ Is there sufficient vertical clearance for the sign and the structure? ❩ Has the structure been designed for the sign? If not, then a report from a structural engineer is required. • Communication ❩ Have the communication requirements for the DMS been determined? ❩ Has an appropriate communication infrastructure been located and confirmed within reasonable proximity to the site? ❩ If there are multiple communication options, have the pros/cons been studied? ❩ If using public communications infrastructure, has service been coordinated with Ashghal?
LCS	The primary function of the lane control signs (LCS) is to maximize safety. Secondary benefits are better driver education and enforce correct lane use behavior, as well as improve roadway capacity. LCS are dynamic road traffic signs with a relatively small dimension. The following list is intended to be a high-level guidance to assist ITS practitioners with the many criteria associated with an LCS design. The criteria contained in this manual should be followed while designing a new LCS. It is important to note/clarify that there will be instances where all of the criteria in these guidelines cannot be met. The designer should detail the justification for selecting an LCS design, despite not being able to meet all criteria of the designer and approved by the Overseeing Authority. The goal of this process is to provide practitioners with guidance, as well as to provide consistency in DMS installations. • Predesign Planning ❩ Is this deployment consistent with needs outlined in the concept of operations? ❩ Is this deployment consistent with the ITS architecture? • Longitudinal Placement? ❩ Is the LCS visible and unobscured? ❩ Is the spacing between LCS appropriate to give drivers enough time to change lanes? • Vertical Placement ❩ Is the approaching segment of roadway relatively flat (between 0-4% vertical grade)? • Sign Matrix Type ❩ Has a sign matrix type that is consistent with the visibility and message requirements of the roadway been chosen?

(table continued in next page)

Table 18-4 Driver Information Equipment Requirements (continued)

Equipment	Requirements
	• Structure ❳ Have visibility, road speed/volume, right-of-way, and maintenance issues been considered while selecting a type of sign structure? ❳ Is there sufficient vertical clearance for the sign and the structure? ❳ Has the structure been approved for mounting LCS on it? • Communication ❳ Have the communication requirements for the LCS been determined? ❳ Has an appropriate communication infrastructure been located and confirmed within reasonable proximity to the site? ❳ If there are multiple communication options, have the pros/cons been studied? ❳ If using public communications infrastructure, has service been coordinated with Ashghal?

18.4.3 Enclosure and Power

The general requirements for enclosure and power equipment are listed in **Table 18-5**.

Table 18-5 Enclosure and Power Equipment Requirements

Equipment	**Requirements**
Enclosure	The following aspects should be studied and the respective questions answered in the design: • Need: Is an enclosure required at this location and what type should be used? Enclosure types for parking or local roads projects may vary from those specified in the national ITS strategy. • Location: Where is the enclosure located? • Standards for the State of Qatar are for expressways. Designers should check with Ashghal on enclosure selection before finalizing the design considerations. • Access: Can personnel safely access the enclosure? • Is the enclosure located within the manufacturer's recommended distance to the detector/LCS and DMS and is the system/sign visible from the enclosure? • Mounting: Is the enclosure mounted on an existing structure (where possible)? • Protection: Does the location and orientation provide adequate protection? • In some cases, enclosure poles and enclosures may need to be treated with a suitable anticorrosive paint or powder coating. • Maintainer's pad: Has a maintainer's pad been provided at the main door of the enclosure? (This may not be required in several circumstances, depending on the size and site of the enclosure).

(table continued in next page)

Table 18-5 Enclosure and Power Equipment Requirements (continued)

Equipment	Requirements
Power	The following aspects should be studied and the respective questions answered in the design: • Metering › Have metering options for power been determined? (This may present issues across parking, local roads, and expressways, and any liaison with Kahramaa, if required, needs to be prioritized as an urgent activity per scheme). › Have the power requirements for the LCS/DMS/detection system and all the system components been determined? • Availability › Has an appropriate power source been located and confirmed with the utility company within a reasonable distance from the LCS/DMS/detection site? › Have step-up/step-down transformer requirement calculations been performed? › Have the metering options been determined? • Conditioning › Have the uninterrupted power supply (UPS) and power backup requirements been determined and accounted for?

Section 19

Emerging Technologies and Sustainability

19: Emerging Technologies and Sustainability

19.1 Introduction

This section presents a few emerging technologies that promote sustainability, as well as sustainable solutions that can be adopted while designing and constructing parking facilities. Technology and developments in the automobile industry such as the formation of transportation network companies (TNC), electric vehicles and autonomous vehicles and their parking needs are discussed. For the purpose of this manual, sustainability primarily refers to the reduction of carbon emissions, increase in energy efficiency and use of recycled construction materials. Various sustainable solutions such as reduced carbon emission, increased energy efficiency, recycled construction materials, and increased parking density that can be accomplished while planning, designing, and constructing parking facilities are covered in this section.

19.2 Transportation Network Companies (TNC)

Car-hailing companies, collectively called Transportation Network Companies (TNC), use the same car fleet as private vehicle owners. In some countries, special areas are provided for TNC pick-up or drop-off of passengers. Seattle-Tacoma International Airport in Washington and San Jose International Airport in California, USA, are examples of such arrangements. The design of these areas is the same as that for other pick-up or drop-off areas in **Section 6.6.3**.

These TNC pick-up or drop-off areas should be considered in areas where pick-up and drop-off result in double-parking and blocking through traffic lanes, such as airports, shopping malls, hospitals, etc. All design guidelines, dimensions, and recommendations made in the QPDM for the respective vehicles are to be followed in consultation with the Overseeing Authority.

Efficient TNC operation is associated with appropriate wayfinding practices. Specific logos and names related to the TNC are included in the wayfinding signs or markings. Development of wayfinding signs and markings related to TNC is an exercise for the future when TNC starts functioning in Qatar in a large scale.

19.3 Online Shopping

Online shopping is a form of electronic commerce that allows consumers to directly buy goods from sellers over the Internet by using a web browser or a mobile application. The goods can either be delivered or picked up. The size of the delivery vehicle can vary, depending on the goods to be transported. For example, powered two-wheelers are used for food delivery and commercial vehicles are used for furniture. Appropriate parking space, both at the origin and destination, should be provided for these vehicles.

This is a private business parking and should be provided in an off-street parking facility only. For commercial vehicles, separate loading and unloading areas should be considered at locations where loading/unloading can cause double-parking and block through-traffic lanes. All design guidelines, dimensions, and recommendations made in the QPDM for the respective vehicles should be followed in consultation with the Overseeing Authority.

19.4 Electric Vehicle Parking

The number of electric vehicles (EVs) are increasing worldwide, and some countries have legislative mandates to promote the use of EVs. EV dimensions are similar to the Parking Design Vehicle (PDV). Parking stalls and aisles designed for the PDV should accommodate EVs, but electric charging stations will be needed.

The charging technology is fast evolving, hence, it is recommended that appropriate standards are followed in consultation with the Overseeing Authority. Most of the currently available chargers are wired, as shown in **Figure 19-1**. Wireless charging technology, as shown in **Figure 19-2**, is fast evolving and gaining popularity. “Electric Vehicle and Charging Infrastructure Guidelines in the State of Qatar” by Tarsheed and Kahramaa shall be referred to for specifications.

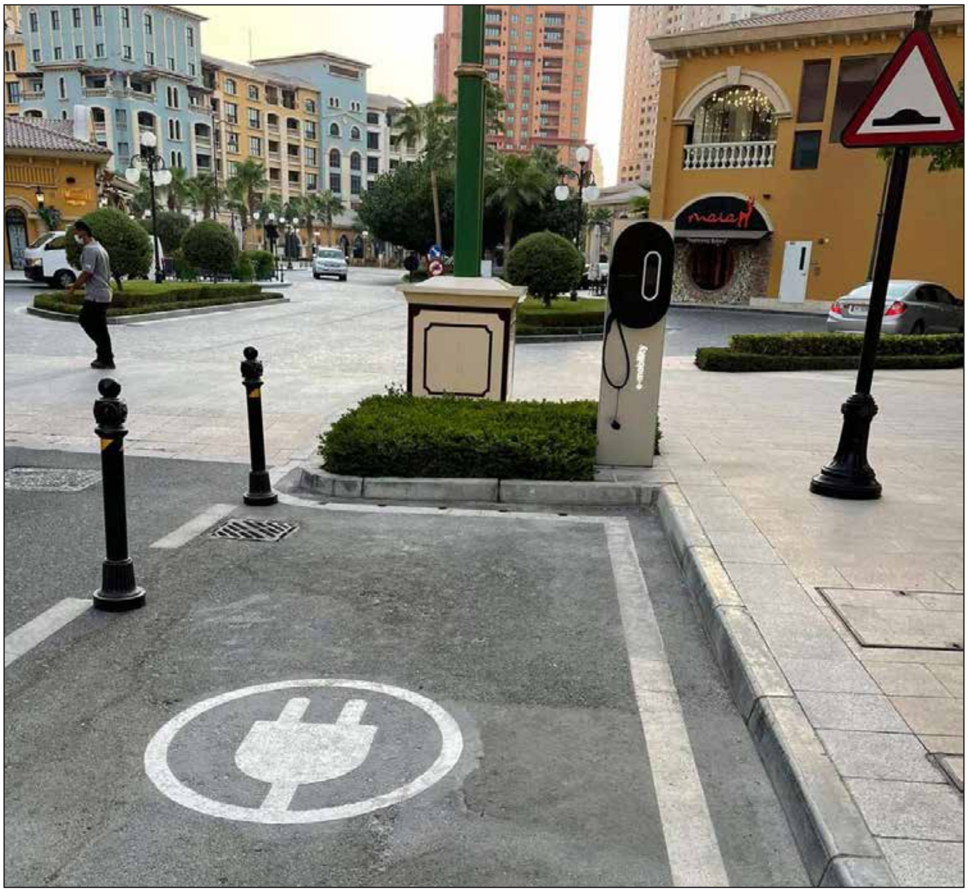


Figure 19-1 Wired Electric Vehicle Charging Unit

SOURCE: www.carmagazine.co.uk

Figure 19-2 Wireless Charging Unit

A set of preliminary design components for EV parking is set out in this section, which requires periodic review by the Overseeing Authority.

1. Determine the charge level:
   - Level 1 wall outlet with a standard electrical outlet, for residents and employees
   - Level 2 charger with a Standard J 1772 connector, for the public or visitors
   - DC Fast Charger for retail and short-term parking
2. Identify the proximity to power: locate power source to minimize installation cost, such as near an elevator
3. Select appropriate mounting position (**Figure 19-3**):
   - Wall
   - Pedestal
   - Overhanging
4. Select the charger protection mechanisms:
   - Bollards around charging station
   - Wheel stops
5. Identify the required number of cord sets
6. Assess the environmental conditions
7. Hazards: Locate charging cords to avoid tripping hazards, or make use of retractable cords
8. Allot the maximum time limit a vehicle can be used for charging at different locations
9. Provide accessible designs
10. Comply with all general design guidelines for PDV for different parking facilities, including dimensions, design considerations, signage and pavement markings, technology application, safety requirements, and supporting infrastructure
11. Follow signage and pavement markings: There are no standard pavement markings or time limits for EV parking, but the Manual on Universal Traffic Control Devices (MUTCD) markings and signage guidance has noted time limits and restrict parking only while charging. EV parking stalls are usually painted green to differentiate them from standard and disabled stalls. **Figure 19-4** shows a typical EV parking stall. Appropriate signage and markings are included in **Section 17**.

Figure 19-3 EV Charger Mount

Figure 19-4 Electric Vehicle Parking Stall

Typical layouts for EV parking with charging points are shown in **Figure 19-5** and **Figure 19-6**.

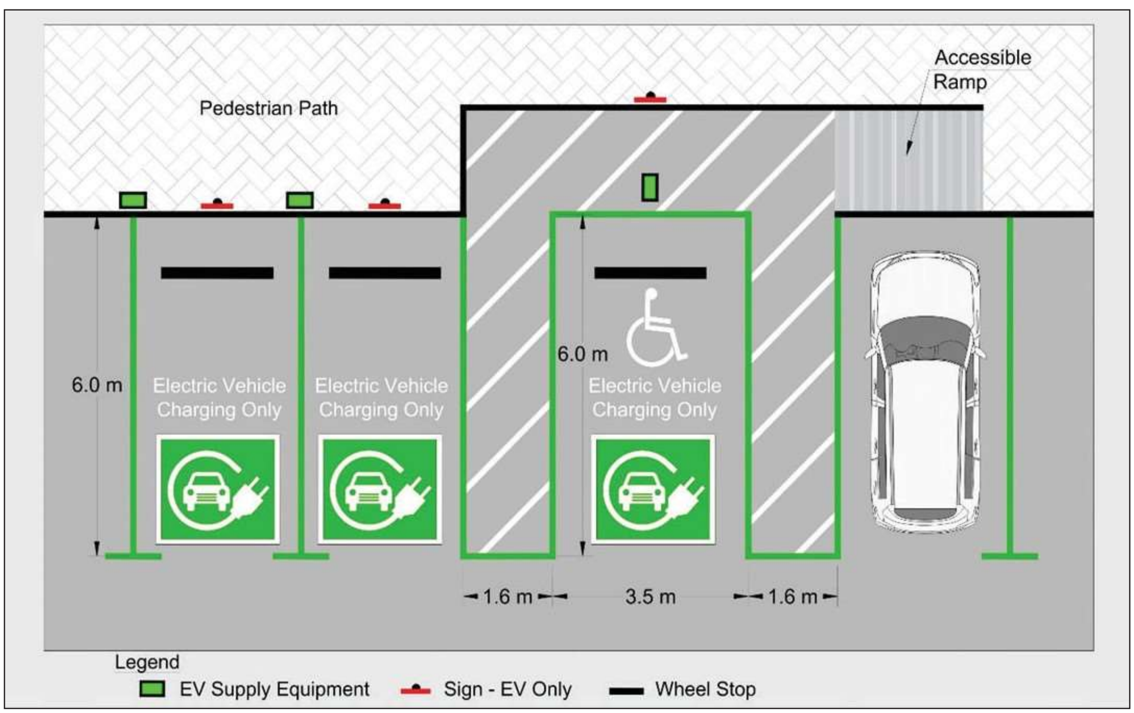


Figure 19-5 Typical Electric Vehicle Perpendicular Parking Layout

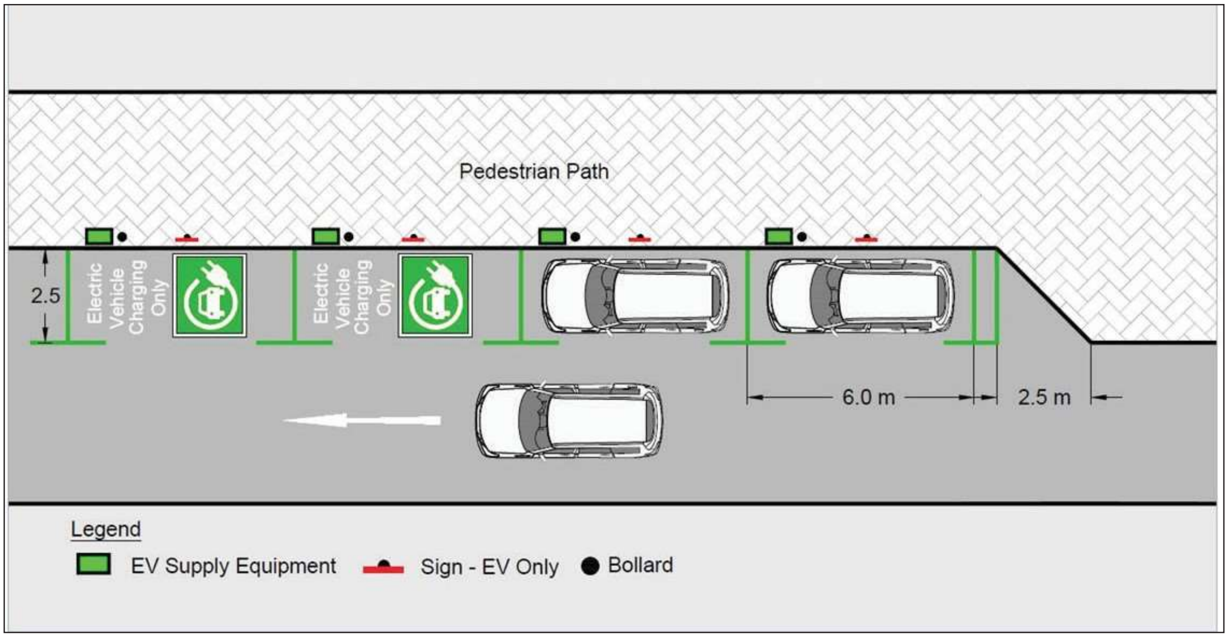


Figure 19-6 Typical Electric Vehicle Parallel Parking Layout

19.5 Autonomous Vehicles

Autonomous vehicles are still in the development phase. The parking features and requirements are still being researched by various agencies and institutions across the world. It is anticipated that autonomous vehicle dimensions will remain the same as those of existing vehicles. The only exception may be additional headroom or height for sensors and cameras. **Section 4.1.3** may be referred to for more information about headroom.

It is a general consensus that autonomous vehicles will comprise a certain portion of the vehicle fleet in the future, leading to an associated reduction in demand for parking. It is, however, difficult to plan for this in the absence of any data and relevant experience. When designing new parking structures, it may be prudent to consider designs that allow conversion of some or all the structures to suit the future parking requirements.

Requirement of no door opening at the parking stall and lack of human intervention warrants smaller parking stall dimensions which increases parking efficiency. Certain key features related to autonomous vehicle parking are the following:

- Smaller parking stall dimensions
- Lesser aisle widths and turning radii
- Need of elevators of smaller capacity and smaller stair widths for access of crew members only
- Reduction in lighting and ventilation requirements
- Reduction in number and types of signage as well as extent and type of pavement marking

It is also important to monitor curb space use and traffic congestion levels to identify areas that may be used for future autonomous vehicle passenger pick-up and drop-off areas, as well as the potential impacts on traffic flow.

19.6 Sustainable Solutions

Current and future developments, irrespective of industry, widely embrace the adoption or application of sustainable development practices. Parking development is no exception in this regard. The parking design process should refer to the requirements put forth by the Global Sustainability Assessment System (GSAS) to introduce, monitor, and achieve sustainable solutions. Different practices are emerging and developing. In general, sustainable solutions focus on the following:

- **Reduce Carbon Emission:** Reduced carbon emissions are achieved by ensuring ease in traffic movement, introduction of efficient circulation within the parking facility, as well as in the approach of reducing idling, especially at access controls, entries, and exits.

- **Increase Energy Efficiency:** This can be achieved through the smart planning of the parking layout. Avoiding overuse of lighting and controlled use of heating ventilation and air conditioning (HVAC) can significantly improve energy efficiency.

- **Recycled Construction Materials:** Use of recycled construction materials in the construction of parking facilities that conform to sustainable solutions, including pavement for grade parking.

- **Increased Parking Density:** By smart planning to minimize unusable space, the ratio of parking space to the development area can be improved.

Section 10, which deals with automated parking, advocates for and embraces the focus areas of sustainable parking solutions. Additionally, automated parking also helps to achieve enhanced land use efficiency, enhanced parking density, localized drop-off and collection areas, and limited use of lighting.

19.6.1 Innovative Surface Treatments

This section is presented for illustrative purposes only. It is recommended to consult the Overseeing Authority for the design, planning, and implementation of innovative surface treatment.

Interlocking Paver Blocks

Paving with interlocking paver blocks, set in sand or gravel, is an alternative paving system. Unlike concrete or poured asphalt impervious paving surfaces, interlocking pavers are separate blocks laid out on a prepared base. When built with a storage bed infiltration system, these pavers function similarly to porous paving systems. Refer to **Section 20** for design requirement for interlocking paver blocks. The uneven surface of these paver blocks also gives a sense of warning, which helps the drivers remain cautious, reduces vehicular speeds, and improves safety conditions.

Special Considerations

The use of interlocking concrete blocks is not advisable under the following conditions:

- The water table is less than 0.5 m from the surface.
- A stormwater sewer is less than 1 m below the surface.
- A spill risk of fuel, oil, detergents, pesticides, or other hazardous liquids is present.
- The pavement is subject to tidal influence.

Design Components

The fundamental components of interlocking paving are:

- Surface of interlocking pavers with open joints
- Subsurface base storage reservoir of open-graded aggregate
- Edge restraints
- Under-drain system
- Geotextile layer at the discretion of the engineer
- Impermeable geo-membrane (optional, to prevent soil infiltration)
- Geo-grids for sites with heavy vehicle loading
- Monitoring wells and cleanouts

The voids between the interlocked pavers allow stormwater from the parking surface to collect and then seep into the storage bed, which is made of sand or crushed stone. In some pavements, the water then gradually infiltrates over time into the sub grade soils; in others, the water is held within the pavement, from where it is discharged in a controlled manner to downstream drainage or is harvested and used as gray water. A typical example of interlocking paver blocks is presented in **Figure 19-7**.

SOURCE: marshalls.co.uk [1]

Figure 19-7 Interlocking Paver Blocks

Grass Pavers

Grass paving systems, as shown in **Figure 19-8**, are another option for an alternative surface that is mostly permeable. However, they have limited applicability because grass cannot survive the daily traffic and the extreme hot weather of Qatar. Grass-based systems are typically used for emergency fire lanes or temporary overflow of parking areas.

In cases where more frequent parking is expected, pavers should be filled with fine gravel or other permeable materials. It should also be noted that certain types of alternative pavers, including block, grid pavers, and gravel, are not always suitable for the accessible areas.

1 https://www.marshalls.co.uk/commercial/product/priora-permeable-block-paving

SOURCE: www.truegridpaver.com/grass-parking-pavers

Figure 19-8 Grass Pavers

19.6.2 Other Sustainable Solutions

Green Roofs and Walls: Constructing the parking garages with green roofs and green walls enhances the appearance of the structure. Living green walls can completely transform the facade of otherwise bare parking structures, turning them into a central design element in developments rather than something to be hidden away.

Use of Recycled Construction Materials

1. Reuse of existing facades or shell
2. Use of recycled materials, such as silica fume, fly ash, and steel
3. Replacement of concrete parking and traffic related products (e.g., wheel stops, speed humps, sign bases), with those made of 100% recycled rubber

Energy Efficiency

1. Use of energy efficient light sources, such as natural lighting, fluorescent, induction, and light emitting diodes (LED)
2. Installation of photovoltaic solar panels
3. Use of computerized lighting controls and voltage reduction
4. Use of sensors or timers to reduce light levels in certain zones when not in use or needed
5. Use of solar-powered lights for parking lot
6. Use of solar panels for power, as well as shade structures and facade treatments

Section 20

Construction Elements

20: Construction Elements

This section provides a general guidance for the construction elements related to parking facilities. All construction requirements follow the Qatar Construction Specifications (QCS) issued by the Ministry of Municipality and Environment (MME). The latest QCS may be referred to for more details. In general, the basic design life of the various permanent design elements should be:

- Parking Facility Structural Works: 120 years
- Pavements for the Parking Areas: 20 years (per the QHDM)
- Parking Facility Signage: 10 years (per the QTCM)
- Parking Facility Pavement Markings: 5 years (2 years in high abrasion areas) depending on the application procedures, abrasion damage, and whether thermoplastic material or roadway paint is used

This section also includes several components related to the Building Management Systems (BMS). A BMS, also known as a Building Automation System (BAS), is a computer-based control system installed in buildings to control and monitor mechanical and electrical equipment, including ventilation, lighting, power, fire, and security systems. A basic BMS is required for a multistory parking structure, which includes:

1. Fire management
2. Systems for air conditioning and fire fighting
3. Security and Intelligent Parking Management System (See **Section 18**)

20.1 Headroom

In a parking structure, headroom is the clear, vertical height (vertical clearance) which exists from the top surface of a floor to the underside of the ceiling or ramp or electrical/mechanical system. The floor-to-floor height should be designed considering the clear headroom required and the construction depth of the floor slab and its supporting beams. Allowance must be made for ventilation equipment requiring an increased floor-to-floor height. The span adopted for the structure determines the construction depth. Operationally, a clear span arrangement with all columns located outside the parking floor area is ideal. This entails greater construction depth and may not be feasible. It is advised to refer **Section 4.1.3** for PDV headroom calculation. **Section 8** includes the application of the headroom.

20.2 Surface Treatments

In a parking structure, the coating systems on the floor must be particularly durable. At the same time, they must provide good grip to prevent skidding. Strong epoxy resin coatings have proven to have better grip and are often used in conjunction with road grit or similar materials. A sufficient coating thickness is required to enhance durability. A 1 to 1.5 mm epoxy resin coating with aggregate is recommended for parking areas and driveways, and a minimum 2 mm coating for ramps. Polyurethane coatings can be used for exposed surfaces, such as driveways. The parking facility pavement in activity centers should be consistent with the broader urban design color palette in the area. As with other parking facility surfaces, it is extremely important to ensure that pedestrian areas and stair shafts are safe, having durable and slip-resistant surfaces.

20.3 Pavement Design

Parking facilities are generally subjected to low repetitive loads. Pavement with concrete pavers is generally proposed for at-grade parking facilities, both on-street and off-street, because of low vehicle loads. Underground utilities are likely to be present under on-street parking spaces. To facilitate easy removal and replacement of pavement for underground utility maintenance, pavers are preferred for on-street parking spaces.

Flexible pavement is another pavement type suitable for both on-street parking spaces and off-street parking facilities. Pavement composition for on-street parking spaces should follow the same composition as the adjacent road. The pavement composition for off-street parking facilities are to be based on the capacity of the parking lot and user characteristics, accommodating standard pavement design principles following the QHDM. There are two inputs that must be determined to calculate the appropriate thickness of the pavement:

California Bearing Ratio (CBR): Ground conditions are often quantified in terms of the CBR, which is used to evaluate the subgrade strength. Design of subbase should consider construction conditions and long-term loading. Loads on the pavement will be eventually transmitted through the sub-base into the natural ground or subgrade. The pavement design will prevent the foundation from being overloaded by using pavement structural layers to adequately reduce the vertical strain at the top of the sub-grade.

Equivalent Standard Axle Load (ESAL): For pavement design purposes, the damaging effect of vehicle axles is expressed in terms of an equivalent standard axle load. To determine the cumulative axle loads over the design life of the pavement, it is typical to convert the number of each class of heavy vehicle axles to an equivalent number of 80 kilonewton standard axles. Caution should be exercised while arriving at the ESAL factors. The ESAL will depend on the parking traffic characteristics, type of development (industrial, commercial, or residential), and project location. The cumulative millions of single axle load value is derived by multiplying the ESAL by the design life (20 years for pavement) and applying relevant growth factors.

The following steps should be followed to determine a pavement type and thickness for off-street parking facilities:

1. Identification of traffic class for pavement design based on the number of parking spaces and to delineate any areas likely to be used by heavy trucks
2. Estimate ESAL using standard procedures
3. Estimate/establish the design CBR for the project site
4. Calculate pavement thickness using the CBR and ESAL, following standard procedures

The pavement design should be in accordance with the QHDM Volume 2, Part 12.

The following guidelines are included according to the QHDM for design of pavement:

A. Low parking turnover area with traffic load <0.5 million ESAL

- 80 mm precast interlock block
- 50 mm bedding sand
- 150 mm granular base material, CBR ≥80%
- 150 mm granular subbase material, CBR ≥70%
- +300 mm subgrade of CBR >15%

NOTE:

- *Where the existing CBR is greater than 25%, the subbase layer should be reduced to 100 mm.*
- *Where the existing CBR is greater than 50%, consider eliminating the subbase layer altogether.*

The above pavement composition is adoptable for parking areas meant only for cars, such as residential and office uses.

B. High parking turnover area with traffic load 0.5–1 million ESAL

i. 80 mm precast interlock block

ii. 50 mm bedding sand

iii. 150 mm granular base material, CBR ≥80%

iv. 200 mm granular subbase material, CBR ≥70%

v. +300 mm sub-grade of CBR >15%

Note:

- *Where the existing CBR is greater than 25 percent, the subbase layer should be reduced to 150 mm.*
- *Where the existing CBR is greater than 50 percent, the subbase layer should be reduced to 100 mm.*

Figure 20-1 shows a typical paver pavement composition.

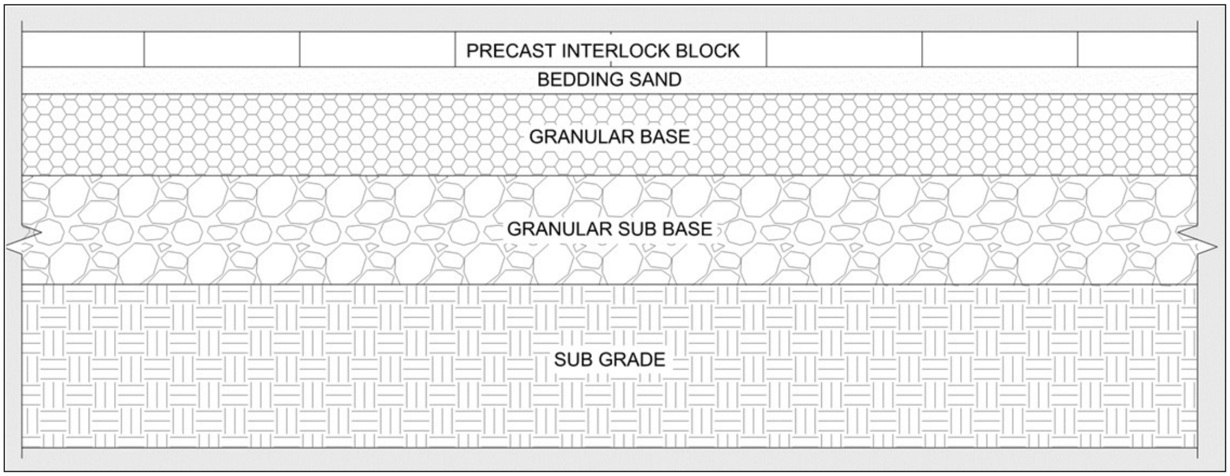


Figure 20-1 Paver Pavement Composition

C. The flexible pavement design for CBR >15% and up to 2 million ESAL

i. 50 mm asphaltic concrete wearing course

ii. 80 mm asphaltic base course

iii. 150 mm granular subbase course, CBR ≥70%

iv. +300 mm subgrade of CBR >15%

Figure 20-2 provides typical flexible pavement composition for a CBR >15% and up to 2 million ESAL.

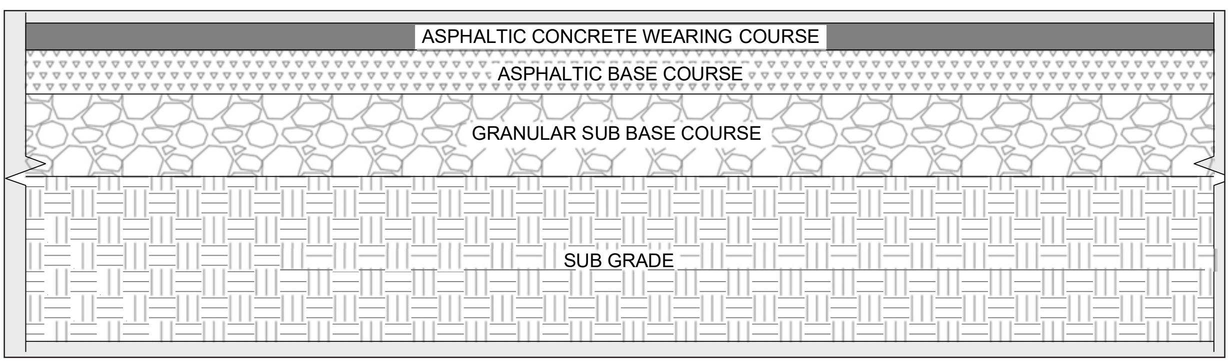


Figure 20-2 Flexible Pavement Composition - CBR > 15% and up to 2 million ESAL

Porous pavement for parking areas are recommended for efficient surface water drainage. They are best used in granular soils but can be used in fine-grained soils with the addition of subdrains to improve surface drainage. Construction of this should be executed by experienced contractors. Porous pavements are not recommended where clogging of pavement is possible (e.g., because of spillage of any materials). This would need frequent maintenance including high-pressure jet washes. Hence, this type of pavement is not recommended for commercial parking. The design of porous pavements must incorporate recommendations made in the QHDM Volume 2, Part 10.

20.4 Drainage

Well-designed and properly maintained drainage is essential to ensure that all the water that is deposited on exposed surfaces is rapidly discharged through an effective drainage system. Standing water is detrimental to both the structure and the operation of parking facilities. A well-designed drainage system that includes appropriate grade profiles remove water rapidly from parking facility surfaces. Surface water drainage for flat surface parking facilities requires no special consideration other than providing for low points, minimum slope, and the direction of slope. Parking structure decks need more complex drainage systems to reduce water seepage and corrosion. Refer to the QHDM for additional guidance.

The roof is the most exposed area, and drainage should be designed considering local rainfall statistics. In stormy conditions, some build-up of water is inevitable. The edges of decks should be designed to contain water and prevent the decks below from becoming wet. Intermediate floors can get wet by rain blowing through openings and dripping from parked cars.

The quantity of water deposited on intermediate decks from parked cars is likely to be about 2 liters per parked vehicle depending on turnover. Retail parking facilities have short stays and more water, while commuter or business parking facilities tend to have less turnover and less water from parked cars. Drainage network analysis programs and methods are used to design drainage systems. Although the direction of fall depends on the geometry of the parking facility, falls and drainage channels should be designed to suit the type of structure upon consideration of sensitive structural details. Provided the drainage is well designed, it is not essential to lay the fall of the decks outward toward the exterior of the parking structure. Where car wash facilities are operated or allowed inside car parks, allowances should be made for higher than normal discharges of water through drainage channels and associated pipework. The provision of channels and/or galleries must follow the guidelines described and provided at locations that collect surface water and avoid the accumulation of volatile fumes.

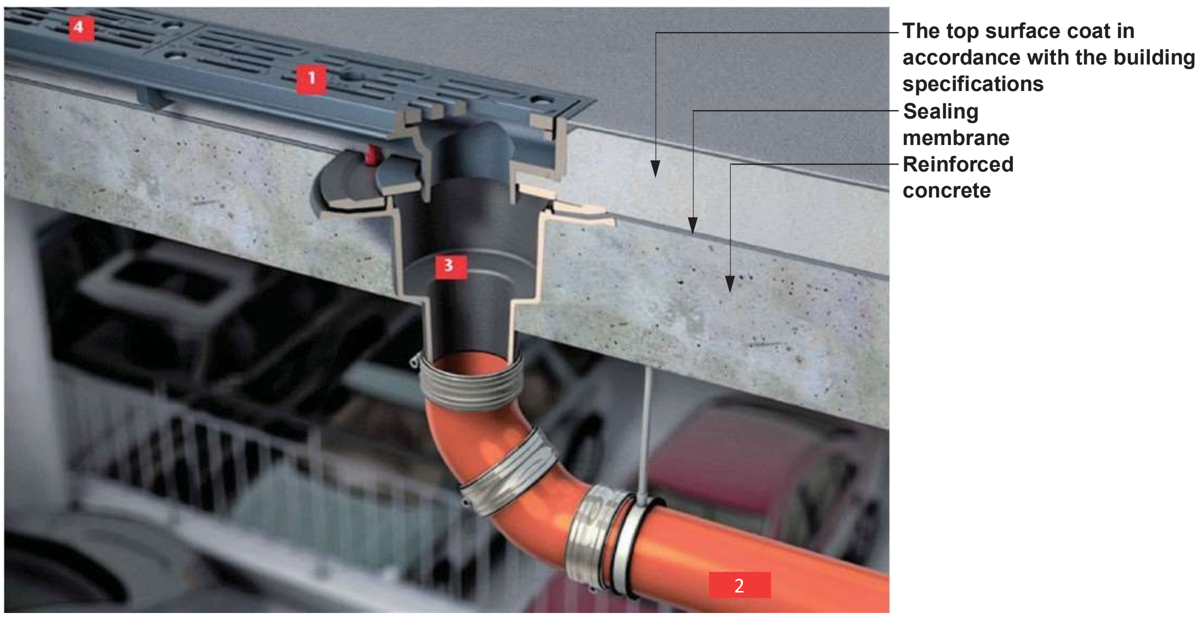
Rainwater drainage should be collected from uncovered area of ramps at all entrances through channels and pipes, discharging to a sand trap, oil interceptor, and sump pits. The water should be moved by a duplex submersible pump set (one duty and one standby) pumping the discharge directly to the nearest external deceleration chamber. Seepage channels can be proposed at parking facility outer walls to collect any local groundwater seepage through the structure. Minimum grades for exposed areas should be at least 2% for drainage.

20.4.1 Piped Systems

Piped systems should be arranged to be as unobtrusive as possible, both externally and from multistory within the parking facility. Wherever possible, downpipes should be located on the shielding side of the column to avoid traffic impacts and fixed so that they do not encroach into adjacent parking spaces. Protective hoops or shielding should be provided where it is impossible to use the structure to shield the pipes. It is essential to make adequate provision for access and clearing out of the drainage system.

Traps for protection against oil, grit, and gasoline entering the surface water disposal system should be provided in accordance with the requirements of the local authority.

A typical section of drainage configuration at the deck slab of a multistory parking structure is shown in **Figure 20-3**.



Notes :

1. Drainage channel 2. Drainpipe
3. Drain body 4. Channel unit

SOURCE: Modified from Parking Deck Drainage Brochure, ACO Technologies.

Figure 20-3 Multistory Parking Deck Slab Drainage Configuration

20.4.2 Ramps and Circulation Areas

Drainage falling toward ramps should be avoided. If the geometry of the facility does not allow for this, drainage paths must be intercepted to avoid water discharging onto the ramps. Adequate drainage should be provided at the bottom of ramps, particularly in the roof and entry levels, to remove water quickly and to prevent stagnation of water. If the operator periodically washes down all levels or operates a valet service inside the facility, drainage should be provided at the bottom of all ramps.

20.4.3 Pedestrian Areas

Where decks need to be sloped, pedestrian areas should ideally be located at the higher end of the grade. Staircases and elevators should be above the general deck level or discreet drainage must be provided to intercept water flowing toward the staircases and elevators. Drainage channels, slots, and grates should be sized to minimize pedestrian trip hazards.

20.4.4 Off-Street At-Grade Parking Facilities

Key drainage design considerations for off-street at-grade parking facilities that align with the QHDM are included below:

- Complete a flood risk assessment following the QHDM.
- Develop a mitigation strategy for parking lots used or proposed to be used for critical uses, such as emergency or essential services, hospitals, bulk storage, and educational facilities.
- Apply high flood standards for off-street parking lots, as they are used by both pedestrians and vehicles; a flood depth of maximum 0.10 m and duration of 10 minutes are recommended.
- Conduct proper planning of gullies with respect to both the gully spacing and the size of the gully in-take.
- Locate gullies along curbs inside an off-street parking facility or divide the parking area into multiple zones and locate low points; connect gullies to the municipal drainage network.
- Consider soak ways if the municipal drainage network is not available or constrained by capacity.
- Use design criteria detailed in Surface Water Capture on Flat or Shallow Gradients, based on the design approach outlined in Drainage of Level or Nearly Level Roads (Whiffing and Young 1973).
- Implement crossfalls in large parking facilities between 0.5% and 1% to avoid additional earthwork required to achieve higher grading.
- Consider 100% impervious parking and paved areas including paved parking lots, roofs, and driveways.
- Install oil and petrol interceptors and grit traps for large parking facilities, which filter runoff before discharging to the drainage system.

20.5 Fire Safety

Active and passive fire protection should be included in all design aspects. The objectives are to develop life-safety and property-protection strategies to mitigate the potential fire risks associated with parking facilities. All aspects of design and construction of a parking structure must be designed with this objective in mind. The design of a parking facility should consider preventive, mitigation, and event management measures to attain this objective.

20.5.1 Building and Hazard Classification

The National Fire Protection Association (NFPA) 101 and NFPA 5000 prescribe conditions for underground structures, consistent with the configuration of underground, enclosed, and multistory parking structures.

Parking structures used only for the storage of vehicles should be classified as ordinary hazard occupancy according to NFPA 101 and NFPA 5000.

20.5.2 Mixed and Separated Occupancies

Separation from parking areas by walls or partitions that can resist passage of smoke should be adopted for offices or other similar spaces that are related to the operation of the parking facility and are less than 300 m^2 in area (reference NFPA 88A). This is not applicable for cashier or attendant booths. Compartmentalization of the parts of the parking structure must comply with the requirements of NFPA 88A when located within 3 m or attached to or immediately below a building or another occupancy.

20.5.3 Fire Engineering Design

The fire engineering design starts with the evaluation of risks and hazards associated with the building configuration characteristics and its intended use and operation. Prevention of fire incidents starts with the overall architectural and structural design, taking into consideration the prescribed requirements of applicable codes and standards related to safety. These include the NFPA standards, Qatar Civil Defense Department (QCDD) guidelines, and/or an engineering analysis when no prescribed requirements are developed or are insufficient for the condition of the building. The prevention process includes the selection of materials, the allocation and fire separation of spaces, and management of movement of occupants, among others.

The evacuation and rescue of the building occupants in the event of a hazard or emergency is the final stage of managing a risk. Emergency procedures for each of the emergency categories should be established. The procedures should specify the necessary tasks to be performed within a time or event sequentially by the appropriate emergency response agency and personnel.

Interior Finish

Interior finishes must be in accordance with the requirements of NFPA 101. Interior wall and ceiling finish materials should be Class A, Class B, or Class C. Suspended ceilings must not be permitted in the parking lots and other ancillary areas. Interior floor finish materials in exit enclosures and exit access corridors should be Class I or Class II. Interior floor finishes except for exit enclosures should comply with the requirements of NFPA10.

Parking Structure External Surfaces

All external surfaces must comply with the requirements of QCS, NFPA, QCDD, and International Building Code. External surfaces should be constructed of noncombustible materials and in a way to prevent explosive spalling when subjected to high temperatures.

20.5.4 Evacuation Strategy

Evacuation of the occupants from a parking facility in the event of an emergency should follow the QCDD guidelines. According to those guidelines, when a fire is detected in any area of the parking facility, users in the zone of incidence will move toward the closest emergency exit. Exits should be provided by a combination of fire-rated and smokeproof stop lobbies, corridors, and stair shafts that lead occupants to exit discharge points at-grade level and to the outdoor public way safe area. Enclosed, fire-rated, and smokeproof evacuation corridors should connect to stair shafts that discharge at-grade level outside the parking facility. These allow the safe egress from ancillary areas. Stair shaft doors must lead directly to the outside of the building complex. Refer to **Section 12.5.3** for additional guidance on emergency exits.

Areas of refuge should be provided on all levels of the facility at elevator lobbies and by stair shafts. Elevator lobbies not complying with the criteria for exits and/or areas of refuge should be marked with clear exit signs indicating “no exit” and/or “no area of refuge.”

The areas of refuge should comply with the requirements stated in NFPA 5000. During a fire emergency, when a fire detection device or fire alarm system is activated, all passenger elevators should be brought to the ground level and parked with the landing doors open. At least one elevator in the building must serve as a fire elevator and should be compliant with the Qatar Civil Defense Fire Safety Standard requirements. In addition to providing fire department staff access to every level of the structure, the designated fire elevator can be used with assistance from firefighting staff for rescue of the disabled.

20.5.5 Means of Egress and Circulation Elements

The quantity, dimensions, and other specific requirements for the means of egress are primarily identified in NFPA 101 and NFPA 5000 or as otherwise modified by NFPA 88A.

Number of the Means of Egress

A minimum of two means of egress should be provided from every floor or section of the parking structure according to the requirements of NFPA 101.

Exits Headroom

Means of egress in all parking facility areas should be designed and maintained to provide a minimum headroom of 2.5 m. Any projections from the ceiling must provide a headroom of not less than 2.03 m, with a tolerance of 19 mm, above the finished floor.

Headroom on stairs and stair landings should not be less than 2.03 m for storage applications, according to NFPA 101, as measured vertically above a plane, parallel to and tangent with the most forward projection of the stair tread.

The final headroom must be finalized in consultation with the Overseeing Authority following the guidance provided in this section, applicable standards, and consideration of any special requirements.

Walking Surfaces

Walking surfaces in the means of egress should be slip resistant under foreseeable conditions and should comply with the requirements of NFPA 101.

Stairs

Stairs should comply with the requirements of NFPA 101. The required stair width must be calculated based on the total occupancy number, with a minimum width of 1,220 mm.

Doors

Doors should comply with the requirements of NFPA 101. While the listed width requirements are not to be less than 810 mm of clear width, the actual design clear width is a minimum of 850 mm. The required width should be based on the total occupancy.

20.5.6 Exit Stairs Shafts

Stair shafts should be provided for the evacuation of parking facility users from each of the levels and discharge at-grade level. These shafts must consist of smokeproof enclosures that should be continuously enclosed by barriers having a 2-hour fire resistance rating from the lowest point to the level of exit discharge, following the requirements of NFPA 101 and NFPA 88A.

Vestibules or areas of refuge should be provided at each floor. The door opening into the vestibule should be protected with an approved fire door assembly having a minimum 2-hour fire protection rating for buildings with 4 or more floors. The fire door assembly from the vestibule to the stair enclosure should have a minimum 20-minute fire protection rating. According to NFPA 101 and NFPA 88A, the fire protection rating is 1 hour for structures with up to 4 floors.

20.5.7 Elevators

Elevators should conform to the requirements of NFPA 5000 and ASME A17.1/CSA B44 Safety Code for Elevators and Escalators and comply with the provisions of the Americans with Disabilities Act Accessibility Guidelines (ADAAG) and the local Qatar regulating authorities. Elevators are the primary means of vertical transport between parking structure levels. They should be designed separately for each intended use, such as public elevators, service elevators, and fire department elevators.

Elevators used by fire department personnel (fire elevators) should be provided in accordance with the QCDD Fire Safety Standards. Fire elevators should have access to every floor of the facility. These elevators should be adjacent and accessible to an exit staircase, with an approach to the firefighting lobby on each level. The firefighting lobby should have a minimum 2-hour fire resistance rating and pressurized to a minimum of 10 air changes per hour. Lobby doors should have no less than a 2-hour fire protection rating and should be self- or automatic-closing.

The power supply to the designated fire elevator should be connected to a submain circuit exclusive to the fire elevator and independent of any other main or submain circuit. Automatic fire sprinklers should not be installed in fire service access, elevator machine rooms, and machinery spaces. A clean agent fire suppression system must be used to protect elevator machine rooms.

A pictorial symbol of a standardized design designating the elevators that act as fire elevators should be installed on each side of the hoist way doorframe on the portion of the frame that is at right angles to the fire service access elevator lobby, following NFPA 5000.

20.5.8 Signage, Illumination, and Emergency Lighting

Marking of the means of egress should be provided in accordance with NFPA 101. Signage in accordance with NFPA 101 and symbols according to NFPA 170 are to be provided for all egress routes. Exit signs should be clearly visible from any direction of exit access. Directional signs with an indicator showing the direction of travel should be placed in every location where the direction of travel to the closest exit is not evident.

Following the NFPA 5000 requirements, the exit stair enclosure structures should be provided with signage at each floor-level landing to the exit. The signs should include a chevron-shaped indicator to show the direction to the exit discharge. Continuous illumination of the means of egress should be provided for the duration of the building operations and according to the requirements of NFPA 101.

Illumination levels for stairs should be provided with at least 10 foot-candles measured at the walking surfaces. Minimum illumination levels for floors and other walking surfaces other than the stairs should be at least 1 foot-candle measured at the floor. Exits and circulation paths of the parking facility should be equipped with an emergency lighting system that complies with the requirements of the NFPA 101 and powered by a standby source that provides power for at least 1-1/2 hours in the event of the normal lighting's failure.

20.6 Ventilation, Air Conditioning, and Fire Fighting Systems

A key aspect of design is the mechanical services related to ventilation and air conditioning (VAC) and the fire alarm and firefighting systems. This section covers general design criteria and system descriptions for ventilation, air conditioning, and fire safety. Guidelines issued by QCDD Fire Safety Standards (FSS) should be adhered to.

20.6.1 VAC System

The objective of the design of the mechanical ventilation and air conditioning system is to consistently regulate the indoor temperature and humidity to maintain a prescribed comfort level and to ensure recommended indoor air quality.

The design should ensure the selection of the optimum VAC system with respect to life expectancy, initial and operating costs, and system reliability. The following sustainable and energy efficiency measures should be considered for the VAC system design:

- Energy efficient equipment, variable speed drives, and high-efficiency motors
- Fresh air requirements according to the GSAS and American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
- Control system that minimizes energy use and maintains required indoor air quality
- Mechanical equipment selected and installed in a way that minimizes noise and vibration
- Ease of access to equipment for maintenance, redundancy, and backup

20.6.2 Basic Design Parameters

Climatic Criteria

VAC load calculations should be based on the climatologically design data for the State of Qatar, according to QCS 2014.

Occupancy Estimate

The occupancy rates used should be based on the ASHRAE Handbook, Standard 62.1, 2016.

Ventilation Requirements

The ventilation requirements for different spaces should be based on the ASHRAE Handbook, Standard 62.1. 2016.

Filtration

Filtration rates should adhere to the ASHRAE application handbook and standard. Outdoor air should be filtered properly using fresh air and a sand-trap intake louver with removable washable filters, according to QCS 2014.

Noise Criteria

All equipment should be installed to meet the ASHRAE recommendations for noise and vibration control.

Ductwork Distribution System

Ductwork sizing and room air distribution should be based on the Sheet Metal and Air Conditioning Contractors' Association (SMACNA) standards. The low- and medium-pressure rectangular sheet-metal duct gauges and reinforcing framing should follow the latest edition of the ASHRAE Handbook and the updated SMACNA Manual.

Building Indoor Air Quality

Measures for ongoing monitoring and evaluation of indoor air quality should be provided to identify a decline in indoor air quality that may occur, as a result of changes in occupancy patterns, operational changes, maintenance issues, or other factors. Indoor air quality should be monitored in all critical areas by means of permanent detection to monitor carbon dioxide, carbon monoxide, and volatile organic compound concentrations. Detectors should be linked to the main building management system.

Smoke Control Systems

In the parking areas, smoke extraction must be performed at a rate of 10 air changes per hour to clear smoke in the event of a fire. This should be in accordance with the requirements of the QCDD. Important egress circulation elements and other areas of the facility are required to be separated by means of smokeproof enclosures. Stair enclosures, elevator lobbies, areas of refuge, smoke stop lobbies, or exit passageways are among spaces that require pressurization or mechanical ventilation to avoid the migration of the products of combustion produced by fires in adjacent spaces. These enclosures should be pressurized with the use of an approved engineered system with a design pressure difference across the barrier, following the QCDD guidelines. The pressure difference across door openings should not exceed an amount that allows the doors to be opened by 133 Newton of force.

Smoke control for the VAC systems should be designed in accordance with NFPA 90A and 92.

General Ventilation and Smoke Control

General ventilation should be provided through mechanical means to parking lots and ancillary areas, as described in this section, and in accordance with the Qatar Construction Specifications, QCDD Guidelines, and the NFPA standards, as applicable. According to NFPA 88A, all enclosed parking structures should be ventilated by a mechanical system capable of providing a minimum of 300 L/min per m^2 of floor area during hours of normal operation. This system should be installed in accordance with NFPA 90A. Ductwork construction should be of noncombustible material.

According to the QCDD guidelines, parking areas should be ventilated at an average rate of six air changes per hour. Demand-controlled ventilation must be variable and based on concentrations of carbon monoxide and other particulates that should be diluted to maintain acceptable levels in circulating air.

20.6.3 Fire Detection Alarms and Fighting Systems

Parking facilities should be equipped with an approved automatic addressable fire detection system and an automatic fire alarm system conforming to the requirements of the NFPA 72 and the QCDD Fire Safety Standards. Systems to fight fire events should meet the standards prescribed by the QCDD Fire Safety Standards. The following means of firefighting should be considered as appropriate for parking facilities.

Automatic Sprinkler System

The parking facility should be provided with an approved automatic sprinkler system throughout the facility as per the following NFPA standards requirements:

- NFPA 88A states that an automatic sprinkler system should be installed in portions of enclosed parking structures, the ceilings of which are less than 600 mm above grade, regardless of type of construction.
- NFPA 5000 prescribes use of approved automatic sprinkler system installed under supervision, in accordance with NFPA 13, for underground structures having an occupant load of more than 50 users. The automatic sprinkler system should be provided at all the areas and at all the floor levels traversed in reaching the exit.
- The system is to be a combined standpipe/fire-sprinkler system.

Clean Agent Fire Suppression Systems

Clean agent fire suppression systems should be provided in critical areas, such as technical rooms with electric or electronic systems in accordance to NFPA 2001. These gaseous fire suppression systems should be automatically activated, controlled, and should include a predetermined delay with abort switch and manual reset. Fire suppression systems other than clean agent fire suppression systems, such as carbon dioxide are not acceptable.

Standpipe System

NFPA 88A and NFPA 5000 prescribes Class I standpipe systems in accordance with the NFPA 14 requirements. Pressure, flows, pipes, valves, and accessory size including other characteristics of these standpipe systems should be provided in accordance with the requirements of NFPA 14.

Portable Fire Extinguishers

Portable fire extinguishers should be distributed throughout the parking facility on each level in accordance with NFPA 10. Portable fire extinguishers should be installed in a conspicuous manner and properly spaced. The distance between them should not exceed 30 m. Multipurpose dry chemical 9 kg extinguishers should be used for most parking facility areas. CO_2 portable fire extinguishers should be used in electrical equipment and communication rooms. All fire extinguishers should be marked in a way such that the public can readily see them.

Foam System

A low expansion foam spray fire suppression system must be provided in fuel tank rooms as required by NFPA 30 and NFPA 37, and in accordance with NFPA 16, Standard for the Installation of Foam-Water Spray Systems. The deluge foam fire suppression systems should be automatically activated by a room detection system and controlled by a dedicated control panel that communicates with the building fire alarm system.

20.7 Lighting

The latest set of guidelines of the Chartered Institution of Building Services Engineers (CIBSE) should be referred to for all lighting issues. The QHDM may be referred for street lighting design.

All functional areas of a parking facility should be adequately lit.

- Exterior elements: Guide 6
- Emergency lighting: Guide 12
- Various types of transport facilities (e.g., road, rail, transit): Guide 15
- Stairs: Guide 16

The following should be considered in the lighting design:

1. Adequate lighting at decision points, information boards, and potential conflict areas
2. Ambient lighting to avoid shadows
3. Lighting requirements and minimum category standards for facilities that operate beyond daylight hours
4. Energy-efficient lighting

Locations of light poles and trees (to be planted) should be planned to ensure that there are no conflicts. Light poles and tree should be provided with adequate and exclusive spaces.

For planning purposes, the likely size of the trees or the size of the plantings when mature should be considered. **Figure 20-4** shows lighting in a parking facility that is well lit and minimizes light spill into adjacent areas.

SOURCE: https://www.schreder.com/

Figure 20-4 Lighting Design to Minimize Light Spill

20.8 Landscaping

Landscaping should be an integral part of the parking area and should be considered early in the design process to ensure its appropriate accommodation. Landscape design should develop a pleasant user experience and be integrated with the surroundings.

Landscape features should not adversely impact safety. The guidelines provided in the Qatar Public Realm Guidelines, 2014 (QPRG) and the QHDM, Landscape and Planting Design, Part 3, Vol 22 should be referred to for landscaping design.

Dead areas within the parking lot should be considered for landscaping development to prevent unauthorized use. Landscape features should not interfere with any design element.

20.8.1 General Guidance

The following points provide general guidance regarding landscaping in parking facilities:

1. Provide landscape along the boundary or perimeter of at-grade off-street parking facilities
2. Use landscape screening to obstruct view of parked vehicles from the public Right of Way
3. Limit landscaping to the perimeter for facilities having less than 20 parking spaces
4. For facilities with more than 20 parking spaces, following recommendations are made:

- Landscaping along the boundary or perimeter of the facility and landscaping islands
- Landscaping islands at the ends of every parking aisle spaced at no more than 15 stalls in a parking bay
- Continuous landscaping islands where more than three parking bays are planned or at a spacing of not more than 36 m
- One tree each for every five parking spaces
- 65% of the total trees planted in interior landscaping islands
- Trees to be spaced no more than 10 m apart, along continuous landscaping islands
- The boundary or perimeter landscaping to be with dense hedges and trees

5. Install landscaped cart islands in shopping area
6. Incorporate well-integrated hard and soft landscape treatments consistently throughout the parking facility
7. Integrate landscaping with pedestrian and parking functions
8. Provide soft landscaping (ground cover and trees) along pedestrian priority pathways throughout the parking facility and areas where screening is required
9. Allocate sufficient space to landscaping to ensure that it does not impede pedestrian and vehicle movement, safety, or other elements

An example of landscaping features for a parking facility with more than 20 parking spaces is provided in **Figure 20-5**.

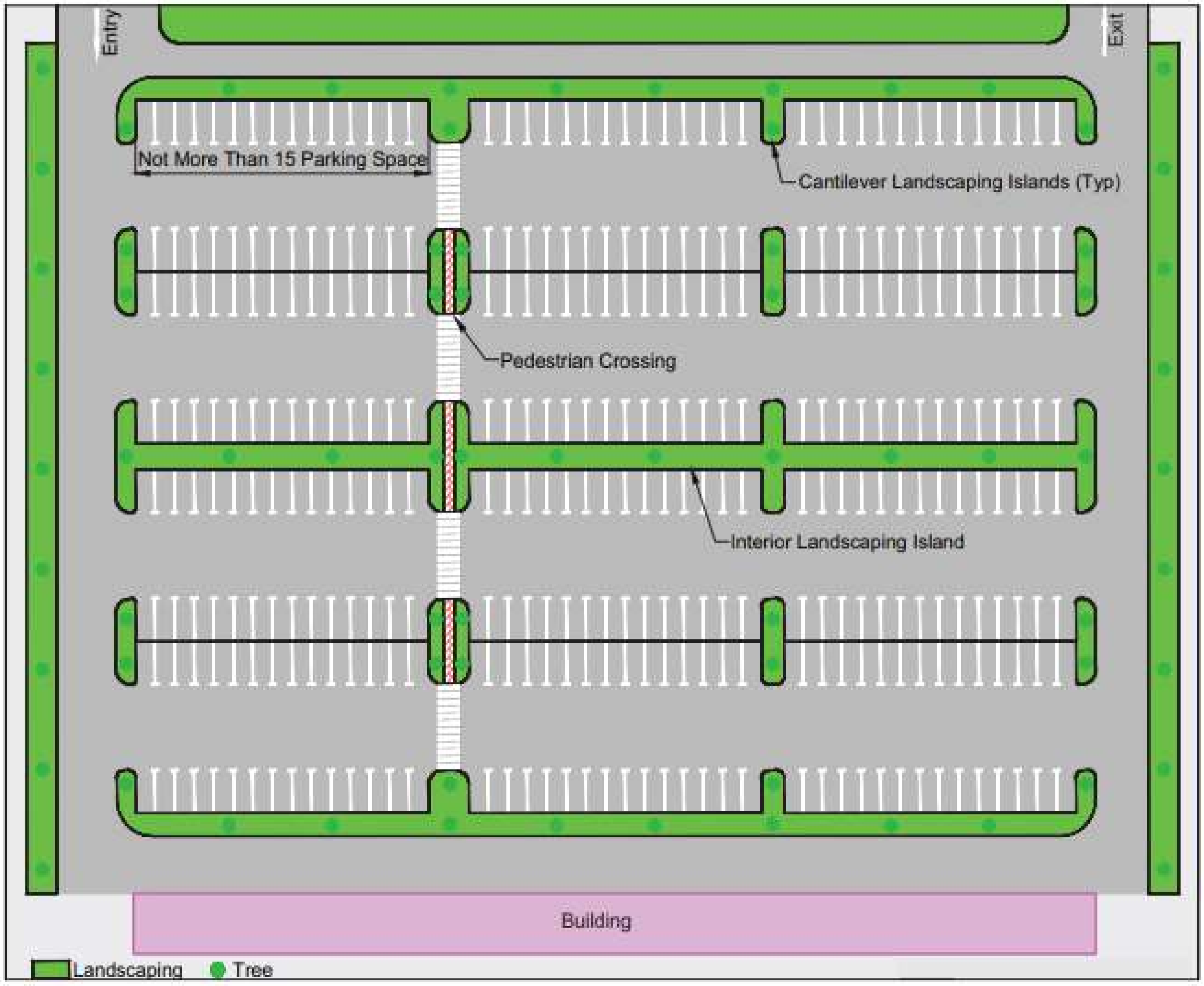


Figure 20-5 Parking Lot Landscaping Layout

20.8.2 Visibility Splays

The following are the requirements of visibility splays:

1. Landscaping or overhang from landscaping should not obstruct pedestrian or vehicle view lines.
2. Landscaping should not interfere with ability to access car doors, access to pedestrian paths, and provision of lighting and signage.
3. Sight distance triangles should be clear of any visual obstruction, including landscaping. Landscaping or hardscaping over 60 cm in height (that will block the line of sight)should not be permitted inside the sight triangle.
4. Landscaping should not obstruct surveillance cameras. The cameras should be positioned to accommodate landscaping leaving no blind spots.

20.8.3 Vegetation

The following are the tree and plant recommendations as part of landscaping:

1. Trees should be provided with sufficient space to promote healthy growth and shade. Guidance on clearances is provided in **Figure 20-6**, **Figure 20-7,** and **Figure 20-8**.

2. Soft landscaping should be provided with passive irrigation and adequate drainage.

3. Gulf Organization for Research and Development (GORD) Global Sustainability Assessment System (GSAS) documents should be referred to identify trees and vegetation suitable for the Qatar climate and local environment.

4. Tree species should have a singular trunk form.

5. Ground cover should be hard and grown to a mature maximum height of 500 mm except where vehicle overhang occurs. Other appropriate ground cover should be used where vehicle overhang occurs.

6. Garden beds without trees should be a minimum of 400 mm in width.

7. Shrubs are generally not acceptable and should be used only where appropriate, such as along screening walls or fences.

8. Bioswales should be adopted where feasible.

See the Qatar Public Realm Guidelines 2014 (QPRG) for additional guidance. See also the QHDM, Volume 3, Part 22.

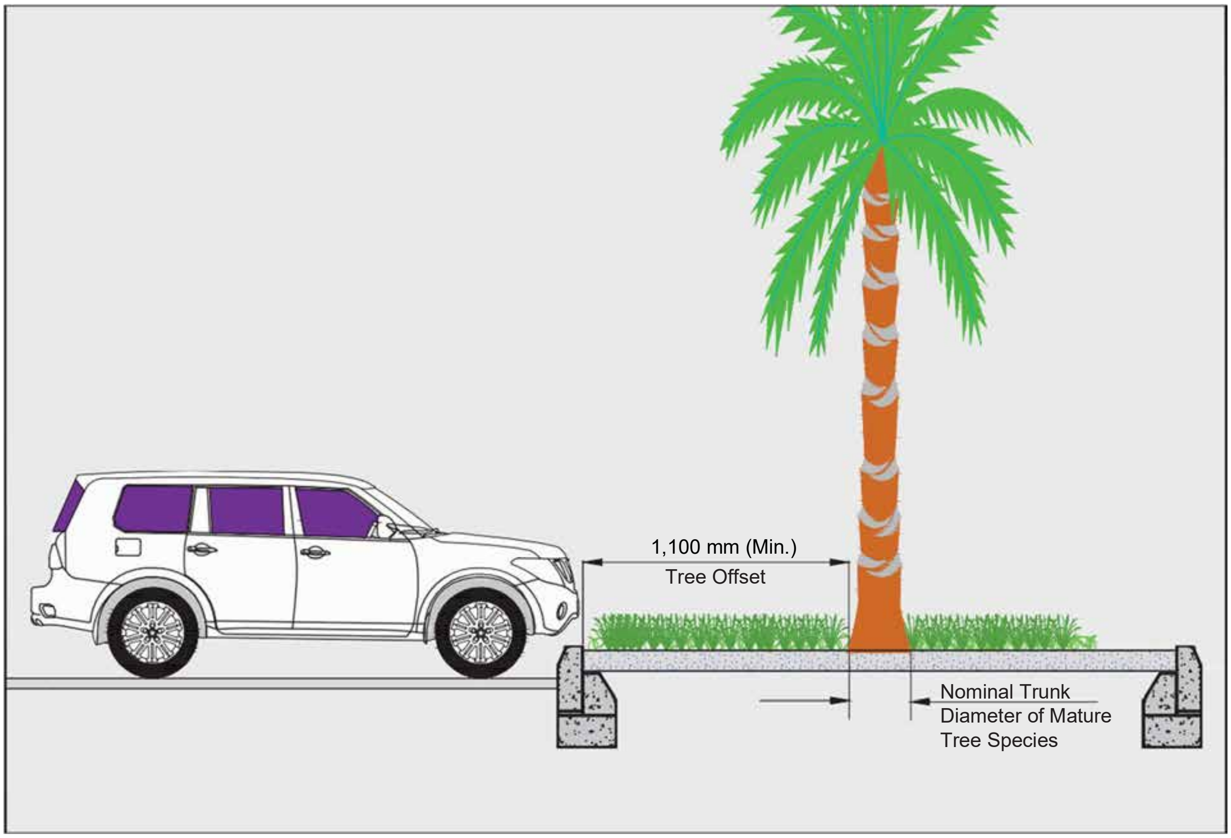


Figure 20-6 Vehicle Front/Rear Tree Clearance

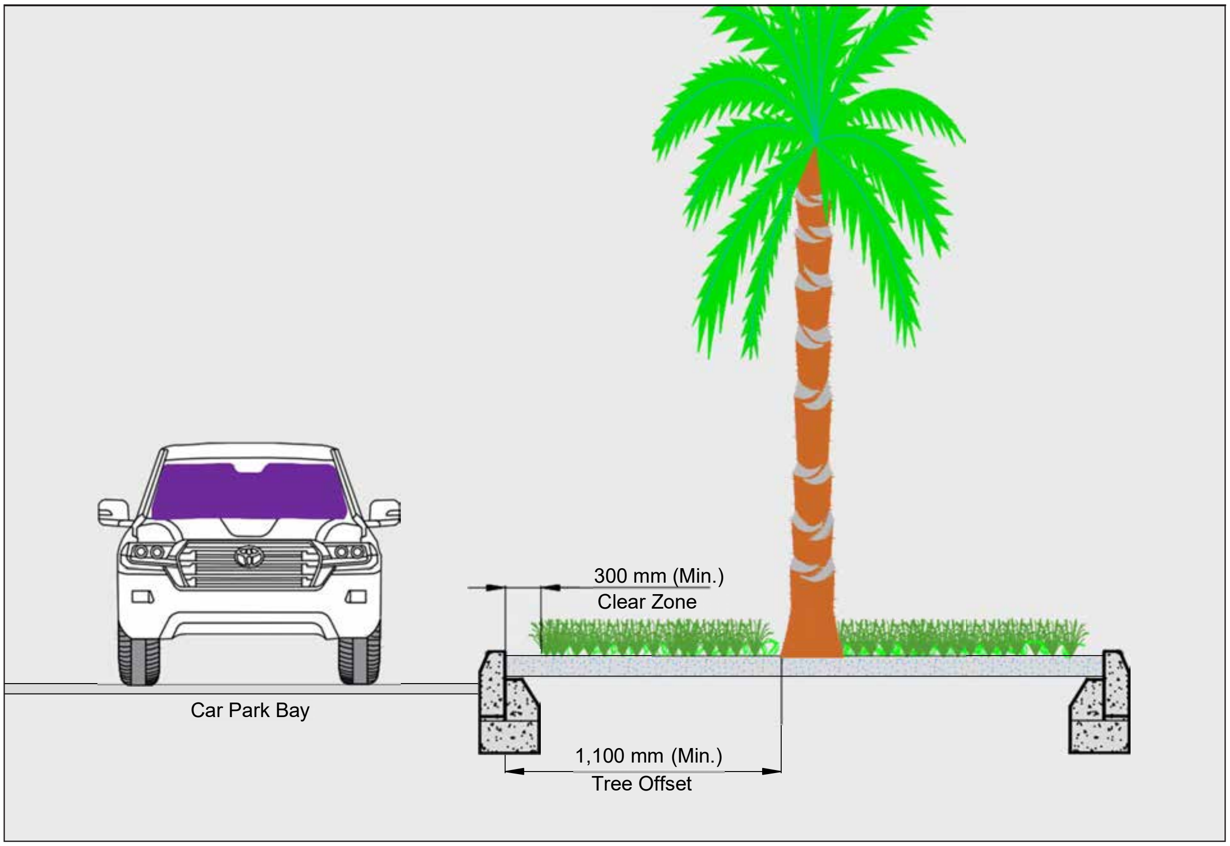


Figure 20-7 Vehicle Side Landscaping Clearance

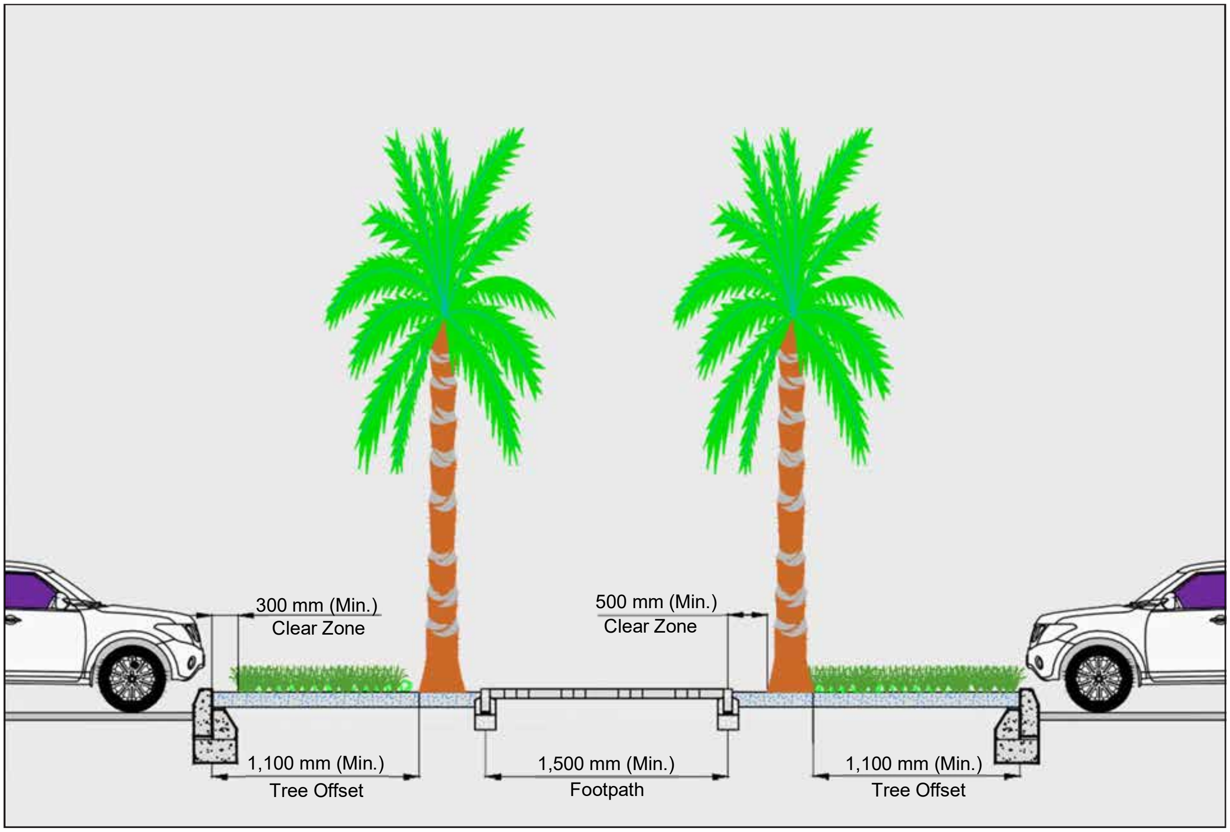


Figure 20-8 Sidewalk Landscaping Clearance

20.9 Column/Corner Guards

One of the important factors to consider in a parking structure is to guard the columns, walls, and vehicles from the impact as a result of any potential collision and scrapes. Use of appropriate guards is the most efficient and cost-effective way to minimize the impact in the incidence of a collision. These guards can be used on flat surfaces and rectangular or circular columns. The placement method including the height of placement of guards should be based on a safety audit. Use of other materials other than rubber and plastic should be justified and approved by the Overseeing Authority. There are generally two types of guards; one used to protect corners and the other used for columns or walls.

20.9.1 Column Corner Guards

The column corner guards, shown in **Figure 20-9**, are widely used on rectangular columns. They are used at high traffic areas, such as shopping malls, and public parking areas where there are potential hazards associated with vehicles, shopping carts, industrial trolleys, or forklifts. The following are the general design specifications:

- Width: 65 mm to 125 mm
- Height: 1,000 mm to 1,200 mm
- Color: Black and yellow (retro-reflective)
- Placement height: Generally, 10 cm from the finished floor level (to be confirmed through a safety audit)
- The design can be tailored based on site specific requirements

Rectangular column guards are shown in **Figure 20-9**.

Figure 20-9 Column Corner Guards

20.9.2 Column/Wall Guards

Flexible column or wall guard material is available in rolls and widely applied to round columns and walls. The following are the general design specifications:

- Height: 30 mm
- Length: 5,000 mm
- Width: 200 mm
- Placement height: Generally, 50 cm from the finished floor level (to be confirmed through a safety audit)
- Color: Black and yellow (retro-reflective)

Column guards are shown in **Figure 20-10**.

SOURCE: www.areasafe.com.au/rubber-column-guard/

Figure 20-10 Column/Wall Guards

20.10 Canopy Covered Parking

Parking canopies are commonly used to provide shade. References made in **Section 8** are applicable for canopy covered parking. It is advised that off-street accessible parking stalls, pick-up, and drop-of areas should be covered. Similarly off-street parking facilities with longer parking duration should be covered wherever possible. GSAS recommendations can be accommodated on a case-by-case basis in consultation with the Overseeing Authority.

Canopies consist of tensile fabric typically supported by frames or ties. Canopies provide shade from sun, wind, ultraviolet rays, and dust, help reduce heat build-up inside cars that can damage the windshield, car interior, and electronics, Canopies may not be suitable for locations with heavy winds.

The supporting frames of a canopy should not be placed at the sides of the aisle or driveway. A minimum clearance of 300 mm should be maintained from the face of the supporting frame to the parked or moving vehicle. The supporting frame dimensions should be considered along with other design guidelines when finalizing the parking layout. Typical canopy parking is presented in **Figure 20-11**.

Figure 20-11 Typical Canopy Parking

The following are different types of fabric material used for parking canopies:

High-Density Polyethylene (HDP) fabric is manufactured using high-quality materials for longer life. It is designed for maximum strength, durability, and protection. This fabric can withstand harsh weather and resist ultraviolet rays. It is one of the most cost-effective fabric shade materials.

Polyvinyl chloride (PVC) mesh is another popular and cost-effective canopy material that is designed to keep interior temperatures cooler during warm weather conditions. This type of fabric is used in area with high ultraviolet radiation. It is strong, durable, and long-lasting.

Polytetrafluoroethylene (PTFE) fabric is a Teflon®-coated fiberglass membrane material widely used in roofing and canopies. This material demonstrates high durability, strength, resistance to ultraviolet rays, and heat insulation.

20.11 Traffic Mirrors

A Traffic mirror is a convex mirror used to help see around blind and hidden corners, especially in parking garages and internal lanes. Traffic mirrors are suitable for both outdoor and indoor uses. Traffic mirrors should be used to enhance safety wherever a design solution limits site distance due to site or other constraints. Traffic mirrors can also be used to improve conditions in existing parking lots and garages. Provision of mirrors should be adopted in consultation with the Overseeing Authority. The following parameters should be considered:

- Mirrors can be wall-, ceiling-, or pole-mounted
- Angular coverage should have 160-degree wide-angle view

- A highly polished mirror refection that provides a better image quality
- A large curvature radius that minimizes distance distortion
- Appropriate diameter can be 30 cm to 100 cm depending on the site constraints
- Coverage distance from viewer to mirror and mirror to area being viewed should be 5 m to 60 m depending on the site conditions

20.12 Maintenance and Customer Services

A well-maintained and operated facility gives the appearance of good management. Well-lit and designed facilities with clear sight lines reduce the likelihood of vandalism or actions that threaten public safety.

A facility with a high-level of customer service ensures that customers feel confident and safe while leaving their car in the facility. Staff should have a clear understanding of their role in providing customercare.

A key customer service principle is ensuring availability of security personnel wearing uniforms and identification badges. Staff should be accessible on-site to customers. Customer service area should be well-marked and easily accessible to the customers. Staff assigned should be effective in communicating with the customers when information is sought.

Section 21

Parking Safety Audit

21: Parking Safety Audit

The Parking Safety Audit (PSA) is a thematic Road Safety Audit (RSA) in accordance with the Qatar Road Safety Audit Guide. It is a systematic and formal process to review the safety of a parking facility for all users. The audit qualitatively reports potential safety issues including identification areas, and opportunities to enhance the facility environment, safety, and user experience. This section details out the procedures to conduct PSA for new or existing parking facilities.

21.1 Scope

The main purpose of the PSA is to identify the potential safety concerns associated with the parking facility. The PSA can be conducted for all kinds of parking facility projects including redevelopment, or a new facility. The guidelines given in this section are general PSA guidelines valid across all facilities, though individual facility may require additional considerations based on its characteristics in the PSA. The audit team will be independent of the design team. The PSA will consider facility users, pedestrians, interface to the Right-of-Way (ROW) and operating environment irrespective of the parking facility demand. The outcomes of the audit should minimize the risk posed to all the users of the parking facility.

21.2 Stages

The PSA must be done in a coordinated manner to produce significant benefits at a reduced cost to the developer. Parking facility projects can be audited during the following stages:

- Concept Design
- Preliminary Design
- Detailed Design
- Pre-opening (after construction)
- Existing Facility

The PSA may not be required during the construction stage unless the parking facility is open to public during construction. The Client or the Overseeing Authority will mandate the audit at specific stage(s) as required.

21.3 Key Steps

The following steps must be included during a PSA process:

1. Project identification to be audited
2. Audit confirmation
3. Audit program and gateway process
4. Selection of Audit team
5. Audit briefing and approvals
6. Desktop study
7. Site visit
8. Draft report with decision tracking form
9. Audit debrief
10. Final report with decision tracking form
11. Audit close out

An overview of the parking facility audit process is shown in **Figure 21-1**.

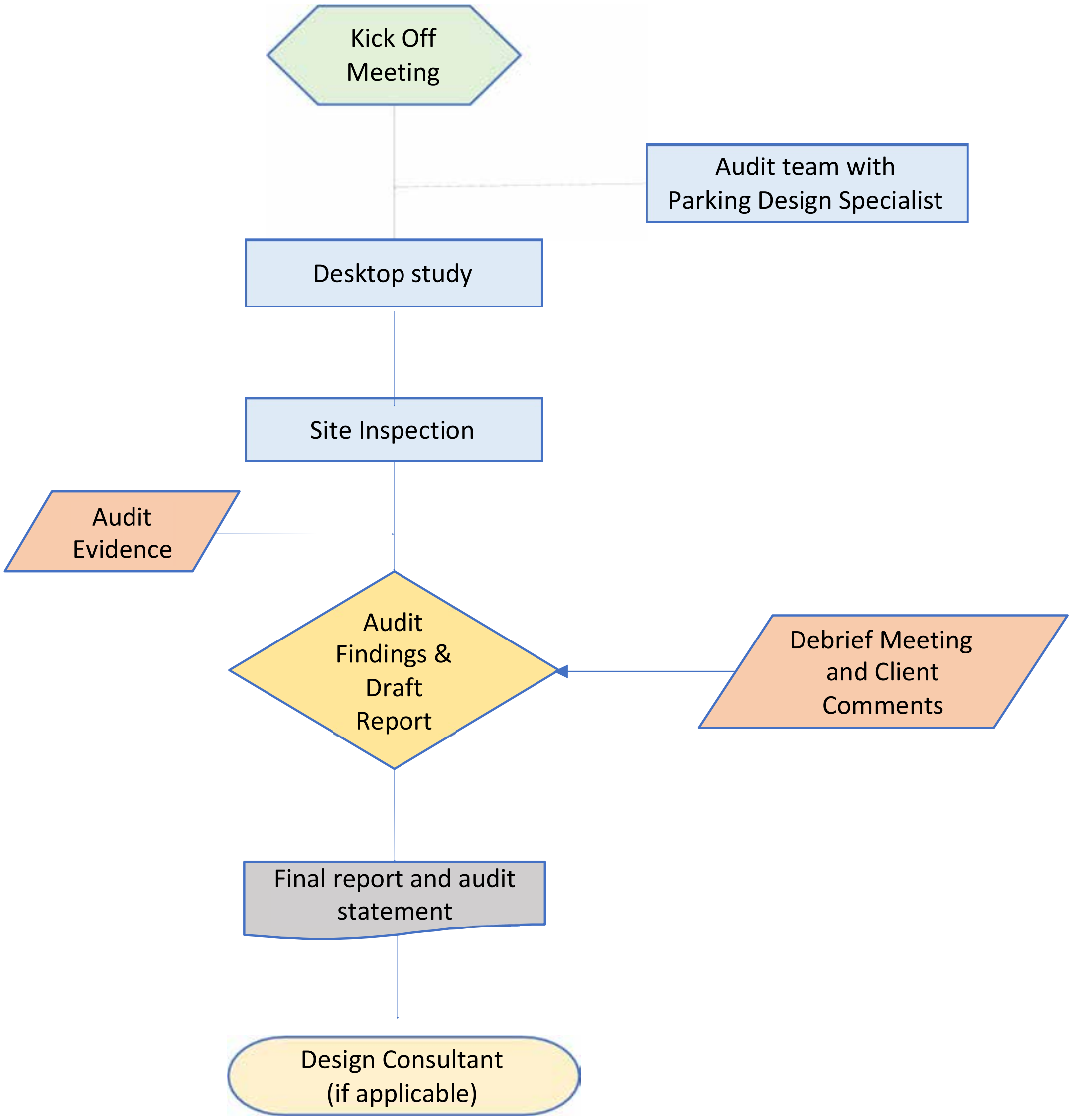


Figure 21-1 Parking Safety Audit Process

21.4 PSA Team and Roles

The following three parties with defined roles are involved in the audit process:

1. **Client Organization:** For public on-street and off-street parking facilities, the client organization is the authority responsible for the management of on-street and off-street parking facilities. For private parking facilities, the client organization is the entity responsible for the operation and maintenance of the facility. The client organization in coordination with the Overseeing Authority commissions the audit and decides on the recommendations of the audit team.

2. **Design Organization:** The design organization is responsible for the effective design of the parking facility. It is also expected that the design organization has road and parking safety engineering experience to ensure maximum safety of the design. The design organization may be instructed by the client organization to modify the design based on the audit report.

3. **Audit Team:** The audit team is commissioned by the client organization to perform the audit and produce an audit report that will identify potential safety concerns of the proposed or existing facility and resolve measures to mitigate the safety risk.

Road Safety Audit Guide should be referred to regarding the detailed roles and responsibilities of each party involved in the audit process. A parking design specialist should be called to perform as an expert advisor to the audit team and should have the following qualifications:

1. A degree in Transportation Engineering or related field
2. At least twenty years of experience in areas of parking design, technology, planning, and control systems
3. Well-versed knowledge on specifications, maintenance and operation procedures, traffic, and local safety standards, and International Best Practices
4. Experience of being the safety inspector/safety audit/expert witness for at least 5 parking facilities, with a minimum of one underground and one above ground parking garage.

21.5 Important Considerations for Audit

The Parking Safety specialist must consider all the guidelines for the design elements presented in the QPDM for both on-street and off-street parking facilities. Some of the key areas and issues to be reviewed in the PSA should include, but not limited to the following:

- Parking boundaries
- Signage
- Pavement Markings
- Lighting
- Access, ingress/egress, vehicle circulation, and traffic flow
- Speed calming measures
- Pedestrian movements
- Interface with other road users
- Interface to ROW
- Loading/unloading decks
- Sight distances
- Access/accessible parking compliance
- Security
- Other environment and management aspects

A checklist to be used as an aid in the PSA is presented in **Appendix C**.

21.6 Risk Assessment

The risk assessment and risk management methodology presented in this section should be adopted for a parking project in consultation with the Overseeing Authority. The definitions to be used for this risk assessment align with the pertinent ISO 31000 definitions and are presented in **Table 21-1**.

Table 21-1 Risk Management Definitions

Term	ISO 31000 Definition
Risk	Effect of uncertainty on objectives
Risk Management	Coordinated activities to direct and control an organization with regard to Risk
Risk Management Framework	Set of components that provide the foundations and organizational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management throughout the organization
Risk Management Policy	Statement of the overall intentions and direction of an organization related to risk management
Risk Management Plan	Scheme within the risk management framework specifying the approach, management components, and resources to be applied to risk management
Risk Attitude	Organization's approach to assess and eventually pursue, retain, take, or turn away from risk
Risk Identification	Process of finding, recognizing, and describing risks
Risk Assessment	Overall process of risk identification, risk analysis, and risk evaluation
Risk Analysis	Process to comprehend the nature of risk and determine the level of risk
Risk Evaluation	Process of comparing the results of risk analysis with risk criteria to determine whether the risk and/or its magnitude is acceptable or tolerable
Event	Occurrence or change of a particular set of circumstances
Likelihood	Chance of something happening
Consequence	Outcome of an event affecting objectives
Level of Risk	Magnitude of a risk or combination of risks expressed in terms of the combination of consequences and their likelihood
Risk Treatment	Process to modify risk
Control	Measure that is modifying risk
Residual Risk	Risk remaining after risk treatment
Monitoring	Continual checking, supervising, critically observing, or determining the status to identify change from the performance level required or expected

SOURCE: Adapted from Transportation Risk Management: International Practices for Program Development and Project Delivery, USDOT Report No. FHWA-PL-12-029, 2012.

Risk management usually involves a process of identification, analysis, evaluation, treatment and monitoring and review of uncertainties in a coordinated manner. The uncertainties (risks) are expected to be identified in conjunction with a parking safety audit process.

It is expected that a safety audit will be conducted periodically and there is a need to maintain a risk assessment register (or record) as a tool for risk management. Key elements of the risk register are rating, likelihood, and severity of risks. For monitoring of the risks, the risks identified in the risk register should be assigned to an appropriate owner in consultation with the Overseeing Authority. The rating or ranking of all identified risks are assessed based on the highest likelihood and severity. Likelihood and severity values are presented in **Table 21-2**.

Table 21-2 Values for Risk Likelihood and Severity

No.	Likelihood of Risk		No	Severity of Risk	
1	Extremely Unlikely	Highly improbable, never known to occur	1	Minor Risk	Minor damage or loss with no injury
2	Unlikely	Less than 1 per 10 years	2	Moderate Risk	Slight injury, moderate damage, or loss
3	Likely	Once every 5-10 years	3	Serious Risk	Serious injury, substantial damage, or loss
4	Extremely Likely	Once every 1-4 years	4	Major Risk	Fatal injury, major damage, or loss
5	Almost Certain	Once a year	5	Catastrophic Risk	Multiple fatalities, catastrophic damage, or loss

SOURCE: DMRB, GD 04/12, Standard for Safety Risk Assessment on the Strategic Road Network.

Risk ratings are identified based on the values presented in **Table 21-3**. The mitigation actions are identified based on an overall risk ranking and are assigned a color. This is known as the black, red, amber, green (BRAG) scoring system, with each color denoting a risk level.

Table 21-3 Table BRAG Risk Assessment Scoring System

Risk Assessment Rating Table		No.	Severity of the Hazard				
			Minor	Moderate	Serious	Major	Catastrophic
			1	2	3	4	5
Likelihood of the Risk	Extremely Unlikely	1	LOW	LOW	LOW	MEDIUM	MEDIUM
	Unlikely	2	LOW	LOW	MEDIUM	MEDIUM	HIGH
	Likely	3	LOW	MEDIUM	MEDIUM	HIGH	HIGH
	Extremely Likely	4	MEDIUM	MEDIUM	HIGH	CRITICAL	CRITICAL
	Almost Certain	5	MEDIUM	HIGH	CRITICAL	CRITICAL	CRITICAL

SOURCE: Adapted from Transportation Risk Management: International Practices for Program Development and Project Delivery, USDOT Report No. FHWA-PL-12-029, 2012.

Note:

Green: Low Overall Risk — Good; might need some refinement
Amber: Medium Overall Risk—Cause for concern; needs attention
Red: High Overall Risk—Highly problematic; requires urgent and decisive action
Black: Critical Overall Risk—Focused management attention is required

A sample list of risk areas and risk control measures is included in **Table 21-4.** These control measures are for the purpose of example only. In coordination with the Client Organization, the parking design specialist should consider site conditions, available technology, feasibility of the solutions, and other factors that control risk.

Table 21-4 Typical Parking Safety Concerns and Potential Mitigation Measures

No.	Areas or locations that pose risk	Potential Ways to Control Risk
1	• Vehicle route safety and condition • Slippery conditions	• Provide sufficient space to maneuver vehicles • Develop preventive maintenance and control measures • Maintain vehicle routes and keep surfaces free from oil, grease, debris and obstructions, etc.
2	• Poor line of sight for drivers and pedestrians • Inadequate reaction time to recognize and react to risks • Poor vehicle visibility	• Maintain line of sight at crossing locations, intersections, loading areas and pick-up/drop-off areas. Add or maintain lighting as required • Conduct preventive maintenance and repair

(table continued in next page)

Table 21-4 Typical Parking Safety Concerns and Potential Mitigation Measures (continued)

No.	Areas or locations that pose risk	Potential Ways to Control Risk
3	• Vehicle and Pedestrian Conflicts	• Consider one-way system • Consider barriers to separate vehicles/pedestrians • Provide and maintain separated pedestrian routes • Provide and maintain separated pedestrian crossings
4	• Poorly parked vehicles	• Enforce vehicle are parked inside bays only • Clearly mark and designate parking areas • Display parking restrictions and enforcement
5	• Vehicles, drivers, and speeds	• Enforce parking restrictions • Design self-enforced low speed environment • Post conspicuous speed signs. Supplement with road markings • Implement traffic calming measures
6	• Operations of Commercial and Delivery vehicles	• Prohibit unattended running commercial vehicles • Restrict commercial vehicles activities to designated areas • Convey restrictions and requirements to vehicle operators • Schedule commercial activities at off-peak hours • Designated goods delivery and collection points
7	• Lack of Security	• Install CCTV cameras and alarm systems in the parking facility • Install emergency call boxes • Communicate emergency escape plan in the event of a fire
8	• Entry and Exit	• Separate adjoining cyclist and pedestrian movements • Ensure vehicles can safely enter or join lane traffic

21.7 On-Street Parking Safety Audit

Safety audit for on-street parking facilities will normally be included in the RSA. No separate PSA for on-street parking facilities is usually required. Any new road projects or improvements to existing roads that include or impact the provision of on-street parking should be included as part of a standard RSA.

21.8 Common Considerations for PSA

The following presents some of the potential concerns which must be considered during the conduct of PSA.

- Structural columns not adequately away from the driveway
- Inadequate lighting at entrance of parking structures and at parking stalls
- Lack of adequate contrast between floor and wheel stops/curbs
- Lack of proper signage and marking
- Poor maintenance of the facility
- Accessible parking with no aisles and inadequate width
- Parking on traffic lanes
- Loading activity on footpath
- Lack of pedestrian facilities
- Lack of or misleading pedestrian signage
- Trash bins and other obstacles placed on-street
- Angled on-street parking with no buffer

A few examples of potential issues observed in the State of Qatar that should be considered in PSA are summarized in the **Table 21-5**.

Table 21-5 Observed Examples of Concerns to be Considered in Parking Safety Audit

 Inadequate parking signs. Columns are close to the driveway	 Poor design and low lighting
 Poor contrast, lighting, and poor signs and markings	 Poor maintenance, markings, and absence of wheel stops
 Vehicles parked within the sight triangle	 Accessible parking width is less than required standard with no accessible aisle, proper signage, and marking

(table continued in next page)

Table 21-5 Observed Examples of Concerns to be Considered in Parking Safety Audit (continued)

 Taxis parked in travel lane affecting traffic flow and safety	 Trash receptacles in on-street parking promote double parking and impact traffic flow, and safety
 Vehicle using parking space with unsafe loading practice and is encroaching the footpath	 45-degree parking with no buffer

Section 22

Departures from Standards

22: Departures from Standards

22.1 Introduction

This section provides guidelines and criteria that should be followed in regard to special cases where adherence to the design parameter(s) or standard(s) mentioned in the Qatar Parking Design Manual (QPDM) cannot be met. Such instances should exclusively be treated as Departures from Standards.

The designers are required to submit an application to the Overseeing Authority for any Departure from Standard. This application must be supported with the following information:

- Documentation upholding the reasons for the Departure
- Appropriate technical analysis of the potential operational and safety impacts of the Departure
- Identification of evidentially effective mitigation measures to address any potential adverse impacts

The designer or developer or owner should also be engaged with the Overseeing Authority to clarify any queries raised upon the scrutiny of the submitted documents. The Overseeing Authority reserves the right to accept or reject an application for Departures from Standards either partially or completely. The process for documentation and approval of Departures given in this section, is applicable for new parking facilities as well as upgradation of existing facilities. The process also applies for both on-street and off-street parking design also.

This section categorically explains:

- Descriptions and examples of indicative parking items or elements that might be considered for Departure from Standard.
- The procedures with sequential steps that need to be followed by the design organizations when applying to the Overseeing Authority for consideration of a Departure from Standard for any parking design project in the State of Qatar.
- The documentation needs along with appropriate type and depth of information to be submitted by the design organizations when applying for a Departure from Standard.
- The need for measuring performances post implementation of the Departures.
- Departure from Standard and respective mitigation measures that must be provided to the safety auditor for consideration as part of the PSA.

22.2 Departure from Standard

A Departure from Standard is a documented decision to design a parking element following the design criteria that does not meet the minimum values or ranges established for the given project. A Departure is thus a technical decision or action including administrative review and approval of that action.

The process of Departures from Standards enables the justified acceptance of a deviation from the prescribed standard. Such acceptances are conditioned by sufficient technical analysis and complete documentation of the reason for the deviation for future reference. A parking design project may proceed with any Departure from Standards only if the Overseeing Authority concludes that the Departure is acceptable, including appropriate mitigation measures.

Departure from Standard might be required when any of the criteria or parameters given in the manual pertaining to the design items or elements cannot be met. **Table 22-1** presents an indicative list with few design items or elements only, which might be considered for Departure from Standard. There may be other design items or elements, such as, sight distance at intersections, buffer space, parking angles, column spacing in structures, clearances, pedestrian path dimensions, ramp dimensions and clearances, minimum outside and inside radii, super-elevation, provision of on-street parking for higher category roads, incorporation of new technology, design vehicles, supporting infrastructure and safety requirements, etc., that might be raised and considered for Departure from Standard. It is highly recommended to discuss the respective design element with the Overseeing Authority and subsequently raise the application for the Departure from Standard.

Table 22-1 Indicative List of Departures from Standard for Design Items or Elements

No.	Design Items/ Elements	Trigger for Initiating Departures of Standards Process	Reference Section
1	Compact Cars	Provision of dedicated spaces for Compact Cars	4.2.1
2	Overhang	If parking stall dimensions are to be modified by providing no wheel stops	4.4
3	Vertical Clearance	Clear heights lower than that specified in this manual	4.1.3
4	Roadway Speed for On-Street Parking	Parking provided on roadways with posted speed greater than 50 kph.	5.3
5	Road Category for On-Street Parking	Parking provided on road categories major arterials and above	5.3
6	Parking Dimensions: Off-Street	Parking dimensions are different from the one estimated with the PDV (stall, aisle, angle, blind aisle, circulation width, etc.)	6
7	Valet parking	If the parking design parameters including stall dimensions and aisle widths, etc., are to be altered for valet operation	6.6.1
8	Stopping Sight Distance	Elements that do not meet the minimum stopping sight distance specified for the design speed	QHDM
9	Driveway Throat Lengths	Throat lengths that do not meet either the lengths mentioned in **Section 7.2.3** or calculated through traffic assessment	7.2.3
10	Grade and transition length	Access ramps grade and transition that do not meet the prescribed design standards	8.7.3

22.3 Departure from Standard - Procedures

The procedure that must be followed for any Departure from Standard involves multiple steps. These steps are presented in **Figure 22-1** and also explained in this section (**Section 22.3.1** to **22.3.6**). Departures from Standards are approved on a case-by-case basis because the location and the need for Departure from Standard for each project could be unique. Approval of a Departure from Standard for one project with a given design dimension does not guarantee an approval for a similar request for another project with different traffic and context features. The Overseeing Authority reserves the right for the final decision on a Departure from Standard which can either be an approval or a rejection.

Figure 22-1 Departure from Standard - Procedures

22.3.1 Identification and Justification for a Departure from Standard

Any parking facility should meet or exceed the design criteria specified in the QPDM. However, the factors that can cause Departures from Standards include, adverse impacts on existing parking structures, parking supply in smaller plots, land acquisition, project delivery, etc. Excessive construction costs may be cited as a consideration, but the reduction or savings in construction cost cannot merely be the justification for a Departure from Standard.

The identification, and justification for a Departure from Standard will require the designer to identify the Departure from Standard and justify it through a complete evaluation and documentation of the effects of adopting the QPDM design standards. This analysis establishes a threshold and baseline for judgment, and the ultimate justification for the acceptance of the proposed Departure from Standard. Any Departure from Standard may affect the operational quality or safety performance of the parking. At this stage, an initial consultation with the Overseeing Authority is required before proceeding to the next step.

Operational quality may involve reduced capacity, increased delay, or a restriction on the accessibility, or mobility for certain users. Any and all such estimated adverse effects should be evaluated and documented to the best possible abilities. The evaluation should include proposed mitigation measures that can be shown as being effective in addressing the specific identified adverse impact. The proposed mitigation measures and their cited effectiveness should be taken from reference to professional literature, research, and technical references cited in the QPDM.

22.3.2 Development and Evaluation of Multiple Alternatives

Multiple design alternatives must be developed and evaluated to address the requested Departure from Standard. These alternatives should address appropriately the issues related to parking elements and design criteria or minimum dimensions, parking requirements, parking supply, parking profile, parking layout, multimodal integration, pedestrian linkages, user needs, land requirements, impact on structures, integration of supporting infrastructure, safety and costs, etc. The evaluation should highlight the compliance with the QPDM and should be based on sound engineering judgments and evidences.

22.3.3 Risk Evaluation

The designer should evaluate the risks involved in meeting the design criteria and the alternatives to address the requested Departure from Standard. When developing an existing facility, the safety hazards, crash history and the types of crashes must be included for the evaluation. This process should evaluate and document the Departure from the design criteria, along with the probability of the safety or operational problems that may tend to develop due to any deviation from the design criteria. Another factor that influences the risk is the presence of two or more Departures from Standards that interact with each other at a particular location.

The over-riding objective of safety in the State of Qatar is to eliminate fatalities and serious injuries. Crash risk analyses should focus on crash types and conditions that create fatalities and serious injuries. A Departure from Standard that might cause increase in the severity of crashes should also be highlighted to the Overseeing Authority. Internationally peer-reviewed research has established the relationship of roadway design features with crash and injury risk. It is highly recommended that the designer accesses and applies such knowledge to enhance the quantitative assessment of any crash risk.

22.3.4 Evaluation of Mitigation Measures

Mitigation strategies should be accompanied along with the Departure from Standard requests. **Table 22-2** provides a list of mitigation strategies for few Departure from Standard cases. These are indicative and intended to initiate a thought process rather than to be followed without any trial and justification. The developer or the designer is expected to come up with the required mitigation strategies based on the type and scale of Departure from Standard associated with a particular parking facility.

Table 22-2 Indicative Mitigation Measures

Departure from Standard - cases	Suggested Mitigative Measure
Provision of Compact car parking spaces	• Dedicated parking spaces are earmarked for compact car parking • Continuous parking at a convenient location within the facility to ensure that compact car parking spaces does not mix with the normal parking • Use of appropriate signs
Inadequate Vertical Clearance	• Enforcement on certain vehicle types to be defined by the designer or developer • Measures to screen vehicles with heights above allowable limits before entering the parking structure • Signs at strategic locations for the restriction of certain vehicle types
On-street parking provision for roads with posted speeds greater than 50kph	• Parking locations to be clearly earmarked • Adequate Advance Warning signs and visible pavement marking • Road studs along the edge of the buffer lane • Adequate lighting • Information on restricted vehicles, if any
Inadequate Aisle width	• Clear and proper Warning signs and markings. • Signs for restriction or prohibition of oversized vehicles • Appropriate buffer area
Inadequate Stopping Sight Distance	• Advance warning signs, dynamic warning signs, additional "stop" or "yield" signs • Wider shoulder and clear recovery areas • Mirrors at the corners of the facility
Inadequate Driveway Throat Length	• Advance Warning signs • Sufficient "Stop" and "Yield" signs and pavement markings • Increase of access gate capacity • Incorporation of demand management techniques • Measure to increase the vehicle handling at the gates
Steeper Grade	• Additional Warning signs • Additional Rumble strips or speed bumps, where warranted • Signs and markings for access restriction

Mitigation measures must be evaluated for all Departure from Standard criteria that are being requested. A detailed understanding of the potential adverse impacts on the safety of the user and operations must be demonstrated.

22.3.5 Safety Auditing

A detailed safety analysis must be conducted by the approved Road Safety Auditor. This process should assess the Departure from Standard and review all the design parameters that might have an impact due to the departure in the design criteria. The Safety Auditor should also provide observations on the proposed departures. This is an essential report in the Departure of Standard procedures. General guidelines on safety audit for parking facilities are included in **Section 21**. List of authorized Safety Auditors will be obtained from the Overseeing Authority.

22.3.6 Review of the Overseeing Authority

The Overseeing Authority will review the submission of Departure from Standard and proposed mitigation measures. The authority holds the right to approve or reject the Departure from Standard, partially or completely. The following should be noted, with respect to the approved Departures from Standards:

- The approval of a Departure from does not preclude the Overseeing Authority from requesting for certain additional measures that need to be carried out at a future date, in relation to the given approvals.
- The approval of a Departure from Standard with or without comments does not imply that the Overseeing Authority relieves the design organization from the responsibility of the design.
- Departures from Standard are approved on a location-specific basis and related to the particular circumstances identified in each submission. A similar departure approval may be quoted to support a new application but will be evaluated based on its own merits.
- When the same Departure from Standard is proposed for use at more than one location then the Overseeing Authority may allow group Departure from Standard in certain clearly defined circumstances.

22.3.7 Coordination of Departures from Standard

It is the responsibility of the design organization to identify and track Departures from Standard for a project, submit the relevant documentation to the Overseeing Authority for review and approval. The design organization should also note and describe interaction of Departures from Standard if there are more than one. Early submission is advised because applications must be approved before the Departure from Standard is incorporated into the work.

22.4 Departures from Standard Documentation

Departures from Standard documentation should be submitted to the Overseeing Authority for the review and approval. The minimum documentation required for this purpose is presented in **Table 22-3**. **Figure 22-2** presents the template for filing Departure from Standard documentation. Additional information if required by the Overseeing Authority should also be provided to support the Departure from Standard.

Table 22-3 Departure from Standard Documentation

Item	Information to be Provided
Basic Information of Project Details	• General description of the project • Parking type and basic details of the parking • Details of the existing facility, if being upgraded • Identification of the location • Proposed parking layout
Item or Element and Design Criteria	• Design element(s) for which Departure from Standard is sought • Minimum value or range as per the standards. • Value being proposed
Justification	• Reasons for seeking Departure from Standard including any site constraint • Description and quantification of the costs and impacts involved in the fulfilment of the Design Criteria • Provision of tables, charts, and drawings as appropriate to illustrate and clarify the impact • Description of the other alternatives that were considered and potential impacts on safety and operations
Risk Assessment and Mitigation	• Perform risk assessment and record • Proposed mitigation measures being considered • Mitigation measures planned for implementation along with supporting reports and drawings
Safety Audit Report	• Safety auditor's report analyzing the risk assessment and safety aspects related to the application of Departure along with additional safety measures and recommendations in support of the Departure from Standard
Supporting Information	• Examples of similar situation and international practices • Any research and/or other Technical resources adopted as part of the evaluation process

Departure From Standard Document

Project: **Location:**

Project Number: **Designer:**

Design Parameter: **Date:**

Sl. No.	Details
1	**Basic Information of Project Details**
2	**Design Elements and Criteria**
3	**Justification**
4	**Risk Assessment and Mitigation**
5	**Safety Auditor Report**
6	**Supporting Information**
Recommendation	

Note: Each Design Exception is to be submitted with a separate template

Enclosure:

Design Report and Drawings

Road Safety Auditor Report

Road Safety Specialist

Approved ☐

Rejected ☐

Design Consultant **Overseeing Authority**

Figure 22-2 Documentation Template for Departure from Standard

22.5 Performance Monitoring

The final step in the Departure from Standard process is the monitoring of the parking facility after the construction and the documentation of the safety and operational performances of the Departure from Standard. The Overseeing Authority may ask for this information to be provided periodically for a specific duration.

For a parking facility which is constructed with a Departure of Standard, “Post Opening Parking Safety Audit” and “Existing Facility Parking Safety Audit” should be carried out by the owner or developer of the facility. These audits must ensure that the element departing from the standard will not be creating any operational and/or safety hazards, and that the recommended mitigations are satisfactory; otherwise, additional mitigation should be proposed to remediate any residual hazard.

It is advised that monitoring the data collected for a parking facility with a Departure from Standard, and mitigation measures implemented, can be analyzed and used for addressing similar problems that could be encountered in the future. This information can also be collated by the Overseeing Authority for further update of the QPDM.

Appendices

Appendix A

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Appendix B

Parking Design Checklists

Parking Design Checklists

OVERSEEING AUTHORITY

Qatar Parking Design Manual - Parking Design Checklists

Key points: Total 11 checklists, A to K

Separate sets of checklists for three different types of parking, on-street parking, off-street parking (at grade) and parking structure

Refer table below for confirming the applicability of each checklist for type parking

Applicability of Forms to Each Checklist

Forms	Feature	Relevant Section	On-Street Parking Checklist 1	Off-Street Parking Checklist 2	Off-Street Parking Structure Checklist 3
A	On-Street Parking	5	✓	X	X
B	Off-Street Parking	6	X	X	X
C	Parking Structure	8	X	✓	✓
D	Accessible Parking	11	✓	✓	✓
E	Pedestrian Access	12	X	✓	✓
F	Bicycle Parking	13	☆	☆	☆
G	Powered Two-Wheeler Parking	14	☆	☆	☆
H	Bus Parking	15	☆	☆	☆
I	Commercial Vehicle Parking	16	✓	☆	☆
J	Signage and Markings	17	✓*	✓*	✓*
K	Parking Construction Elements	20	✓*	✓*	✓*

NOTE:

✓ *Applicable : All the items in the checklist are applicable to the design of the particular parking facility type*

X *Not Applicable: Checklist is not relevant to the design of the particular parking facility type*

☆ *As Applicable : Checklist items applies only if the feature is included in the design of the particular parking facility type*

✓* *Relevant: Selected items in the checklist might only be relevant in the design of the particular parking facility type*

Appendix B

Submitted by: Date:

OVERSEEING AUTHORITY

Qatar Parking Design Manual - Parking Design Checklists	
Design Check List 1 - On-Street Parking Design	
Basic Information	
Major adjacent land use:	
Frontage of Roadway (Commercial/Retail):	
Parking design Vehicle and parameters:	
(i) Cars:	
(ii) Powered Two-Wheeler:	
Bus stop type:	
Other information, if any:	

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standard (Yes / No)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
A	**On-Street Parking**					
A1	Main road posted speed criteria					
A2	Proposed angle of parking					
A3	Distance between Point of Tangent (PT) of the curve and the beginning of parking bay taper on major road					
A4	Distance between Point of Tangent (PT) of the curve and the beginning of parking bay taper on minor road					
A5	Distance between beginning of parking bay taper and midblock pedestrian crossing					
A6	Distance between Point of Tangent (PT) of the curve of the driveway and the beginning of parking bay taper					
A7	Distance of on-street parking from fire hydrant					
A8	Distance between Point of Tangent (PT) of the curve/bend and the beginning of parking bay taper on the outer side of the curve/bend					
A9	Distance between Point of Tangent (PT) of the curve/bend and the beginning of parking bay taper on the inner side of the curve/bend					
A10	Length of parking stall					
A11	Width of parking stall					
A12	Curb length of parking stall					
A13	Buffer width between on-street parking and adjacent traffic lane					
A14	Width of through lane					

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standard (Yes / No)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
A15	Total width of road (including parking lane)					
A16	Length of the taxi rank					
A17	Effective sidewalk width at the taxi rank					
B	**Off-street Parking**	**Not applicable**				
C	**Off-street Parking Structure**	**Not applicable**				
D	**Accessible Parking**					
D1	Walking distance of accessible parking space from the destination					
D2	Angle of accessible parking space					
D3	Width of the accessible parking space					
D4	Length of the accessible parking space					
D5	Width of access aisle					
D6	Length of van-accessible parking space					
D7	Width of van-accessible parking space					
D8	Width of access aisle for van-accessible parking space					
E	**Pedestrian Access**					
E1	Width of sidewalk					
F	**Bicycle Parking**					
F1	Distance of the bicycle parking hubs from the nearest public transportation station or entrance					
F2	Effective sidewalk width					
F3	Distance between racks (end-to-end)					

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standard (Yes / No)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
F4	Distance between racks (side-to-side)					
F5	Minimum clearance to parked cars					
F6	Clearance of bicycle racks from a curb					
F7	Clearance of bicycle racks from a wall					
F8	Clearance of bicycle racks from a utility cover					
F9	Clearance of bicycle racks from a fire hydrant					
G	**Powered Two-Wheeler Parking**					
G1	Width of the stall					
G2	Length of the stall					
H	**Surface Bus and Coach Parking**					
H1	Length of bus stop including taper					
H2	Width of bus stop					
I	**Commercial Vehicle Parking**	**Not Applicable**				
J	**Signage and Markings**					
J1	Signs for general parking without time limit		X			
J2	Signs for mosque parking		X			
J3	Signs for no waiting, loading and unloading		X			
J4	Signs for prohibition of waiting		X			
J5	Signs for no waiting except taxis, ambulances, or police vehicles		X			
J6	Signs for no waiting by trucks and buses		X			
J7	Signs for tow away zone		X			

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standard (Yes / No)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
J8	Signs for police vehicles		X			
J9	Signs for accessible parking		X			
J10	Signs for limited waiting		X			
J11	Signs for permit parking		X			
J12	Signs for pay and display parking		X			
J13	Signs for shared use parking		X			
J14	Signs for drop-off and pick-up		X			
J15	Signs for prohibited parking		X			
J16	Signs for bicycle parking		X			
J17	Signs for powered two-wheeler parking		X			
J18	Signs for bus stop		X			
J19	Signs for electric vehicle parking		X			
J20	Signs for buffer zone		X			
J21	Signs for resident permit zone		X			
J22	Signs for paid parking		X			
J23	Signs for parking and pay zone		X			
J24	Signs for parking rates		X			
J25	Signs related to payment at parking lot		X			
J26	Pavement marking for parking		X			
J27	Pavement marking for electric vehicle parking		X			
J28	Pavement marking for accessible parking		X			
K	**Parking Construction Elements**					
K1	Lighting design		X			
K2	Surface drainage design		X			

Submitted by: Date:

OVERSEEING AUTHORITY

Qatar Parking Design Manual - Parking Design Checklists	
Design Check List 2 - Off-Street Parking Design	
Basic Information	
Land use:	
Total Number of parking spaces:	
Parking design Vehicle	
(i) Cars:	
(ii) Powered Two-Wheeler:	
(iii) Bus:	
(iv) Truck:	
Speed reducing type:	
Access control Type:	
Pavement Type:	
Other information, if any:	

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standard (Yes / No)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
A	**On-Street Parking**	**Not Applicable**				
B	**Off-Street Parking**					
B1	Length of parking stall					
B2	Width of parking stall					
B3	Width of parking aisle					
B4	Length of blind aisle					
B5	Width of circulation roadway					
B6	Number of access lanes					
B7	Driveway throat length					
B8	Queuing length					
B9	Design Speed					
B10	Width of driveway					
B11	Radius of driveway					
B12	Length of taxi rank					
B13	Length of passenger pick-up/ drop-off					
B14	Length of commercial vehicle pick-up/drop-off					
C	**Off-Street Parking Structure**	**Not Applicable**				
D	**Accessible Parking**					
D1	Walking distance of accessible parking space from the destination					
D2	Angle of accessible parking space					
D3	Width of the accessible parking space					

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standard (Yes / No)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
D4	Length of the accessible parking space					
D5	Width of access aisle					
D6	Length of van-accessible parking space					
D7	Width of van-accessible parking space					
D8	Width of access aisle for van-accessible parking space					
E	**Pedestrian Accessibility**					
E1	Separate entry and exit for pedestrian and vehicular movement		X			
E2	Positioning of pedestrian crossing points with the traffic flow		X			
E3	Raised pedestrian footpaths provided		X			
E4	Dropped curb provided where warranted		X			
E5	Width of pedestrian path					
E6	Walking distance between the parking space and nearest pedestrian entrance					
F	**Bicycle Parking**					
F1	Distance of the bicycle parking hubs from the nearest public transportation station or entrance					
F2	Effective walkway width					
F3	Distance between racks (end-to-end)					
F4	Distance between racks (side-to-side)					

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standard (Yes / No)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
F5	Minimum clearance to parked cars					
F6	Clearance of bicycle racks from a wall					
F7	Clearance of bicycle racks from any other adjacent solid feature					
G	**Powered Two-Wheeler Parking**					
G1	Width of the stall					
G2	Length of the stall					
H	**Bus Parking**					
H1	Angle of parking					
H2	Length of parking stall					
H3	Width of parking stall					
H4	Width of aisle					
I	**Commercial Vehicle Parking**					
I1	Length of parking stall					
I2	Width of parking stall					
I3	Width of aisle					
I4	Width of driveway					
I5	Radius of driveway					
J	**Signage and Markings**					
J1	Signs for accessible parking		X			
J2	Signs for bicycle parking		X			
J3	Signs for powered two-wheeler parking		X			
J4	Signs for drop-off and pick-up		X			
J5	Signs for speed limits		X			

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standard (Yes / No)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
J6	Signs for pedestrian path		X			
J7	Signs for electric vehicle parking		X			
J8	Signs restricting mosque parking		X			
J9	Signs for reserved parking		X			
J10	Signs for family parking		X			
J11	Signs for ladies parking		X			
J12	Signs for expectant mothers parking		X			
J13	Signs for way out		X			
J14	Signs for payment at parking lot		X			
J15	Signs for parking durations		X			
J16	Signs for speed humps		X			
J17	Signs for paid parking		X			
J18	Signs for parking rates		X			
J19	Signs for parking and pay zone		X			
J20	Signs for CCTV surveillance		X			
J21	Pavement marking for parking		X			
J22	Pavement marking for electric vehicle parking		X			
J23	Pavement marking for special use parking		X			
J24	Pavement marking for accessible parking		X			
J25	Pavement marking for Circulation direction		X			
J26	Pavement marking for speed limit		X			

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standard (Yes / No)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
J27	Pavement marking for pedestrian crossings		X			
J28	Pavement marking for reserved parking		X			
K	**Parking Construction Elements**					
K1	Pavement design		X			
K2	Surface drainage design		X			
K3	Lighting design		X			

Submitted by: Date:

OVERSEEING AUTHORITY

Qatar Parking Design Manual - Parking Design Checklists	
Design Check List 3 - Parking Structure Design	
Basic Information	
Land use:	
Total Number of parking spaces:	
Parking design Vehicle	
(i) Cars:	
(ii) Powered Two-Wheeler:	
(iii) Bus:	
(iv) Truck:	
Speed reducing type:	
Access control Type:	
Pavement Type:	
Structure Type:	
Ramp Type:	
Other information, if any:	

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standards (Y/ N)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
A	**On-Street Parking**	**Not Applicable**				
B	**Off-Street Parking**	**Not Applicable**				
C	**Off-Street Parking Structure**					
C1	Angle of Parking Stall					
C2	Length of parking stall					
C3	Width of parking stall					
C4	Length of blind aisle					
C5	Headroom					
C6	Number of access lanes					
C7	Driveway throat length					
C8	Queuing length					
C9	Design Speed					
C10	Width of driveway					
C11	Radius of driveway					
C12	Length of taxi rank					
C13	Length of passenger pick-up/drop-off					
C14	Length of commercial vehicle pick-up/drop-off					
C15	Width of circulation roadway					
C16	Minimum distance of column from the aisle edge					
C17	Width of ramps					
C18	Minimum inner radius of ramps					
C19	Minimum outer radius of ramps					
C20	Grades for ramps					
D	**Accessible (Mobility Impaired) Parking**					
D1	Walking distance of accessible parking space from the destination					
D2	Angle of accessible parking space					

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standards (Y/ N)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
D3	Width of the accessible parking space					
D4	Length of the accessible parking space					
D5	Width of access aisle					
D6	Length of van-accessible parking space					
D7	Width of van-accessible parking space					
D8	Width of access aisle for van-accessible parking space					
E	**Pedestrian Accessibility**					
E1	Separate entry and exit for pedestrian and vehicular movement		X			
E2	Positioning of pedestrian crossing points with the traffic flow		X			
E3	Raised pedestrian footpaths provided		X			
E4	Dropped curb provided where warranted		X			
E5	Width of pedestrian path					
E6	Walking distance between the parking space and nearest pedestrian entrance					
E7	Pedestrian refuge area		X			
E8	Clearly defined emergency exits and routes		X			
E9	No. of emergency exits					
E10	Travel distance to the emergency exits					
E11	Width of emergency escape route					
F	**Bicycle Parking**					
F1	Distance of the bicycle parking hubs from the nearest public transportation station or entrance					
F2	Effective walkway width					

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standards (Y/ N)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
F3	Distance between racks (end-to-end)					
F4	Distance between racks (side-to-side)					
F5	Minimum clearance to parked cars					
F6	Clearance of bicycle racks from a wall					
F7	Clearance of bicycle racks from any other adjacent solid feature					
G	**Powered Two-Wheeler Parking**					
G1	Width of the stall					
G2	Length of the stall					
H	**Bus Parking**					
H1	Angle of parking					
H2	Length of parking stall					
H3	Width of parking stall					
H4	Width of aisle					
I	**Commercial Vehicle Parking**					
I1	Length of parking stall					
I2	Width of parking stall					
I3	Width of aisle					
I4	Width of driveway					
I5	Radius of driveway					
J	**Signage and Markings**					
J1	Signs for accessible parking		X			
J2	Signs for bicycle parking		X			
J3	Signs for powered two-wheeler parking		X			
J4	Signs for drop-off and pick-up		X			
J5	Signs for speed limits		X			
J6	Signs for pedestrian path		X			

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standards (Y/ N)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
J7	Signs for electric vehicle parking		X			
J8	Signs restricting mosque parking		X			
J9	Signs for reserved parking		X			
J10	Signs for family parking		X			
J11	Signs for ladies parking		X			
J12	Signs for expectant mother's parking		X			
J13	Signs for direction to lift and escalators		X			
J14	Signs for parking bay identification		X			
J15	Signs for way out		X			
J16	Signs for payment at parking lot		X			
J17	Signs for parking durations		X			
J18	Signs for speed humps		X			
J19	Signs for paid parking		X			
J20	Signs for parking rates		X			
J21	Signs for parking and pay zone		X			
J22	Signs for CCTV surveillance		X			
J23	Signs for fire extinguisher		X			
J24	Signs for fire exit		X			
J25	Signs for emergency intercom		X			
J26	Signs for pedestrian escape route		X			
J27	Wayfinding signs		X			
J28	Signs for low vertical clearance		X			
J29	Signs for steep grade		X			
J30	Signs for dead end		X			
J31	Signs for hazard warning		X			
J32	Pavement marking for parking		X			
J33	Pavement marking for electric vehicle parking		X			

Forms	Description	Applicable (Y/N)	Value specific to the project	Meets Standards (Y/ N)	Comments (If standard is not met)	Overseeing Authority Approval (Y/N)
J34	Pavement marking for accessible parking		X			
J35	Pavement marking for pedestrian paths		X			
J36	Pavement marking for bicycle paths		X			
J37	Pavement marking for powered two-wheeler parking		X			
J38	Pavement marking for reserved parking		X			
J39	Pavement marking for circulation direction		X			
J40	Pavement marking for speed limit		X			
J41	Pavement marking for pedestrian crossings		X			
K	**Parking Construction Elements**					
K1	Pavement design		X			
K2	Surface drainage design		X			
K3	Lighting design		X			
K4	Drainage design for piped systems		X			
K5	Fire safety design		X			
K6	Ventilation design		X			
K7	Airconditioning design		X			
K8	Column guards		X			

Appendix C

Parking Safety Audit Checklists

Parking Safety Audit Checklists

Submitted by:

OVERSEEING AUTHORITY

Parking Safety Audit Checklist	
Basic Information	
Location of the facility:	
Number of parking spaces:	
Land use served by the facility:	
Functionality of the development associated with the parking facility:	
Other information, if any:	

Parking Safety Audit Checklist					
Checklist	**Description**	**Applicable (Y / N)**	**Meets Criteria**	**Needs Improvement**	**Remark**
A	**On-Street Parking**				
A1	On-street parking is suitable for the road category				
A2	On-street parking is as per QPDM guidelines considering the posted speed				
A3	Angle of parking is as per QPDM guidelines				
A4	Parking stall dimension (length, width) is as per QPDM guidelines				
A5	Adequate number of accessible parking available				
A6	Accessible parking is located appropriately				
A7	Angle of accessible parking is as per QPDM guidelines				
A8	Access aisle and curb ramps provided for accessible parking				
A9	Curb ramp position does not interfere with sidewalk usage				
A10	Adequate sidewalk space beyond curb ramps available				

Parking Safety Audit Checklist					
Checklist	**Description**	**Applicable (Y / N)**	**Meets Criteria**	**Needs Improvement**	**Remark**
A11	Adequate buffer width provided				
A12	Parking not observed on painted or channelized islands or sidewalks				
A13	Parking not provided in sharp curves or bends				
A14	Adequate sight distance available for parking near bends/curves				
A15	Parking not provided within the sight triangle				
A16	Parking provided at minimum distance from intersection				
A17	Parking provided at minimum distance from pedestrian crossings				
A18	Parking provided at minimum distance from fire hydrants				
A19	Bus stops located appropriately				
A20	Bus stop length and width are in line with QPDM guidelines				
A21	Adequate length for taxi rank available				
B	**Off-Street Parking**				
B1	Parking facility adequately signed on the external approach roads				
B2	Parking facility ownership clearly displayed				
B3	User terms and conditions clearly displayed				
B4	Parking Facility located away from intersection influence area				
B5	No obstructions to sight lines at entrance, exit or at key decision points				
B6	Adequate sight distance available for access driveway				
B7	Adequate driveway throat length available				
B8	Adequate width of driveway available				
B9	Adequate radius of driveway available				
B10	Adequate queuing length available				
B11	Posted design speed is suitable for the facility				
B12	Adequate number of access lanes available				
B13	Access control location is suitable				
B14	The access control type and access lanes are adequate to serve the peak traffic				

QATAR PARKING MASTER PLAN
QATAR PARKING DESIGN MANUAL

Parking Safety Audit Checklist					
Checklist	**Description**	**Applicable (Y / N)**	**Meets Criteria**	**Needs Improvement**	**Remark**
B15	Adequate land width available at the access control				
B16	Power back up available for automatic boom operation				
B17	No obstructions on the circulation roadway				
B18	Adequate circulation roadway width available				
B19	Aisle width is as per QPDM				
B20	Parking stall dimensions are as per QPDM guidelines				
B21	Length of blind aisle is as per QPDM guidelines				
B22	Blind spots are absent on mitigated suitably				
B23	Taxi rank provided at suitable location and safe for operation				
B24	Adequate length for taxi rank provided				
B25	Adequate length for passenger pick-up/ drop-off provided				
B26	Adequate queuing length available at exit				
B27	Adequate number of accessible parking stalls available				
B28	Speed reducing features are in line with QPDM guidelines				
B29	Ramp widths are in line with QPDM guidelines				
B30	Ramp radii are in line with QPDM guidelines				
B31	Ramp grades are in line with QPDM guidelines				
B32	Adequate headroom available				
B33	Adequate storage area for shopping carts available				
B34	Dedicated loading/unloading areas available				
B35	Dedicated pick up/drop off areas available				
B36	Dedicated access to different parking zones provided				

Parking Safety Audit Checklist					
Checklist	**Description**	**Applicable (Y / N)**	**Meets Criteria**	**Needs Improvement**	**Remark**
C	**Accessible Parking and Pedestrian Facilities**				
C1	Angle of accessible parking is as per QPDM guidelines				
C2	Wider stalls and access aisle available for accessible parking				
C3	Proper curb ramps available for accessible parking				
C4	Accessible parking spaces located close to destination				
C5	Safe access available to and from accessible parking stalls				
C6	Access aisle and curb ramps provided for accessible parking				
C7	Curb ramp position does not interfere with pedestrian path usage				
C8	Adequate pedestrian path space available beyond curb ramp				
C9	Adequate pedestrian path width available				
C10	Pedestrian path does not conflict with traffic movement				
C11	Pedestrian paths are free of obstructions				
C12	Pedestrian entry and exit are separate from that for vehicles or are segregated using effective physical means, e.g. bollards, curbs and railings				
C13	Dropped curbs available at pedestrian crossing points				
C14	Pedestrian refuge area available in the parking facility				
C15	Wheel stops and other physical obstructions does not pose tipping hazard to pedestrians				
D	**Bicycle and Powered Two-Wheeler Parking**				
D1	Dedicated parking area available for bicycle parking				
D2	Bicycle parking area is well lit safely positioned				
D3	Adequate vertical clearance for bicycle routes available				
D4	Bicycle racks have high visibility and located close to pedestrian access				
D5	Bicycle racks does not contain any protruding elements or sharp edges				

Parking Safety Audit Checklist					
Checklist	**Description**	**Applicable (Y / N)**	**Meets Criteria**	**Needs Improvement**	**Remark**
D6	Adequate clearance available between bicycle racks and obstructions like wall, curb, nearest parked vehicle, garbage bin, landscaping etc.				
D7	Dedicated parking area available for powered two-wheelers				
D8	Parking stall dimensions of powered two-wheelers is as per QPDM guidelines				
D9	Powered two-wheeler parking area is well lit and safely positioned				
E	**Bus Parking**				
E1	Adequate access width available				
E2	Angle of parking is suitable				
E3	Parking stall dimensions are as per QPDM guidelines				
E4	Pedestrian paths are well segregated				
E5	Parking for other modes are segregated				
E6	Safe access to and from other parking areas available				
F	**Truck Parking**				
F1	Driveway radius and width are in line with QPDM guidelines				
F2	Angle of parking is suitable				
F3	Parking stall dimensions are as per QPDM guidelines				
F4	Pedestrian paths are well segregated				
F5	Parking for other modes are segregated				
F6	Safe access to and from other parking areas available				
G	**Signs and Markings**				
G1	All relevant signs and marking for parking area available in line with QPDM guidelines				
G2	All signs and markings satisfy the elements of good signage and marking				
G3	Signs are clearly visible				
G4	Signs are legible				
G5	Signs are reflective where required				
G6	Are signs installed at appropriate locations				

Parking Safety Audit Checklist					
Checklist	**Description**	**Applicable (Y / N)**	**Meets Criteria**	**Needs Improvement**	**Remark**
G7	Signs located clear of any pedestrian and vehicular paths				
G8	Adequate signage and markings for accessible parking available				
G9	Signs and markings for accessible parking meets Americans with Disabilities Act (ADA) standards				
G10	Adequate pavement markings for drivers available				
G11	Pedestrian crossings are marked appropriately				
G12	Signs and markings for emergency vehicles available				
G13	Signs for vehicle entry/exit is clear and legible				
G14	Signs and markings for pedestrian movement is clear and legible				
G15	Pavement marking does not pose a tripping hazard for pedestrians				
G16	Appropriate signs and markings at blind aisles are available				
G17	Adequate signage available at blind spots				
G18	Are there mirrors and/or signs at blind spots?				
G19	Signs for emergency intercom, fire extinguisher etc. provided				
G20	Signs related to paid parking, parking fee, payment mode, location of payment machines etc. are available, clear and legible				
G21	Variable message signs are available and working				
H	**Surface**				
H1	Parking facility is paved				
H2	Pavement is in good condition				
H3	The surface is without undulations				
H4	Surface is free from oil and debris				
H5	Slip resistant surface provided for pedestrians				
H6	Slip resistant surface provided at ramps				

Parking Safety Audit Checklist					
Checklist	**Description**	**Applicable (Y / N)**	**Meets Criteria**	**Needs Improvement**	**Remark**
H7	Are designated surfaces (stalls, travel lane, pedestrian routes) color coded?				
H8	Adequate provisions for draining off surface water available				
I	**Safety and Security**				
I1	The facility is well lit with no dark spots				
I2	All lights, light fixtures, poles are in good condition				
I3	Enforcement/monitoring systems are in place and in working conditions				
I4	Fire safety alarms available and working				
I5	Ventilation and air conditioning systems available and working				
I6	Adequate number of emergency exits provided				
I7	Emergency exit routes are clearly defined and devoid of obstructions				
I8	Adequate access available for emergency vehicles (fire, police, ambulance)?				
I9	Parking facility/structure meet requirements of civil defense procedures?				
I10	Mitigative measures like mirrors adopted at blind spots				
I11	Column guards are provided and in good condition				
I12	Payment machines are conveniently located suitable for wheelchair users				
I13	Fire extinguishers are available, clearly visible and easy to access				
I14	CCTV coverage area is well lit with no obstructions				

Appendix D

Glossary

Glossary

85th Percentile Vehicle

It is the vehicle whose dimensions are more than 85% of vehicles expected to occupy the parking facility.

Or

It is the dimensions that 85% of the vehicles within a car park would not exceed.

Access Road

A road providing access to a local area or individual properties from a local or distributor roads.

Access driveway

An access from a public way to adjacent properly.

Accessible parking

Parking for the disabled or mobility-impaired individuals.

Accessible Route

An accessible route is a continuous unobstructed path connecting accessible parking spaces to a destination, like a building, or a site.

Aisle

A space in a parking lot between rows of parking spaces that vehicles use to drive into and out of the spaces.

Angled Parking

Parking in which the vehicle is aligned at an angle to the curb or, to the axis of the aisle in a parking lot.

Application Programming Interface (API)

API is a system of tools and resources in an operating system, enabling developers to create software applications.

Automated Parking System

An Automated Parking System (APS) is a mechanical system designed to minimize the area and/or volume required for parking cars. Like a multistory parking garage, an APS provides parking for cars on multiple levels stacked vertically to maximize the number of parking spaces while minimizing land usage.

Autonomous Vehicle

A self-driving vehicle that is capable of sensing its environment and moving with little or no human input.

Auxiliary Lane

A lane other than a through lane used to separate entering, exiting or turning traffic from through traffic.

Base Layer

The base course is the layer of material immediately beneath the surface of binder course and it provides additional load distribution and contributes to the subsurface drainage. It may be composed of crushed stone, crushed slag, or other untreated, or stabilized materials.

Bicycle (Bike)

A vehicle having two tandem wheels and propelled solely by human power upon which any person may ride.

Bicycle Path

A way or separated part of a road provided for the sole use of cyclists.

Blue Badge Holder

A Blue Badge Holder on the vehicle represents the vehicle is used by persons with disabilities either as a passenger or driver.

Bollard

A post of stout appearance used on a traffic island, pedestrian refuge, or beside a roadway to deter vehicles from encroaching into a pedestrian area.

Breeching Inlets

The inlet used by the fire brigade personnel to access water. It is normally dry but is used to pump water by connecting to firefighting equipment. Breeching inlets are also commonly known as a Fire Department Connection.

Buffer Lane

A user-specific lane or other special-purpose lane that is separated from the adjacent general-purpose lane(s) by a pattern of standard longitudinal road markings that are wider than normal lane line markings.

Buffer Zone

The buffer zone is the area between the edge of the traveled way and the nearest part of the parking stall.

Building Management Systems

A BMS, also known as a Building Automation System (BAS), is a computer-based control system, installed in buildings to control and monitor mechanical and electrical equipment, including, ventilation, lighting, power, fire, and security systems.

Bus Lay-By

A locally widened area of pavement at a bus stop which allows a bus to stand clear of the travel way. Also referred to as a bus turnout.

Bus Layover Area

The bus layover area is an area used for temporary holding for bus, and where there is no passenger movement.

Bus Station

Bus station is the place meant for city buses to start and end a trip.

Bus Stop

A bus stop is a designated place where buses stop for passengers to get on and off the bus.

California Bearing Ratio

The California Bearing Ratio (CBR) is the ratio of the resistance to penetration developed by a subgrade soil to that developed by a specimen of standard crushed stone base material. The resistance of the crushed stone under standardized conditions is well established. The objective of a CBR test is to determine the relative resistance of the subgrade material under the same conditions.

Central Business District (CBD)

Central Business District, also referred to as the downtown area where generally the business and commercial activities are dominant.

Circulation Efficiency

Circulation efficiency of a parking layout on a single deck is defined as the percent ratio of travel distance required to search all parking stalls in the deck to the minimum travel distance between parking stalls, where the minimum travel distance is equal to half.

Clearway

Clearway refer to stretches of road or street where parking is prohibited and there is no obstruction of movement.

Clear Zone

The unobstructed, relatively flat area provided beyond the edge of the travelled way for the recovery of errant vehicles. The clear zone includes any shoulders or auxiliary lanes.

Column / Corner/ Wall Guard

This is a material which guards the columns, walls, and vehicles from the impact as a result of any potential collision and scrapes.

Controlled Zone Parking (CZP)

A Controlled Zone Parking or Controlled Parking Zone (CPZ) is an area where parking is only allowed on certain parts of the road for a limited time. Different types of control, such as, parking permit, tariff, enforcement etc. may be applied in these Controlled Zones.

Conflict (conflicting)

Where two or more traffic movements cannot be given right-of-way simultaneously due to the likelihood of a crash.

Controller (Parking Lot Controller)

Installed at the front of every parking space to display the current parking space status. If the indicator displays red, it signals that there is a car parked.

Curb Extension

A curb extension is a traffic calming measure that includes extending sidewalks to shorten pedestrian crossing distances and improving visibility between drivers and pedestrians where parked cars may limit visibility.

Design Hourly Volume

A volume determined for use in design representing the traffic that is expected to use the highway in any designated year. It is an hourly volume usually the 30th highest hourly volume expected during the design year.

Desire Line

Route chosen by road user irrespective of the presence of a route, path, or other facility.

Detector

A part of vehicle detecting equipment that initiates the process of detection when traversed by a vehicle. This is usually laid in a roadway, which provides real time occupancy data of parking spaces.

Dropped Curbs

A combined ramp and landing to accomplish a change in level at a curb. This element provides street and sidewalk access to pedestrians using wheelchairs. Also known as a curb ramp.

Divided Roadway

A two-way roadway on which the opposing traffic lanes or travel lanes are separated by a median.

Dwell Time

Refers to the time a vehicle such as a public transit bus spends at a scheduled stop without moving. Typically, this time is spent boarding or alighting passengers including the time spent for traffic ahead to clear, trying to merge into parallel traffic, or idling time in order to get back on schedule.

Dynamic Capacity

Defined as the number of vehicles that can pass in an hour through a location of a parking facility expressed in vph.

Dynamic Efficiency

Defined as the ability of a parking facility to process vehicles under normal operating conditions expressed in vehicles per hour (vph.)

Dynamic Message Sign (DMS)

A large, electronic sign used for traffic control that is capable of displaying one or more alternative messages that may be changed or switched on or off as required. The display can be changed manually, by remote control, or by automatic control. A dynamic message sign can overhang or be located alongside a roadway and is typically used to display information about traffic conditions, travel times, construction, and road incidents.

Electric Vehicle

An electric vehicle (EV) is a vehicle that uses one or more electric motors or traction motors for propulsion. EV applies mostly to cars in this manual,

Equivalent Standard Axle Load

A numerical factor that expresses the relation of a given axle load to another axle load in terms of their effect on serviceability of a pavement structure.

Escape Route

Escape route means a route by which a person may reach a place of safety.

Expressway

A divided arterial highway for through traffic with full or partial control of access and generally with grade separations at major intersections.

Fire Hydrant

A visible fixture placed inside or outside a building, parking area, roadside, etc. that is connected to the municipal or a private water service network. Fire hydrants are designed to instantly provide the water required by fire fighters to extinguish fire.

Flexible Pavement

Defined as consisting of a mixture of asphaltic or bituminous material and aggregates placed on a bed of compacted granular material of appropriate quality in layers over the subgrade. Commonly used to surface roads, parking lots, and airports.

Freeway

A divided roadway for through traffic with fully controlled access and that has grade separation at intersections.

Guide Sign

A sign that shows route designations, destinations, distances, services, points of interest, or other geographical, recreational, or cultural information.

Hard standing

Ground surfaced with a hard material for parking heavy vehicles.

Headroom

The minimum available vertical clearance above a road, footway, or cycleway where it passes under a bridge or other overhead structure.

High-Occupancy Vehicle (HOV)

A motor vehicle carrying two or more persons including carpools van pools, and buses.

Holding Bay

Holding bay is the area in front of the entry module turntable/loading bay in an APS.

Inductive Loop

An energized coil of cable buried in the roadway that uses the disturbance to the electric field caused by the ferrous materials in vehicles passing over it to detect those vehicles. Each detection event is sent to detector packs in the controller where the electrical signal is processed. It is normally passed on as input to the signal control strategy.

Intelligent Transportation System (ITS)

The application of sensing, analysis, control, and communications technologies to ground transportation in order to improve safety, mobility, and effciency.

Intersection

The general area where two or more highways join, or cross within which are included the roadway and roadside facilities for traffic movements in that area.

Ingress/Egress Points

Ingress is entry into the property/bay and egress is exit.

Island

A defined area between traffic lanes used to control vehicle movements. Islands may range from an area delineated by a raised curb to a pavement area marked by paint or thermoplastic markings.

Landscaping

A means of enhancing the street environment for all road users of the right-of-way. Landscaping commonly incorporates vegetation.

Light Rail Transit (LRT)

An urban form of public transportation using the same rolling stock as a tramway but operates primarily along exclusive rights-of-way and has vehicles capable of operating as a single train or as multiple units coupled together.

Line of Sight

A straight line along which an observer has unobstructed vision.

Loading Bay

Loading bay is an area where vehicles are loaded and unloaded. This is applicable for both passengers and goods.

Maneuver Area

Minimum three-dimensional spaces within which it is feasible to complete a maneuver to gain access to a specific facility, component, or fitting in particular while using a wheelchair or a walking aid.

Median

The portion of a highway separating opposing directions of the traveled way.

Metro

An urban transit railway system with a high capacity and frequency.

Mid-Block Pedestrian Crossing

A crossing point that is between intersections and designed specifically to allow pedestrians to cross. Also known as a standalone crossing.

Minor Roadway

A generally low-volume roadway carrying almost exclusively local traffic.

Modular Design

Design of a system by subdividing the system into smaller parts called modules based on their functional and non-functional requirements. This is applicable to Intelligent Parking Management System.

Online Shopping

Online shopping is a form of electronic commerce which allows consumers to directly buy goods from sellers over the Internet by using a web browser or a mobile app.

Overhang

Overhangs are the lengths of a road vehicle which extend beyond the wheelbase at the front and rear.

Overseeing Authority

The highway authority responsible for approving a road construction or improvement projects, including planning, design and implementation, road safety, and departures from standard.

Parking Bay

A parking bay consists of one or more contiguous parking stalls.

Parking Design Vehicle (PDV)

The vehicle that is roughly larger than 85th percent of vehicles that are expected to routinely park in a parking facility.

Parking Safety Audit

The Parking Safety Audit (PSA) is a systematic and formal process to review the safety of a parking facility for all users.

Parking Space (Parking Stall)

A space designed for parking, paved and delineated by road surface markings and large enough to park a vehicle in either by parallel, perpendicular, or angled parking.

Parallel Parking

Parking in which the vehicle is aligned with the edge of the curb.

Pedestrian

Person traveling on foot, using mobility aids (such as a wheelchair), or walking with a bicycle, pram, pushchair, or animal.

Pedestrian activity

This term is used to define the volume of pedestrians at any instant and can be categorized as:

Low- This refers to instances where the pedestrian movement of is very little like that seen in the parking areas of small developments, offices etc.

Medium- This refers to instances where the pedestrian activity is between low and high.

High- This refers to instances where the pedestrian movement is considerable as seen in the parking areas of malls, commercial areas, parks etc.

Pedestrian Crossing (crosswalk)

Any portion of a roadway at an intersection or elsewhere distinctly indicated for pedestrian crossing by lines or other markings on the surface.

Pedestrian Path

Dedicated path meant for pedestrian use in an off-street parking facility.

Pedestrian Refuge

An island, usually in the median, providing as a staging area for pedestrians crossing a roadway.

Perception Reaction Time

The total time it takes for a driver to commence an appropriate response to an impending hazard.

Perpendicular Parking

Parking in which the vehicle is parked at right angles to the carriageway.

Posted Speed

The maximum lawful vehicle speed limit for a location/section as displayed on a regulatory sign.

Refuge Area

A refuge area is a location in a building designed to hold occupants during a fire or other emergency when evacuation may not be safe or possible.

Resident Permit Zone

Residential Permit Zone is a controlled parking area where a permit is required for the residents of that area to park a vehicle for a specified time limit in public parking stalls.

Rest Area

A rest area is a public facility located next to a large thoroughfare, such as expressways, or highways at which drivers and passengers can rest, eat, or refuel without exiting onto secondary roads

Right-of-Way

1. Land, property, or interest therein, usually in a strip, acquired for or devoted to transportation purposes. This can be for roads, railway, as well as electrical transmission lines, oil and gas pipelines. It is reserved for maintenance or expansion of services.

2. The priority in passing or proceeding accorded to one vehicle or person over another.

3. The legal power of passage over another person's land.

Risk Management

Coordinated activities to direct and control an organization with regard to risk.

Road User

Any person making use of any part of a roadway, including pedestrians, cyclists, and drivers of motorized vehicles.

Roadway

The paved area of the roadway used by motorized vehicles to travel from one place to another.

Safety Barrier

A temporary concrete or steel barricade that prevents passage into a dangerous area, meets minimum containment testing criteria, and is capable of providing redirection of vehicles with minimal deflection of the barrier.

School Zone

A designated roadway segment approaching, adjacent to, and beyond school buildings or grounds, or where school-related activities occur.

Service Area

A service area or yards is an area utilized for storage of materials, garbage containers, mechanical equipment etc., and to be accessed by commercial vehicles for specific operations, like loading, unloading, servicing, inspection, and parking.

Service Road

A road parallel to an arterial or similar main road which provides land access, parking, and limited movement (generally one-way) for through traffic. Also referred to as frontage road.

Sight Triangle

Sight triangle is the specified areas along an intersection's approach legs and across the included corners that should be clear of obstructions that might block a driver's view of conflicting vehicles or pedestrians.

Signage

Signage is use of single or multiple signs to communicate a message.

Shared Use Path

A pathway along which the entire width is available to all classes of cyclists, pedestrians, users of motorized, and nonmotorized wheelchairs, baby carriers/strollers, and other authorized motorized and nonmotorized users.

Shopping Cart

A bag or basket on wheels for carrying shopping purchases in particular one on wheels provided for the use of supermarket customers.

Sidewalk

A paved pathway that parallels a highway, road, or street, and is intended for pedestrians. Used in the context of on-street.

Speed Hump

A raised transverse section of roadway used as a speed reduction measure by causing vertical displacement of vehicles.

Static Capacity

The number of parking stalls in a single parking deck (floor) or the entire parking facility.

Static Efficiency

The entire construction area, including ramps and stairs divided by the number of parking stalls expressed as m^2/stall.

Subbase Layer

The subbase course is the layer of material beneath the base course and the primary functions are to provide structural support, improve drainage, and reduce the intrusion of fines from the subgrade in the pavement structure.

Taxi (Taxicab)

A vehicle that has a passenger carrying capacity similar to that of an automobile and that serves primarily as a demand-responsive public passenger vehicle for hire. It may be a converted automobile or one specially built for taxi service.

Traffic

Vehicles, pedestrians or other nonmotorized users that move through an area or along a defined route. The term may be qualified by pedestrian, vehicular, or nonmotorized user to clarify the type of traffic.

Traffic Mirror

A Traffic mirror is a convex mirror used to help see around blind and hidden corners especially in parking garages and internal lanes.

Traffic Signal

A traffic control device by which traffic including pedestrians and cyclists is alternately stopped and allowed to proceed thereby avoiding conflict among traffic streams.

Transverse Markings

Road markings like word, symbol, and arrow pavement markings, stop lines, and parking space markings, that are generally placed perpendicular to and across the flow of traffic.

Truck

A highway freight vehicle. Also referred to as a “goods vehicle.”

Truck Lane

A traffic lane reserved for the use of trucks.

Turnover

The parameter which indicates the number of times a particular parking stall or space is occupied in a unit interval of time. Turnover is considered as low when a parking stall or space is occupied less than 5 times within the operational period of the facility. Turnover is considered as high when a parking stall or space is occupied more than 5 times within the operation period of the facility.

Undivided Roadway

A two-way roadway on which the lanes for travel in opposite directions are not separated by a median.

Valet Parking

Valet parking is a service that operates at places such as hotels, restaurants, stores, or other business establishments in which customer cars are parked by an attendant.

Vehicle Swept Path

The envelop swept out by the sides of the vehicle body or any other part of the structure of the vehicle.

Verge

The strip of land that borders a roadway between the pedestrian path and roadway.

Vertical Clearance

Vertical clearance is the unobstructed distance from the top surface of a floor to the underside of the celling or ramp or electrical/mechanical system.

Video Detector

A type of vehicle detector that uses a video image to detect an approaching vehicle.

Visibility Splays

A visibility splay is a drawing plan that visualizes the angle and distance from which drivers emerging from an access can see and be seen by drivers proceeding along the priority road. It ensures that any buildings work for entrances and exits have good visibility to prevent accidents.

Warning Sign

A sign that alerts road users of a situation that might not be readily apparent on the roadway ahead like a curve or a work zone.

Wearing Course

The top layer of the road surface/parking lot.