Special Report 125

Parking Principles

Highway Research Board
National Research Council
National Academy of Sciences
National Academy of Engineering

Special Report 125

Parking Principles

Subject Area

53 Traffic Control and Operations

Highway Research Board
Division of Engineering
National Research Council
National Academy of Sciences
National Academy of Engineering
Washington, D.C., 1971

Highway Research Board Special Report No. 125

PARKING PRINCIPLES

Library of Congress Catalog Card No. 72-173639
ISBN 0-309-01958-3
Price $10.00 clothbound
$ 8.00 paperbound

Available from
Highway Research Board
National Academy of Sciences
2101 Constitution Avenue N.W.
Washington, D.C. 20418

Printed in the United States of America

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PREFACE

As the population of persons and automobiles grows, the need for adequate parking facilities also grows. Storage is needed *off-street,* because the increasing travel must largely be accommodated in urban areas having relatively fixed limits of land for streets and highways. The accidents directly caused by or involved with curb parking—typically 20 percent of the urban accident total—should be of immense concern. If safety and efficiency are to be given due consideration, the traditional use of our public streets as parking reservoirs must be progressively discontinued.

In the past considerable attention has been given in communities of all sizes to the parking problems of central business districts. Many programs have been conceived and successfully implemented by the construction of off-street parking facilities. Much less attention has been given, however, to the parking needs in neighborhood business or industrial areas. Severe parking shortages exist in moderate- or high-density residential districts of many older cities and have even appeared in relatively new suburban communities. Traffic flow along major routes in cities large and small, old and new, is often impaired by some degree of curb parking. There is clearly an urgent need to view parking as an integral portion of the total urban system of transportation and land use.

The planning and development of the total off-street parking supply for communities involves three levels of government—local, state, and federal. Information and guidance is needed by administrators and enginers at all three levels.

Many people within the administrative ranks of city government—mayors, managers, planners, building officials, directors of finance, police chiefs, and engineers—are involved with some facet of parking or its effects. Planning and zoning appeal boards (including those of urban counties) need to know modern parking specifications and standards.

In downtown areas, business associations and chambers of commerce often need support for parking programs. This can only come about through enlightened member participation. A number of national organizations are also involved with parking as it relates to planning, housing, financing, or operations.

Legislators at the local, regional, or national level are sometimes directly concerned with parking, as in the development of special laws or approval of public

building projects. Funding for urban major route improvements also includes the parking question, and the legislators deserve factual material on the deleterious effect of curb parking.

Over the years considerable parking information has been accumulated. It comes from a variety of sources: the planning and research of the state highway departments and the Federal Highway Administration, the experience of traffic engineers, the action of municipal governments, and the accomplishments of the private parking industry.

Collected material on parking was published by the U. S. Bureau of Public Roads in 1947 in a pamphlet, *Factual Guide on Automobile Parking for the Smaller Cities.* This was followed in 1956 by a booklet entitled *Parking Guide for Cities.* Both were popular as reference sources but are now outdated and out of print. The demand continues, however, for this type of reference material.

In 1967, the Federal Highway Administration recommended that the Highway Research Board Committee on Parking develop a new publication to update and revise the *Parking Guide* booklet. The HRB committee developed an outline and preliminary chapters. Paul C. Box served as technical editor in the development of the final text. The work of the committee was supported and the final text was reviewed by the Federal Highway Administration and was recommended for publication.

In this publication, the Committee on Parking has attempted to view parking across the entire spectrum from the home to the centralized demands of major business centers. New material has been developed by the Federal Highway Administration, principally from recent studies of parking characteristics in downtown areas of cities. Other data have been collected and summarized to allow use by planning and zoning boards; by city, county, and state administrators; and by business associations.

It is not intended that this material be presented in the technical detail of an engineering handbook. Rather, it is a summary of parking principles, procedures, and practices that have proved to be effective in handling parking and terminal problems. Changes and improvements in transportation techniques may be expected over the years, and a continuing responsibility remains to extend knowledge through more research and the application of research results and experience to specific problems.

ACKNOWLEDGMENTS

Many members of the Committee on Parking contributed work of a conceptual nature on the outline of this book and of more definitive scope in portions of the text. Case histories in Appendix C were furnished by several persons, including Henry Mayer and George Ihnat. These were assembled by Walter Rainville, deceased member of the committee.

Valuable assistance was rendered in technical chapter drafting, review, or editing of the text by Jack Hutter of the Traffic Institute at Northwestern University; Robert Stout of the Federal Highway Administration; S. T. Hitchcock, formerly of the Administration; David Witheford, Technical Director of the Eno Foundation for Transportation; and Donald T. Scott of the St. Louis *Post-Dispatch.*

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CHAPTER ONE

INTRODUCTION

THE ROLE OF PARKING IN TRANSPORTATION

Each mode of transportation involves three general elements that are essential to efficient operation: the vehicle, the right-of-way, and the terminal. In railroad transportation these elements are specifically the trains, the tracks, and the stations or yards; for air transportation they are the planes, the airways, and the airports; and for highway transportation they are the vehicles, the roads, and the parking or loading facilities.

After a vehicle has been driven to a destination, its usefulness is greatly diminished if there is delay or difficulty in parking. To be efficient, a motor vehicle transportation system must include adequate parking facilities at all places that "generate" trips. Parking for automobiles and provisions for truck loading and unloading pose problems in nearly every urban area.

Public Transportation

In most cities the use of private automobiles has increased to such a degree that the street systems are hard-pressed to accommodate the traffic. In the central business districts of large cities convenient parking is often scarce and expensive. When commuter trips can be made partly or entirely by public transportation, parking and traffic problems may be lessened. Often it is possible to use the private automobile for only the outer part of a trip and public transportation for the portion in the most congested area.

In such a "change-of-mode" the parking requirement for the private vehicle appears at two locations—the home and the change-of-mode terminal (or transfer point).

Because many people cannot or will not use public transit for part of their trips, downtown areas will continue to require terminal facilities despite the high cost of land and the problems of access. The development of a surplus of parking is likely to be quite uneconomical within such areas and could reduce the use of public transportation. Conversely, disregard of basic parking requirements can undermine the economic vitality of the central core.

In outlying or suburban locations and in smaller cities, industrial and commercial developments may draw from such widespread areas that a high level of public transportation service is simply impractical. The automobile is, and will

continue to be, the chief means of access in such areas, and adequate parking facilities are therefore essential.

Governmental Involvement

The various kinds of trips produce three categories of generalized parking location—the home, the destination such as a downtown area or major generator, and an intermediate transfer point if change-of-mode is possible. Along the routes of travel between these locations, curb parking for abutting properties adds another element, since it tends to impede movement and increase hazard.

Responsibility for parking at the various locations typically involves one or more levels of government. At the home or apartment, the development of off-street parking is a function of private capital. Provision for adequate parking can often only be ensured by rigorous specifications in zoning and building codes. The development and enforcement of such codes is a local responsibility. In most cases, the regulation of curb parking —so closely related to off-street supply— is also a responsibility of local government.

Parking is directly involved with every element of community life. A substantial portion of urban land is required to provide travelways for the automobile, and an even larger area is needed when providing for its storage.

Along major routes of travel, both local and state agencies are frequently involved. Because curb parking represents the antithesis of efficiency and safety of movement, its restriction is an integral part of street regulation and control. Parking prohibitions and off-street supply are directly related, and the supply is nearly always a responsibility of private resources spurred as necessary by local zoning requirements.

Federal-aid funds are often used to improve major traffic routes in urban areas. The federal government has an interest in ensuring use of tax dollars to benefit the maximum number of people and therefore is concerned that roadways constructed to facilitate traffic flow not be obstructed by curb parking.

When a change-of-mode terminal permits transfer to a type of mass carrier, the consolidation of travel along a transportation corridor tends to benefit everyone. The terminal development will likely involve two—often all three—levels of government. Elements of planning, location, access, parking supply, funding, construction, and operation of the complete system are usually too complex for a single agency to handle effectively. In many cases a multiplicity of local governments is involved, sometimes including several counties. The state and federal governments are likely to play important roles in coordination and planning, as befits the regional nature of transportation systems.

At a centralized destination the development of parking terminals can directly relate to several government levels. Zon-

ing, building codes, and parking improvement programs are local in nature. Planning studies and surveys to determine parking needs often utilize state and federal assistance. The enabling legislation under which a city can develop a parking program stems entirely from state laws.

Because of the involvement of all three levels of government—along the routes and at the destinations—it is *essential* that transportation planning activities be coordinated and include adequate consideration of parking and terminal needs. Such planning involves estimation of future needs as well as assistance in the development of adequate facilities.

More than 300 urban areas in the United States are expected to have populations exceeding 50,000 persons by 1985. It has been estimated that future downtown parking demand will require 1.6 million more parking spaces than were available in 1960. A conservative cost estimate for the necessary construction was $4 billion. This estimate is equal to the entire existing investment reported for the commercial parking industry in the mid-1960s(*1*).

Projections of future vehicle and highway technology beyond the 1980s do not indicate any easy solutions to the terminal problems, such as collapsible cars or elimination of personal car ownership(*2*). The development of automated control of vehicular movement along selected routes might produce freeway exit ramps connecting directly to automated storage areas(*3*). However, the terminal requirement and the vehicular space needed would not change significantly.

PARKING ELEMENTS

The many facets of parking are interrelated. For example, parking programs stem from studies of parking needs, but the possible programs must be considered prior to and during the study. The design of parking facilities is closely related to operations, but these separate functions tend to be handled by different people and are obviously performed at different times.

In the development of this text, the principal parking elements have been examined separately where possible. Some duplication, however, has been introduced into each chapter to illustrate relationships with the other parking elements.

A brief summary of the material contained in successive chapters follows.

Parking Characteristics

A fundamental knowledge of parker characteristics is a prerequisite to preparing parking studies, developing programs, locating and designing facilities, and establishing zoning code specifications. Chapter Two summarizes findings from many studies of parker duration, trip purposes, and walking distances, as well as arrival and departure habits.

Comparable data from the CBDs (central business districts) of different-sized cities are presented. There are two principal types of space utilization in the CBD. One is long-duration, all-day parking (usually associated with a work trip); the other is short-duration parking (usually for a business or shopping trip).

Considerable material has been accumulated on parking generation, which is the relationship of parking demand to certain areas or to specific types of buildings. Basic generation data for individual land uses are summarized in Chapter Two. These data are intended to aid local communities in the development of zoning specifications.

Zoning

Zoning controls should be used to ensure adequate self-developed parking as part of all new developments or major renovations of existing buildings. Meth-

ods of specifying parking and suggested unit requirements are included in Chapter Three for residential, commercial, industrial, and institutional land uses. A summary review is made of implementation procedures such as rezoning applications, site plan checking, and inspections.

Off-street parking requirements of zoning ordinances should be realistically related to actual local experience. Many elements affect parking demand, and these vary even from district to district within a given city. Local studies are strongly recommended to measure the parking needs of different land uses in each zoning district. Wide variations are to be expected, particularly for offices in the CBD and for apartments in each district.

Parking Programs

The relative roles of private enterprise and of government in providing new facilities is a matter of policy and parking philosophy. The key factors in the development of a local parking program are needs, methods, financing, and legislation. Successful approaches used to augment parking in business areas include parking authorities or boards, special assessment districts, and merchant associations.

Chapter Four contains examples of city parking administration by bureaus, commissions, and parking authorities. The Milwaukee residential area parking program is also reviewed.

The financing of facilities is closely related to the type of program. Methods include parking meter revenues, bond issues, revolving funds, and benefit district assessments.

Parking Studies

Parking surveys provide the essential data from which programs can be developed to meet needs. Chapter Five points out that existing parking demand is often measured by a comprehensive parking study in the CBD and by limited studies in other areas.

The cost and complexity of the study is closely related to its goal. Parker interviews represent a major cost element but are needed in the larger cities to secure information on actual parking demand on a block-by-block basis.

Most parking studies of the past have been made in downtown business areas. Need exists, however, to conduct studies in older community shopping areas, at industries or institutions, along major traffic routes, and in densely populated residential neighborhoods.

Location and Design

The selection of sites for the larger, centralized parking facility is a complex undertaking. Similarly, the design of a parking garage requires the application of specialized knowledge.

Chapter Six reviews general elements of site location as related to pedestrian and vehicular access. Important design considerations of parking lots and garages are summarized. Tables of parking and driveway dimensions have been prepared for use by engineers and planners as well as for possible inclusion directly into zoning ordinances.

Nearly all parking facilities being built today are of the self-park type. In most cases, "clear-span" garages are strongly preferred. This design places the columns at the ends of parking stalls, thus facilitating maneuverability and retaining the flexibility of adjusting stall widths and angles in the event of significant changes in future vehicle dimensions.

Operation

A comparison between attendant and self-parking operation requires consideration of entry, circulation, and exit pro-

cedures. Despite the larger floor area needed for self-parking, the savings in labor costs usually more than compensate.

Security for self-parkers can be a particular problem in garages. Sonic and television surveillance devices are being increasingly used.

In lots and garages that charge a fee for parking, audit control is important. Automated systems have been in a rapid state of development, but other proven methods are reviewed in Chapter Seven.

Parking at Transit Stations

The experiences of cities with parking lots at bus and rail stations form a basis for considering additional or expanded facilities. Many bus-oriented lots, however, have failed. Factors affecting success or failure are reviewed in Chapter Eight. Certain design features peculiar to parking for transfer terminals are also discussed.

Specific locations for fringe or outlying stations depend on local conditions. Adequate connections with major routes or freeways are needed, as is efficient mass transportation between the terminal and downtown generators. Fringe parking facilities may be placed adjacent to radial highways or inner-belt streets in the areas immediately surrounding the CBD. In large metropolitan areas parking facilities can be constructed in conjunction with transit or suburban rail terminals several miles away from the CBD. This type of parking can improve mass transportation service; at the same time it reduces congestion on major routes and downtown streets.

Curb Parking

Curb parking can seriously impede traffic movement along major routes. It typically contributes to or is directly involved with some 20 percent of urban street accidents.

One of the best and most economical methods of increasing capacity and safety is the removal of curb parking. Methods of prohibition and limitations of various regulations are discussed in Chapter Nine. Warrants for eliminating curb parking on major streets are presented. The special congestion and hazard of angle parking (an obsolete arrangement when used along public streets open to through traffic) are also reviewed.

Information is given on the types, applications, and effectiveness of parking meters. Findings from studies of parking meter removals are included.

Appendixes

Material too extensive for inclusion within the main text has been placed in the appendixes. Model examples of state enabling legislation and city residential parking ordinances are included, as are case histories of bus and rail change-of-mode terminals.

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CHAPTER TWO

PARKING CHARACTERISTICS

Information on the number of parkers, parking duration, trip purpose, time of arrival, and final destination is necessary to the establishment of any parking program. The data can be used to help plan and design the types of parking facilities that are required and that will operate in the most economical and efficient manner.

This chapter summarizes parking characteristics found in numerous studies. Parking generation data for many different types of land uses are reviewed and form the basis for the recommended specifications in Chapter Three.

DOWNTOWN PARKING

Summary of Studies

A number of studies have been made of downtown parking characteristics as related to city size. One of the earliest was the 1947 Factual Guide(*1*). This was followed in 1949 by Highway Research Board Bulletin 19, in which data from 25 cities were analyzed(*2*). In 1956 the *Parking Guide for Cities* summarized the parking study results for nearly 70 cities(*3*). A more recent survey, *Parking in the City Center*, which combines the results of parking reports conducted in the late 1950s and early 1960s, was published in 1965(*4*).

In 1968, the Federal Highway Administration initiated a study to revise and update the latest material on parking characteristics. The project utilized data from parking reports published between 1960 and 1968. Although every city is unique, all cities have certain characteristics in common with other cities. Figures from parking studies made since 1960 in 111 American cities have been tabulated, analyzed, and summarized on the basis of urban area population, and the results are presented throughout this chapter. This composite information can increase our understanding and awareness of parking problems and can assist in the development and implementation of solutions.

The data are intended to provide a general guide for cities considering a comprehensive parking study and also for those that, after completing a study, need to put their results within the framework of a comparable base. The information is *not* intended to be used in lieu of independent surveys, as described in Chapter Five.

The CBD of a city with a population of 20,000 (upper photo) averages 27 blocks in size. The city with 75,000 population (lower photo) has a CBD about one-third larger.

Only cities of more than 10,000 population were included in the analysis. Much less information is available for the smaller cities. The problems in these areas are smaller and at the same time require less extensive studies for the development of an adequate solution or program because there are fewer alternatives.

The 111 cities used in the analysis were divided into seven population groups based on the 1960 urban area population as determined by the Bureau of Census. The number of cities studied in each group and their mean populations are given in Table 2.1. The 99 cities with populations greater than 50,000 represent 43 percent of the 233 urbanized areas in the United States.

Table 2.1—Cities classified according to population grouping

Population Group of Urban Area	Number of Cities Studied	Average Population of Samples
10,000-25,000	6	17,000
25,000-50,000	6	37,000
50,000-100,000	30	68,000
100,000-250,000	33	160,000
250,000-500,000	16	360,000
500,000-1,000,000	15	720,000
Over 1,000,000	5	3,700,000
Total	111	

Average CBD Sizes

For analysis purposes the parking data refer to the downtown area only. A definable CBD exists in most cities and usually contains a "core" area. The core area generally represents the heart of business, commercial, financial, and administrative activity and is usually the area having the greatest parking demand. However, study findings specifically limited to the core were not always available, and consequently the characteristics have been related to the entire CBD.

The areas and number of blocks in typical CBDs and cores are given in Table 2.2. The data show the ranges and relative magnitude involved, but individual cases may vary widely from the average because of the differences among cities in definitions of the CBD. The size of the CBD increases with population, and the core generally covers about 25 percent of the downtown area.

Parking Supply

In the study of a city's parking problem, the actual number, location, and type of available parking spaces must be deter-

Table 2.2—Size characteristics of typical CBD areas, 1968

Population Group of Urbanized Area	Number of Cities Checked	Overall CBD		Core Area Only	
		Area (sq miles)	Number of Blocks	Area (sq miles)	Number of Blocks
10,000-25,000	6	0.15	27	0.04	7
25,000-50,000	6	0.23	36	0.06	9
50,000-100,000	10	0.26	37	0.06	8
100,000-250,000	8	0.38	70	0.08	17
250,000-500,000	8	0.48	99	0.12	20
500,000-1,000,000	5	0.89	115	0.29	36
Over 1,000,000	3	1.74	224	0.45	62

mined. These data are obtained from a comprehensive inventory of the parking facilities in the area of study. Records are then maintained by periodic updating. The relationship found in the CBD studies between types of parking supply and city size is given in Table 2.3. The rates, or average number of spaces per 1,000 population, are also shown for each population group. Figure 2.1 utilizes data from the table to illustrate that total supply increases as size of the city increases, but at a decreasing rate.

As cities increase in size, the percentage of total spaces supplied at the curb decreases from 43 percent to 14 percent, the percentage of spaces in lots ranges between 55 percent and 64 percent, and the percentage of spaces in garages steadily increases. These trends are shown in Figure 2.2.

A further subdivision of curb, lot, and garage spaces is given in Table 2.4, with curb spaces grouped into metered, unmetered, and special types, and lot and garage spaces separated between public and private facilities.

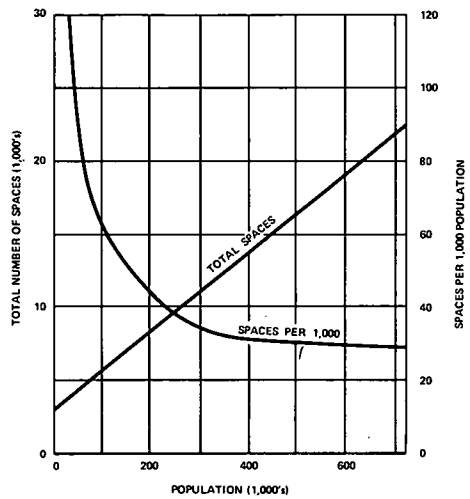


Figure 2.1. Number of parking spaces in the CBD as related to population of the urbanized area.

Facility Use

Table 2.5 indicates how use of facilities in the CBD varies by city size. The parkers are separately identified in their use of curb, lot, or garage spaces. These figures

Table 2.3—Number and percent of total parking spaces classified by type of facility

Population Group of Urbanized Area	Type of Facility			Average Number of Total Spaces	Spaces per 1,000 Population
		Off-Street			
	Curb	Lot	Garage		
10,000-25,000	1,090 (43%)	1,530 (57%)	10 (0)	2,630	150
25,000-50,000	1,430 (38%)	2,420 (59%)	140 (3%)	3,990	120
50,000-100,000	1,610 (35%)	2,790 (60%)	260 (5%)	4,660	70
100,000-250,000	2,130 (27%)	4,760 (62%)	820 (11%)	7,710	50
250,000-500,000	2,450 (20%)	7,910 (64%)	1,940 (16%)	12,300	30
500,000-1,000,000	3,200 (14%)	12,500 (56%)	6,900 (30%)	22,600	30
Over 1,000,000	8,000 (14%)	32,200 (55%)	18,600 (31%)	58,800	20

clearly show that utilization of off-street facilities (particularly garages) increases with city size, whereas curb parking decreases.

In the smaller cities, on the average, curb spaces accommodate 79 percent of the parkers, whereas lots accommodate 21 percent. Thus, curb facilities in such cities account for 43 percent of the total *supply* (Table 2.3), but they accommodate a much higher percentage of the *use*.

A step-by-step comparison can be made between supply and use tabulations. As city size increases, the percentage of available spaces that are off-street increases, as does the percentage of total parkers accommodated in lots and garages. In cities of more than 1 million population, curb facilities account for only 14 percent of the total supply and accommodate 30 percent of the parkers, whereas off-street facilities provide 86 percent of the supply and accommodate 70 percent of the parkers.

Trip Purpose

One of the major determinants of parker characteristics is the trip purpose. The duration of the trip is related to its purpose; duration also affects the type of facility used and the acceptable walking distance.

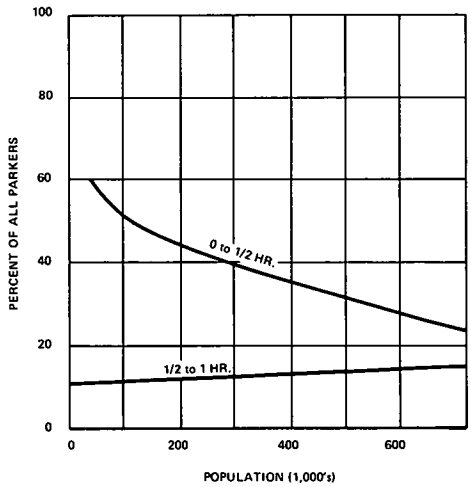


Figure 2.2. Percentage of all parking spaces in the CBD by type of facility.

Table 2.6 shows the percentage use of all types of parking facilities in the CBD for purposes such as shopping, personal business, and work. For example, in cities of 50,000 to 100,000 population, shoppers account for 24 percent of total use; parkers on personal business account for 31 percent; workers represent 20 percent; and the remaining 25 percent involves other purposes such as sales and service. The proportionate use of facilities for shopping trips decreases steadily as the city size increases. Personal business and "other"

Table 2.4—Parking spaces classified by type of facility

Population Group of Urbanized Area	Type of Facility						
	Curb			Lot		Garage	
	Metered (%)	Non-metered (%)	Special (%)	Public (%)	Private (%)	Public (%)	Private (%)
10,000-25,000	47	51	2	18	82	93	7
25,000-50,000	55	40	5	27	73	50	50
50,000-100,000	55	41	4	42	58	56	44
100,000-250,000	47	46	7	52	48	89	11
250,000-500,000	49	40	11	66	34	95	5
500,000-1,000,000	54	38	8	68	32	87	13
Over 1,000,000	27	46	27	67	33	84	16

This regional shopping center in New Jersey has a parking capacity of 10,000 cars. This is equivalent to the total downtown *parking supply for an average city of 275,000 population.*

trips remain relatively constant. The percentage of work trips increases substantially as city size increases.

Further detail on the use of curb and off-street facilities by different types of parkers is given in Table 2.7.

Accumulations

The accumulation of total parkers from 10:00 a.m. to 6:00 p.m., in gross numbers and as a percent of parking supply, is given in Table 2.8. Data from four population groups are shown in Figure 2.3. The accumulation in all cities is relatively constant until 3:00 p.m. The absolute peak tends to occur about 11:00 a.m., but there is little difference between this peak and the early afternoon demand. The 4:00 to 6:00 p.m. decline reflects the typical exodus from the downtown

Table 2.5—Use of facilities classified by type

Population Group of Urbanized Area	Location of Parking Spaces		
	Curb (%)	Lot (%)	Garage (%)
10,000-25,000	79	21	0
25,000-50,000	74	24	2
50,000-100,000	68	31	1
100,000-250,000	52	42	6
250,000-500,000	54	34	12
500,000-1,000,000	33	39	28
Over 1,000,000	30	54	16

Table 2.6—Parking classified by trip purpose

Population Group of Urbanized Area	Trip Purpose of Parkers			
	Shopping (%)	Personal Business (%)	Work (%)	Other (%)
10,000-25,000	38	23	21	18
25,000-50,000	27	35	21	17
50,000-100,000	24	31	20	25
100,000-250,000	21	34	26	19
250,000-500,000	19	33	30	18
500,000-1,000,000	13	25	47	15
Over 1,000,000	10	30	41	19

Table 2.7—Proportion of parkers

Population Group of Urbanized Area	Curb			
	Shopping (%)	Personal Business (%)	Work (%)	Other (%)
10,000-25,000	30	22	11	16
25,000-50,000	22	30	8	14
50,000-100,000	19	24	7	18
100,000-250,000	11	24	6	11
250,000-500,000	10	23	8	13
500,000-1,000,000	3	12	9	9
Over 1,000,000	3	15	4	8

area. The smaller cities are also characterized by a noon period dip, representing cars used for trips to eat lunch outside of the CBD and the lower level of sales and service activity during the lunch hour.

Figure 2.3 also shows the comparison between supply and demand. The percentage of supply being used increases with increased population, but regardless of city size the peak accumulation is always less than the total average supply. This occurs because many of the available spaces that count toward total supply are in the fringe areas of the CBD and are beyond acceptable walking distance. Another reason is the number of reserved or private spaces that are available only to designated persons, such as employees or visitors to specific buildings.

The accumulation of parking for shopping trips tends to peak in midafternoon for the smaller cities (about 3:00 p.m.) and in earlier afternoon for the larger cities (about 1:00 p.m.). Business trips have

Table 2.8—Hourly parking accumulation as related to total parking supply

Population Group of Urbanized Area	10:00 a.m.	11:00 a.m.	12:00 noon	1:00 p.m.	2:00 p.m.	3:00 p.m.	4:00 p.m.	5:00 p.m.	6:00 p.m.
10,000-25,000	1,340 (51%)	1,360 (52%)	1,220 (46%)	1,180 (45%)	1,300 (49%)	1,310 (49%)	1,250 (48%)	1,010 (38%)	550 (21%)
25,000-50,000	2,040 (51%)	2,120 (53%)	1,990 (50%)	1,950 (49%)	2,060 (51%)	2,050 (51%)	2,000 (50%)	1,740 (44%)	940 (23%)
50,000-100,000	2,780 (60%)	2,890 (62%)	2,770 (59%)	2,690 (58%)	2,870 (61%)	2,860 (61%)	2,720 (58%)	2,270 (49%)	1,260 (27%)
100,000-250,000	5,380 (70%)	5,740 (74%)	5,670 (74%)	5,570 (72%)	5,600 (73%)	5,450 (71%)	5,110 (66%)	3,740 (48%)	2,210 (29%)
250,000-500,000	8,050 (69%)	8,710 (71%)	8,780 (71%)	8,680 (71%)	8,660 (70%)	8,300 (67%)	7,710 (63%)	5,540 (45%)	2,840 (23%)
500,000-1,000,000	15,600 (69%)	17,700 (79%)	18,200 (81%)	18,200 (81%)	17,500 (78%)	16,800 (74%)	15,100 (67%)	10,800 (48%)	6,830 (30%)
Over 1,000,000	45,000 (77%)	43,700 (74%)	44,100 (75%)	43,900 (75%)	44,400 (75%)	43,400 (74%)	39,900 (68%)	28,300 (48%)	15,100 (26%)

classified by facility and trip purpose

Off-Street							
Lot				Garage			
Shopping (%)	Personal Business (%)	Work (%)	Other (%)	Shopping (%)	Personal Business (%)	Work (%)	Other (%)
8	1	10	2	0	0	0	0
5	5	13	3	0	0	0	0
5	7	12	7	0	0	1	0
9	9	17	7	1	1	3	1
6	7	18	3	3	3	4	2
5	8	23	3	5	5	15	3
4	13	29	8	3	2	8	3

similar characteristics. Work trips, however, peak at 10:30 to 11:00 a.m. for all city sizes.

The accumulation of cars at the curb tends to remain nearly constant from 11:00 a.m. to 3:00 p.m. in the larger cities and until 4:00 p.m. in the smaller cities. In the larger cities, the curb parking at 9:00 a.m. and at 5:00 p.m. is only about 40 percent of the accumulations during midday. In the smaller cities, however, the curb parking at these times is approximately 80 percent of the midday accumulation.

These differences are principally due to greater prevalence of rush-hour parking restrictions in the larger cities and to a higher percentage of employee parking at the curb in the smaller cities.

In off-street facilities, parking peaks at 10:00 to 11:00 a.m. for all city sizes. This condition is created by the relatively high percentage of employees who park off-street in all cities.

Duration

Parking duration, or length of stay, varies with type of trip and increases with the size of the urban area. The average duration changes from a little over 1 hour in the smaller cities to about 3 hours in the larger cities (Table 2.9). The length of stay for both shopping and personal business increases greatly in the larger cities. The duration of worker parking increases, but to a lesser degree. This would be expected because the length of workday varies little between small and large cities.

The proportions of parkers are classified by the length of time parked in Table

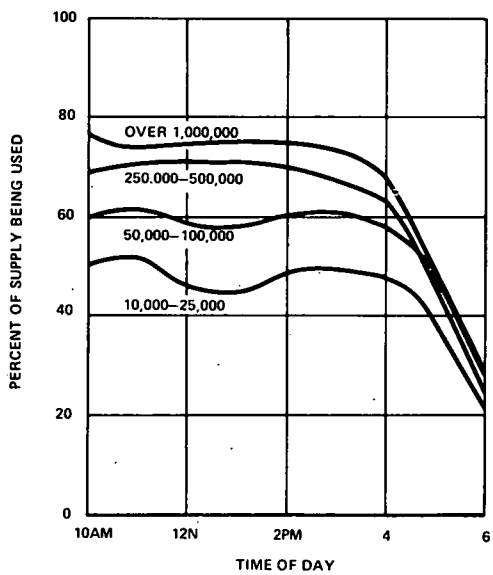


Figure 2.3. Hourly parking accumulation as related to supply in areas of various population groups.

Table 2.9—Length of time parked classified by trip purpose

Population Group of Urbanized Area	Trip Purpose: Shopping (hours)	Personal Business (hours)	Work (hours)	Average All Trips (hours)
10,000-25,000	0.5	0.4	3.5	1.3
25,000-50,000	0.6	0.5	3.7	1.2
50,000-100,000	0.6	0.8	3.3	1.2
100,000-250,000	1.3	0.9	4.3	2.1
250,000-500,000	1.3	1.0	5.0	2.7
500,000-1,000,000	1.5	1.7	5.9	3.0
Over 1,000,000	1.1	1.1	5.6	3.0

2.10. The short-time parkers (up to ½ hour) are affected most by city size (Fig. 2.4).

Durations at curb spaces are relatively constant with respect to type of parking facility. Average parking durations at off-street facilities increase with city size, and such facilities have far longer parking times than curb facilities.

Walking Distances

Average walking distances as a function of trip purpose and city size are given in Table 2.11. Average distances tend to increase with greater city size. Trip purpose is an important element, with workers walking the greatest distances.

The effect of facility type is given in Table 2.12. The curb parker tends to walk a shorter average distance than the person who parks in a lot or garage, but exceptions appear in several instances. It is clear, for example, that people will walk further if they use a lot in a large city. Presumably, the lot is cheaper, and people equate the extra walking time to monetary savings.

The relationships among city sizes, duration of stay, and walking distances are given in Table 2.13. Figure 2.5 is a graph of data from four size groupings of urban areas. For any given duration,

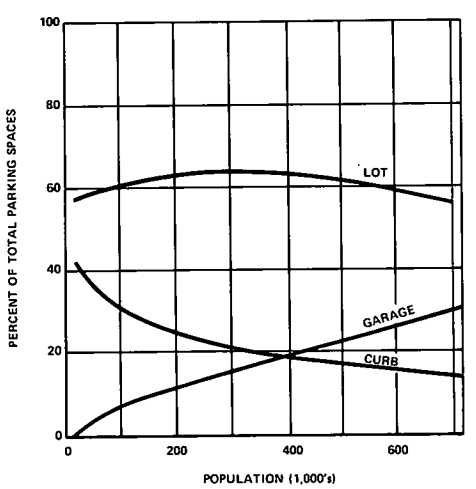


Figure 2.4. Proportion of all parkers parking 0 to ½ hour and ½ to 1 hour.

Table 2.10—Parking classified by length of time

Population Group of Urbanized Area	Length of Time Parked (hours): 0-0.5 (%)	0.5-1 (%)	1-2 (%)	2-5 (%)	Over 5 (%)
10,000-25,000	60	14	10	10	6
25,000-50,000	59	15	10	9	7
50,000-100,000	60	15	10	10	5
100,000-250,000	46	14	11	13	16
250,000-500,000	38	15	17	15	15
500,000-1,000,000	24	12	13	18	33
Over 1,000,000	16	12	20	12	40

people walk considerably farther in the downtown areas of larger cities than they do in the smaller ones.

Turnover

Parking turnover measures the utilization of a parking space by indicating how many times different vehicles use the space during a specified time period. Curb turnover is particularly affected by posted maximum time limits *and* by the level of enforcement. Turnover is obviously a direct function of duration.

Table 2.14 gives the ratios for curb and off-street facilities, as found for the 8-hour period between 10:00 a.m. and 6:00 p.m. For both types of facilities, the turnover rates *decrease* as city size increases. Also, parking turnover at the curb is 3 to 4 times higher than in off-street facilities.

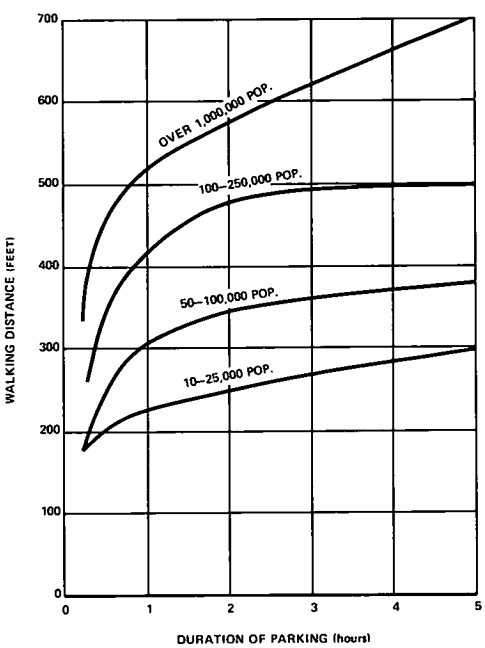


Figure 2.5. Length of time parked in relation to distance walked from parking place to destination.

Table 2.11—Average distance (in feet) walked from parking place to destination classified by trip purpose

Population Group of Urbanized Area	Trip Purpose: Shopping	Personal Business	Work	Other
10,000-25,000	200	200	270	190
25,000-50,000	280	240	400	210
50,000-100,000	350	290	410	260
100,000-250,000	470	390	500	340
250,000-500,000	570	450	670	380
500,000-1,000,000	560	590	650	500

Table 2.12—Average distance (in feet) walked from parking place to destination classified by type of facility

Population Group of Urbanized Area	Type of Facility: Curb	Off-Street: Lot	Off-Street: Garage	Overall Average
10,000-25,000	210	210	—	210
25,000-50,000	250	350	100	280
50,000-100,000	280	380	240	280
100,000-250,000	370	540	330	420
250,000-500,000	390	760	700	550

Table 2.13—Average distance (in feet) walked from parking place to destination classified by length of time parked

Population Group of Urbanized Area	Length of Time Parked (hours): 0.5-1	1-2	2-5	Over 5
10,000-25,000	220	250	280	330
25,000-50,000	270	290	370	500
50,000-100,000	310	350	370	430
100,000-250,000	420	380	500	440
250,000-500,000	440	510	590	740
500,000-1,000,000	480	480	560	910
Over 1,000,000	520	560	680	900[a]

[a] Estimated from limited sample.

Table 2.14—Parking turnover classified by type of facility

Population Group of Urbanized Area	Type of Facility						
	Curb				Off-Street		
	Metered	Posted	Special	Average	Lot	Garage	Average
10,000-25,000	—	—	—	6.7	1.8	0.3	1.8
25,000-50,000	—	—	—	6.4	1.5	0.6	1.5
50,000-100,000	7.8	2.8	3.7	6.1	1.7	0.8	1.6
100,000-250,000	8.1	3.1	4.4	5.7	1.6	1.0	1.5
250,000-500,000	7.1	2.5	3.3	5.2	1.4	1.1	1.4
500,000-1,000,000	6.6	1.1	3.9	4.5	1.2	1.4	1.2
Over 1,000,000	5.5	3.6	2.9	3.8	1.1	1.0	1.1

PARKING GENERATION

There is a strong need to know the parking requirements of individual land uses or parking generators. Public officials must determine which zoning provisions are needed to ensure that adequate off-street parking is provided for all new and improved buildings. The site developer is interested in the kind and type of parking facilities he should provide his customers and employees. Industry is concerned with public relations in the local neighborhood and community.

Elements Affecting Demand

There are a number of elements that influence parking demand. These are discussed in the following sections.

Population Characteristics—Basic characteristics of the population affect parking demand. These include family size and age distribution, income, car ownership, and residential density. Within the normal driver age limits of 16 to 76, the younger group has the more pronounced influence on parking needs. The teen-age penchant for car ownership affects both residential and school parking needs.

This cobblestone levee along the Mississippi River is in use as a municipal free lot. Note the ramp connection to and from the major route on the left. Such free or low-cost parking will often induce employees of the CBD to walk long distances.

Population density influences parking demand because low density generally means less effective public transportation and, in a suburban area, often means higher income. Low density means little walk-in or transit access to a given destination and hence a high proportion of auto trips for shopping or employment.

Land and Building Use—The term "land use" normally involves the principal activity or use of a given site, and is generally the "building" use. A recreational area such as a park, playground, campsite, or lake, however, may have no buildings but will still generate a parking demand.

Demand may be related to land or building *area,* to *persons* in occupancy, such as employees, visitors, or spectators at a sports event, or to *units* such as homes, apartments, beds of a hospital, pumps of a gasoline service station, or seats of a theater. A wide range of parking demand exists for any given method of comparison. For example, if building areas are used as a measure, beauty salons can have a parking demand of 13 spaces per 1,000 sq ft, whereas a warehouse can have a demand of only 0.7 space per 1,000 sq ft.

A fuller discussion of specification measures is given in Chapter Three.

Alternative Transportation Modes—The alternatives to parking at the site include walking, taxi, group riding, mass transit, and auto pickup/dropoff. Whatever the alternate method of arrival and departure, it reduces parking demand. The availability and attractiveness of the alternate are both important. Attractiveness involves comfort, schedule, travel time, walking distance, and cost. In theory, urban dwellers could take taxis to work, if charges were acceptable and taxis were readily available.

Traffic Access—Traffic access affects parking and vice versa. The amount of total parking demand for a facility may be limited by the inability of access streets to handle the flow within an acceptable time limit. Thus, a large industrial plant might have a total parking demand of 10,000 spaces, but the discharge within a short period of time of 10,000 cars onto only one or two streets would cause serious traffic congestion. Parking use would drop sharply until the number of parkers that could be discharged from the facility in a reasonable time was reached. Street capacity would thus have limited the parking demand.

Parking Facility Congestion —Congestion, as measured in unacceptably long waits to enter or leave a parking facility, will reduce the demand. Here the reference is essentially to internal deficiencies in operation rather than to problems on the access street system. Internal congestion on entry or exit can be caused by (a) inadequate numbers or placement of control gates, ticket dispensing machines, or attendant booths, (b) a poor circulation system, (c) deficient aisle widths, or (d) inadequate stall widths. Methods of avoiding such deficiencies are discussed in Chapter Six.

Shortages—Parking use also is influenced by the available parking supply. A deficiency in available parking spaces, as related to needs, will result in a subnormal use. The reduction may be artificial (as in the case of enforced transit riding by industrial employees who would otherwise drive) or real (as in reduced sales by retail stores caused by a scarcity of parking spaces).

In moderately high turnover curb parking, only about 85 percent of the spaces can be used before an apparent shortage appears. Thus, a motorist looking for a curb space may see two vacancies on the other side of the street, as well as a space opening up on his own side, after he has passed it. By the time he circles the block these particular spaces are filled, and an

opposite pattern of vacancy might temporarily appear.

Location—The location of a parking facility in relation to the user's destination is a prime factor in parking use. Convenience is measured in terms of walking distance. Contemporary motorists dislike walking, as illustrated by the success of drive-in facilities. Most cities have a great surplus of total available parking supply, but the CBD parking often is not located in the area of peak demand.

Cost—Parking cost and use are strongly interrelated; higher rates reduce the demand. In downtown areas parking is more expensive and spaces are harder to provide, whereas outside the CBD parking facilities are adjacent to most parking generators. In some instances remote areas may attract parking by offering lower fees and providing shuttle bus service to the downtown so that users are not faced with a long walk. Promoters often use this technique to increase the attendance at sporting events when the anticipated crowd requires more parking space than available locally. This method might also be used by merchants to promote downtown shopping during peak shopping seasons.

Local Administration—Parking needs relate to local administration in several ways. For optimum good to the total public, there should be (a) enlightened and updated zoning and building codes and policies, (b) adequate and unbiased machinery for sensible variation, (c) competent building officials and engineers who properly check parking and site plans, (d) impartial enforcement of code requirements, (e) proper follow-up inspection of actual construction, (f) extensive curb parking restrictions, and (g) strong police enforcement of parking prohibitions. Parking conditions will be affected to the degree that local administration supports, or fails to support, such measures.

Estimation of Parking Demands by Occupancy

The detailed data on parker characteristics have been limited to overall findings from the CBD areas of various cities. In the comprehensive parking study, much of the information is gathered by some sort of direct field contact with the parker, or at least his vehicle. In the absence of direct parker data, the type of land use can form a base for predicting parking demand in the CBD as well as other areas of the city.

In theory, parking demand could be predicted on the basis of building occupancy. For each land use, the travel mode for each daily occupant might be estimated. Simultaneously, the "peaking" characteristics of each land use would be determined through estimates of the maximum daytime and evening accumulations of people. Parking space requirements, in turn, would reflect the peak daytime and evening accumulations of the auto drivers.

Development of such an estimate requires knowledge not only of methods of travel but also of the relationship between occupancy and building area. However, a considerable range exists in occupancy per square foot of building area. Taking only one type of occupant as an example, the average number of employees per 1,000 sq ft of net rentable area has been calculated for several building types. Data from the CBD of Los Angeles are given in Table 2.15.

This degree of detailed information is not available in most cities. Moreover, wide variation is found between buildings of the same general classification. Of even greater importance, practically no data are readily available on other occupants, such as shoppers and visitors.

Lacking full occupancy calculations, information on the type, intensity, and location of specific land uses within a region

Table 2.15—Number of employees as related to building area

Building Use	Number of Employees per 1,000 sq ft
Offices, including governmental	5.0
Retail	1.8
Service	3.8
Hotel	0.7
Institutional	1.1
Manufacturing and wholesale	3.3

SOURCE: Wilbur Smith and Associates, "Los Angeles CBD Parking Study," 1967, Table 9.

can normally provide a measure of planning guidelines for parking. Characteristics and requirements are therefore reviewed in the following sections on selected land uses. The measures developed are also the suggested yardsticks for establishing parking as given in Chapter Three, but are subject to fitting local conditions. It is essential that competent local studies be made to establish proper values for special conditions. The variation in availability of public transportation is a major element and has the greatest effect in the CBD.

Retail Land Uses

The parking demand of individual retail stores varies with the size and type of store as well as its location in a CBD, in a planned shopping center, or at an isolated point.

Small Retail—The peak-hour parking generation of small retail stores, as sampled in the CBDs of 10 cities, ranged from 0.9 to 3.8 spaces per 1,000 sq ft of building area. The average was 2.1 spaces.

A study of 17 small retail stores in suburban areas of Washington, D. C., found a peak-hour parking demand of 2.8 spaces per 1,000 sq ft of gross building area (*5*). When related only to net retail area, the demand was found to be 4.6 spaces per 1,000 sq ft.

Department Stores—The peak-hour parking generation per 1,000 sq ft of building area averaged 2.0 spaces for department stores in the CBDs of 12 cities checked. Demand was found to be greatest in the intermediate-size cities having an urbanized area population of about 250,000. One study identified the kinds of parking needs—0.6 long-term space needed for employees and 1.5 short-term spaces for shoppers (*6*).

The characteristics of department stores in outlying areas are most closely related to planned shopping centers, as described in the following section.

Shopping Centers—In 1967 there were more than 11,000 shopping centers in North America, and the number was expected to increase to over 15,000 by 1975 (*7*). By contrast, there were only 2,000 centers in 1957. As a traffic and parking generator of local to regional significance, the shopping center is therefore a relative newcomer.

Three types of centers are recognized: the *neighborhood,* averaging about 40,000 sq ft of gross floor area; the *community,* with about 150,000 sq ft; and the *regional,* with 400,000 to over 1,000,000 sq ft (*8*). Parking demands expressed on a floor area basis are highest for the neighborhood center because its chief tenant is usually a high-activity supermarket.

A study of 23 centers of community to regional size found an average of only 3 percent of the persons arrived by public transit (*9*). The Stonestown center in San Francisco, well served by public transit, had only 7 percent of entering persons arriving by transit (*10*). Another 7 percent walked in. Had these persons all arrived by car, however, the increased parking demand would have been only 11 percent. By the end of the 1960s Evergreen Plaza in Chicago was the only major center in North America with enough transit patronage (15 to 20 percent of trips) to significantly affect parking requirements (*7*).

These findings are not intended to imply that future centers should not be designed for improved transit access and *internal* transport of persons. They do show, however, that the automobile is overwhelmingly the typical method of travel to shopping centers.

A study at Shoppers World in Framingham, Massachusetts, provides data on parking durations for a typical Friday (Table 2.16). The values are equivalent to an average duration of 1.2 hours. Shopper parkers in the CBD of cities with more than 100,000 population have a similar length of stay.

Periods of peak demand in any type of center depend on operating hours. In the 1950s it was typical to find early closing (usually 6:00 p.m.) and 1 or 2 days of late closing at about 9:00 p.m. With early closing, parking demand peaks in midafternoon, whereas with late closing a peak occurs in early afternoon, with the absolute peak at 7:00 to 8:00 p.m. Saturday exhibits a midafternoon peak with *either* early or late closing hours and usually has the heaviest single traffic hour of the entire week.

During the 1960s late closing became a daily pattern for increasing numbers of centers. Sunday openings began to appear and showed peaking characteristics in the afternoon. A major change in shopper attitudes would be required to abort the trend toward 7-day, late-closing operation.

Table 2.16—Distribution of parkers classified by length of time parked

Length of Time Parked (hours)	Percent of Parkers
0-0.5	24
0.5-1	23
1-2	38
2-5	11
5 and over	4
Total	100

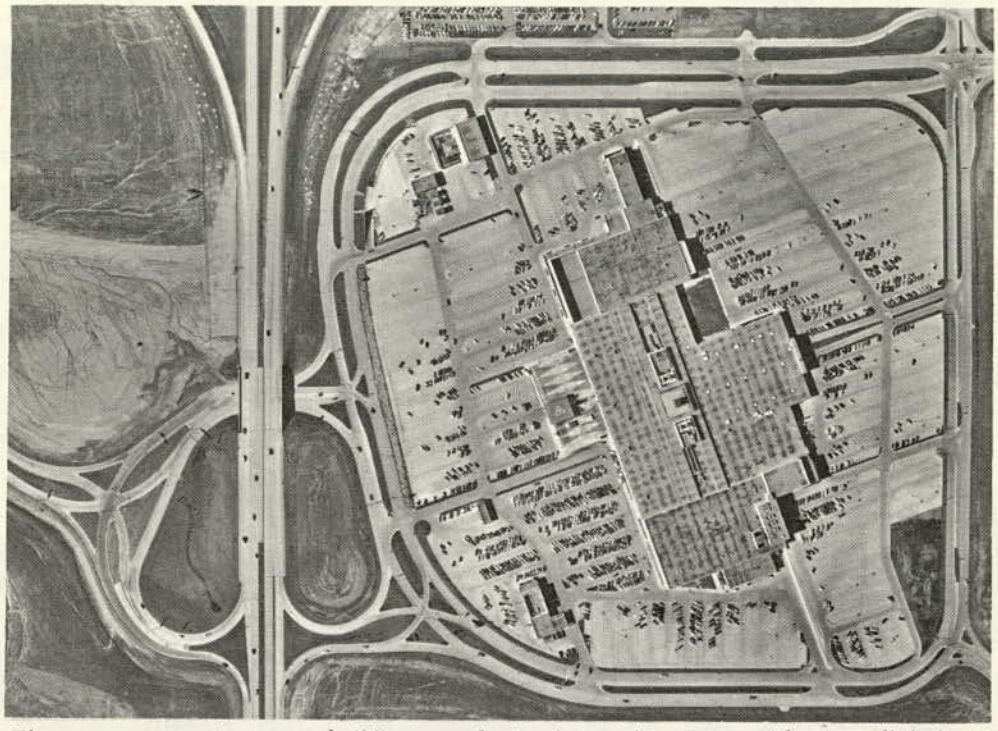
SOURCE: Donald E. Cleveland and Edward A. Mueller, "Traffic Characteristics at Regional Shopping Centers," Bureau of Highway Traffic, 1961, Figure 41.

The regional centers increasingly contain office and recreational facilities such as theaters and bowling alleys. A very high proportion of office area can, of course, increase the early afternoon secondary peak, even with the late closing shifting shopper demands into the evening hours. Evening-oriented recreational parking can also reinforce the late shopper activity. A projection of current trends indicates that future centers will include most of the existing CBD activity. Municipal buildings, apartments, and schools may well join expanded and diversified shopper facilities.

The degree to which future developments will affect shopping center parking characteristics is unknown. The shifts will most likely be toward greater similarity with the conventional CBD. The characteristics of centers presented herein may therefore represent the general conditions on the one side, whereas those on the other limit have previously been given in the CBD section.

Research carried out for the Urban Land Institute at 270 centers in North America (*11*) found a need for 5.5 parking spaces per 1,000 sq ft of gross leaseable area (GLA). The figure was suggested as a zoning reference for centers with few walk-in or transit-riding shoppers. The value is exclusive of theater or office space (exceeding 20 percent of GLA), for which additional parking supply would be needed on peak days. The recommended addition for offices would be 2.5 parking spaces per 1,000 sq ft in excess of the 20 percent factor.

Although the suggested basic ratio would not handle the parking demands for the three busiest days, the economic feasibility of catering to the absolute peak conditions may be questioned.



The regional shopping center buildings are the focal point for parking aisles. A well-designed circumferential street or highway system is, however, essential for access and egress. This development near Omaha illustrates modern concepts of land planning, functional parking, and highway improvement. (Source: Nebraska Department of Roads.)

Office Buildings

Data from transportation studies have been analyzed for 20 major office buildings ranging in size from 160,000 to 1,130,000 sq ft of gross floor area (*12*). All buildings but one were in a CBD, and nearly half had public (city, county, state, or federal) ownership. All office buildings tend to include secondary uses such as restaurants and shops. The percent of pure "office" allocations found in this study ranged from 63 percent to 88 percent of gross building area.

Trip purposes for the various office buildings are given in Table 2.17.

The auto predominated as a travel mode to all the buildings and accounted for an average of 58 percent of trips as a driver and 20 percent as an auto passenger.

The average parking duration was 5.6 hours at the public buildings versus 6.0 hours at the private offices. The relative use of curb and off-street parking is given in Table 2.18.

The parking spaces required per employee ranged from 0.2 to 0.6, with an average of 0.4 at the time of maximum accumulation. This peak varied between 8:00 a.m. and 2:00 p.m., but tended to occur in midmorning.

On an area basis, peak-hour parking demand averaged 2.0 (but with a variation of 0.7 to 4.6) spaces per 1,000 sq ft of gross building area. However, if only the

Table 2.17—Percent of parking trips to office buildings classified by trip purpose

Type of Building	Trip Purpose			
	Work	Personal Business	Serve Passenger	Other
Public	60	26	10	4
Private				
Owner-tenant	85	4	10	1
Multi-tenant	60	22	8	11
Average	64	20	9	7

SOURCE: Louis E. Keefer and David K. Witheford, "Urban Travel Patterns for Hospitals, Universities, Office Buildings, and Capitols." NCHRP Report 62, Table E-4.

Table 2.18—Percent of parking trips to office buildings classified by type of facility

Type of Office Building	Work Trips[a]		All Other Trips[a]	
	Curb	Off-Street	Curb	Off-Street
Public	30	70	63	37
Private	20	80	43	57
Average	24	75	57	43

SOURCE: Louis E. Keefer and David K. Witheford, "Urban Travel Patterns for Hospitals, Universities, Office Buildings, and Capitols." NCHRP Report 62, Table E-15.

[a] Only those trips that resulted in parking; an average of 1 percent of driver work trips and 39 percent of all other driver trips did *not* involve parking.

"usable" area is related, the range of demand was 1.0 to 7.1 spaces per 1,000 sq ft, with an average of 2.6.

A Roanoke, Virginia, study of parkers by trip purpose found that CBD office buildings generated a peak-hour demand of 2.5 long-term spaces per 1,000 sq ft for employees and 0.1 short-term space per 1,000 sq ft for visitors (*6*).

Figures from offices that are generally in the CBD may also be compared with those from private, owner-occupied suburban buildings (*13*). On a per-employee basis, this demand was found to average 0.6 space. On an area basis, peak parking accumulation was about 2.9 spaces per 1,000 sq ft gross and 3.2 per 1,000 sq ft of usable area.

Subsequent studies at another suburban building with 100,000 sq ft of usable office space found that peak demands were 3.3 spaces per 1,000 sq ft for gross area and 3.9 spaces for usable area.

A study of 19 suburban office buildings found the generation to be 3.2 spaces per 1,000 sq ft of gross floor area or 4.1 per 1,000 sq ft of net office area (*5*). These were small buildings, having 1,800 to

This multipurpose building is typical of contemporary design in Philadelphia. The 20-story office tower rises from a 5-story garage base with parking for 600 cars. (Source: Pennsylvania Department of Highways.)

21,000 sq ft of office space, and were served by little or no public transit.

For office buildings with mixed tenants, Monday midmorning represents the peak condition. During other days of the week, travel by executive and sales personnel tends to lower the demand.

Other Commercial Uses

Banks—The peak-hour parking generation of banks, as found in studies of 11 downtown areas, averaged 3.3 spaces per 1,000 sq ft of building area. A study of trip purposes in one of these cities found 2.2 spaces needed for employees and 3.1 spaces for customers, or a total of 5.3 spaces per 1,000 sq ft of building area (*6*).

Restaurants—Data from the CBD areas of seven cities gave an average peak-hour parking demand of 2.8 spaces per 1,000 sq ft of building area. Another study of seven small restaurants in suburban areas found a demand of 6.1 spaces per 1,000 sq ft of gross floor area and 8.5 spaces per 1,000 sq ft of net floor area (*5*). These restaurants had 25 percent to 30 percent of their floor area in use for food preparation and service.

Hotels—Hotel studies in the CBD areas of eight cities found peak-hour parking demand to average 0.7 space per 1,000 sq ft of building area. The range was 0.4 to 1.0 space.

Medical Buildings—Peak-hour parking demand of CBD medical buildings varies widely. Studies in eight cities found a range of 1.1 to 8.6 spaces, with an average of 5.0 spaces needed per 1,000 sq ft of building area.

Industrial—Parking characteristics at 50 major industrial plants have been summarized in a special report (*9*). Data show that the bulk of parking is free and located in off-street facilities (Table 2.19).

The mode of travel was predominantly by auto. For plants with less than 5,000 employees, public transportation handled only 11 percent of the trips. Many of the larger plants were located in older cities with substantial levels of transit service. The percentage of trips by transit increased to 22 percent in the employment group of 5,000 to 10,000, and to 31 percent in the two plants of largest size.

Table 2.19—Distribution of parking use classified by type of parking for industrial employees

Number of Employees	Type of Parking				
	Curb		Off-Street		
	Free	Meter	Free	Meter	Other
0-1,000	2%	—	94%	1%	3%
1,000-2,000	3	—	94	1	2
2,000-3,000	7	—	89	1	3
3,000-4,000	4	1%	92	1	2
4,000-5,000	23	1	72	2	2
5,000-10,000	8	5	84	2	1
Over 10,000	13	—	73	11	3
Average	10	1	84	3	2

SOURCE: Louis E. Keefer, "Urban Travel Patterns for Airports, Shopping Centers, and Industrial Plants," NCHRP Report 24, 1966, Table 42.

Another study of 22 suburban industries was limited to the smaller employment group (*15*). Parking demand was found to correlate quite closely with employment. The average value found was 0.5 space occupied per employee. However, over half of the industries had demands exceeding this value, ranging up to 0.8 space per employee.

A strong trend exists toward suburban site selection by industry. For the period 1954 to 1965, 63 percent of new industry was reported to have been constructed outside the central cities (*16*).

Industrial parking needs are affected by three conditions: (a) multiple-shift operations, which create the overlap problem at shift change time, (b) differences between office and plant personnel (the of-

fice employees typically arrive and depart later than the main shift and also have a higher parking demand per person), and (c) the absentee rate.

The main shift employment has been found to range from 44 percent to 93 percent of the daily total. The second shift seldom exceeds 20 percent, whereas the night shift tends to peak at 10 percent. The peak demand may be created by main and second shift overlap, or by main shift plus office. The condition of overlapping shifts and office work period seldom occurs.

The absentee rate is a factor in parking needs. It was found in one transportation study (*9*) to vary with plant size. Those having under 500 employees averaged 3 percent; firms with larger employment averaged 10 percent. Parking demand may also be affected by seasonal or cyclical variations in employment and by pickup/dropoff practices.

Parking lot counts at 61 industries showed a peak demand ranging from 0.60 to 0.76 space per employee (*17*). The average of 0.65 indicates a need of two spaces for every three employees.

Institutions

Universities and Colleges—The university is the largest institutional-type parking generator. Data relating campus population to parking supply and demand have been correlated for 51 United States and Canadian universities (*18*). Over half of the universities had populations exceeding 10,000 persons (the highest had 45,000). As population increased, the number of spaces per person was found to decrease, as shown in Table 2.20.

Table 2.20—Parking supply for each of five campus population groups

University Population	Spaces per Person
Under 10,000	0.3 to 0.4
10,000-15,000	0.2 to 0.35
15,000-20,000	0.15 to 0.25
20,000-30,000	0.1 to 0.2
30,000-40,000	0.07 to 0.2

SOURCE: V. Setty Pendakur, "Access, Parking and Cost Criteria for Urban Universities," *Traffic Quarterly*, Eno Foundation for Highway Traffic Control, July 1968, Table I.

The university has four classes of parkers: administrative and service staff, faculty, students, and visitors. Car occupancy ratios at nine colleges averaged 1.1 for faculty, 1.3 for staff, and 1.5 for students (*18*). The occupancy ratios increase for all classes as (a) parking supply decreases or (b) as fees charged for parking increase.

Data from transportation studies show that college parking demand has a peak in the midmorning (typically 9:00 to 10:00 a.m.), when as few as 20 percent or as many as 60 percent of the total daily arrivals have typically accumulated (*12*). The maximum parking accumulation, as related to campus population, has been found to vary from as few as 29 to as many as 390 cars per 1,000 persons. This wide range is partly due to differences in availability of public transportation, proportions of on-campus residence, and student auto-use regulations. The prediction of parking demand is extremely difficult, and the use of "average" values may be inappropriate.

Hospitals—Over 75 percent of trips to hospitals are made as an auto passenger or driver, and more than 80 percent of hospital parking typically takes place in off-street lots or garages (*12*). Hospitals frequently suffer parking shortages, and measurement of actual demand is often constrained by this lack of supply. Parking accumulation at one suburban hospital may be used to illustrate the hourly trends where an adequate supply does exist (*19*). The variation found, expressed as the total

Table 2.21—Parking demand for 316-bed general hospital

Time	Accumulation per Occupied Bed				
	Number of Employees	Number of Cars Parked			
		Doctors	Employees	Visitors	Total
Midnight to 6:30 a.m.	0.4	0.1	0.1	0.1	0.3
7:00-7:30 a.m.	0.9	0.1	0.2	0.2	0.5
7:30-8:00 a.m.	0.8	0.2	0.3	0.2	0.7
11:00 a.m.	1.1	0.2	0.3	0.6	1.1
2:00 p.m.	1.1	0.1	0.3	0.6	1.0
3:00-3:30 p.m.	1.3	0.2	0.3	0.7	1.2
4:00-4:30 p.m.	0.7	0.2	0.2	0.5	0.9
6:00 p.m.	0.4	0.2	0.1	0.3	0.6
7:00 p.m.	0.3	0.2	0.1	0.6	0.9
8:00 p.m.	0.3	0.2	0.1	0.6	0.9
10:00 p.m.	0.3	0.2	0.1	0.2	0.5
Midnight	0.3	0.1	0.1	—	0.2

SOURCE: Paul C. Box and Associates, unpublished field study.

number of parking spaces used per occupied hospital bed, is compared with accumulation of employees in Table 2.21.

Checks made on other weekdays and different months showed similar characteristics, except for a trend toward a peak total demand of 1.4 to 1.5 spaces per occupied bed.

Hospitals differ in services available. In general, services increase in proportion

The parking needs for hospitals are increasingly being met by construction of garages. This Phoenix facility is of particular interest because it shows the parking removed from the top deck to allow use as a helipad for rapid delivery of accident victims from remote areas. (Source: Valley Area Traffic and Transportation Study, Phoenix.)

to the number of beds available. In addition to basic services, there are options such as teaching (nurses and intern programs) and research that may have little relationship to the number of beds provided. Similarly, the availability of on-site residence, nearby off-site residence, and public transportation all affect the parking demand within the hospital site.

The parking demand is generated by three classes of people: hospital employees, visiting doctors, and visitors to patients. The peak period of employee concentration occurs between 3:00 and 3:30 p.m. At this time the day shift and the afternoon shift overlap. In addition there is a substantial visitor load. These conditions combine to produce the maximum parking accumulation found during the field studies.

A trend has developed for hospitals to spread visitation hours throughout the day and evening (the hospital in the subject study allowed visitors from 11:00 a.m. to 8:00 p.m.). This is beneficial from the parking standpoint, since it reduces the midafternoon peak.

There is a general increase in the number of employees per bed as the size of hospital increases, and there has also been a rising trend in employees per bed over the years.

Stadiums and Auditoriums—The construction of auditoriums and stadiums near or adjacent to the CBD is becoming more common. Examples are found in Kansas City, Detroit, New Haven, Seattle, Pittsburgh, and St. Louis. The availability of public transit will affect parking demand. Motor vehicle occupancy rates will also affect demand, and these have been found to vary by types of event. Studies have shown auto trips to football games involve approximately 3.5 persons per car, but baseball only 2.5 (*20*). Attendance characteristics for certain types of events at the Kiel Auditorium (St. Louis) are given in Table 2.22.

Most all-purpose stadiums are currently being designed to handle between 100 and 130 events per year, and fortunately few of these events coincide with normal peak-hour traffic and parking demand. Major league baseball has approximately 75 playing dates per year, but only about five games are scheduled during weekday afternoons. Most games are at night and on the weekend, with only a few doubleheaders. Professional football can only be expected to play 10 games per year. These

Table 2.22—Auditorium patron travel mode

	Percent Arriving by:			
	Auto			
Event	Driver	Passenger	Transit	Taxi and Walking
Basketball	39	50	5	6
Jazz	27	52	4	7
Pop concert	31	49	14	6
Symphony	41	49	5	5
Philharmonic	30	51	13	6

SOURCE: Paul C. Box, "Parking Generation Studies," *Highway Research Abstracts*, April 1962, Table 11.

The sports stadium has a surge-type parking demand of extreme magnitude. The football crowd averages 3.5 persons per car, but many others arrive by chartered bus.

are usually scheduled on Sunday afternoon and cause few traffic and parking problems. Other events that may take place in a covered stadium include political rallies, religious meetings, professional boxing, home shows, automobile shows, and boat shows.

Crowds at major-league professional football games average approximately 45,000 people per game. For baseball, the average crowd is approximately 15,000 to 17,000 fans, but a "design" crowd of 25,000 is often provided for. Furthermore, a baseball crowd can be expected to exceed 25,000 fans about 8 to 10 times per year (*20*).

A walking distance of 1,300 to 1,500 ft is usually assumed for the design crowd of 25,000. It is often not practical to provide all the parking needed for the 45,000 design crowd, and in these cases the parker can be expected to walk distances more than 2,000 ft. Many cities now are designing for shuttle bus service to pick up passengers at remote locations and bring them to the game. Furthermore, bus use by out-of-town groups, if promoted properly, can generate as high as 200 to 300 charter buses per game.

Summary of Institutional Parking Needs—A report in 1960 developed "suggested planning standards" for several kinds of institutions (*21*). These have been converted to a per-unit basis and are shown in Table 2.23. The application of these values to zoning standards appears to be warranted by the results of other studies.

Table 2.23—Planning standards for institutional parking

Type of Institution	Number of Parking Spaces
College/university	0.5 to 0.7 per student
Senior high school	0.2 per student plus 1.0 per staff member plus evening activity needs
Hospitals	1.0 to 1.4 per bed
Auditoriums	0.25 per seat
Stadiums	0.25 per seat

SOURCE: Wilbur S. Smith, "Access and Parking for Institutions," Eno Foundation for Highway Traffic Control, 1960, Table II.

Airports

Outside of the CBD, a metropolitan airport is usually the second largest single parking generator in the urban area. Airports have widely differing characteristics, and these characteristics are based almost entirely on the scheduling of flight arrivals and departures and the total number of passengers handled. As with hospitals, it is a 24-hour-a-day, 7-day-a-week demand. Also, the use of airports by passengers has been increasing at a rate of approximately 14 percent per year.

Transportation studies have found that in getting *to* the airport, the proportion of trips represented by automobile drivers (a large number of whom are parkers) ranged from 52 percent at Chicago's Midway Airport to 82 percent at Atlanta's airport (*9*). With respect to all trips to and from the airport, people drove or rode as a passenger in an automobile in from 85 percent to 100 percent of the trips sampled. Furthermore, the proportion of automobile drivers was significantly higher for business trips than for other trips.

Employees are a major factor in parking demand. A survey at the John F. Kennedy International Airport found 70 percent of the 42,500 employees to be on duty at the same time (*22*). Only 11 percent of these used public transit.

Two-thirds of all airline-related parking at the Philadelphia International Airport was found to be for periods of less than 4 hours (*23*). These parkers were bringing air travelers to the airport or picking up arriving passengers. At this airport, about 25 percent of all air travelers parked for over 24 hours. In order to

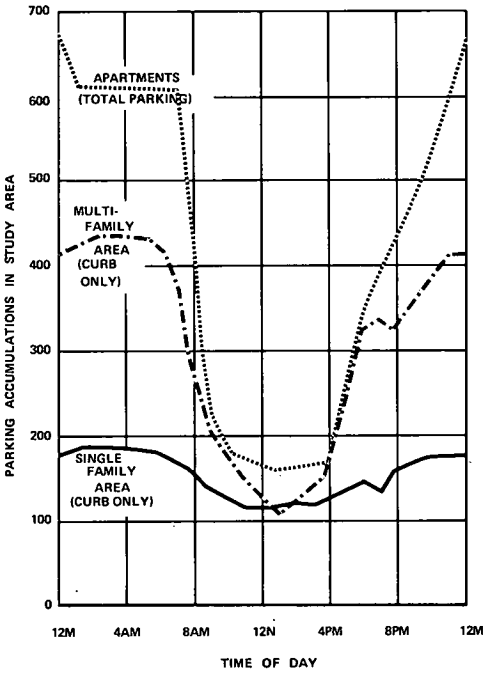


Figure 2.6. Variation in parking accumulation in residential areas by time of day.

save space near the terminal for the high-turnover short-term parking, many cities provide reduced-rate long-term parking at a more remote location, with shuttle bus service to the terminal.

Residential

The patterns of residential parking demands are important when considering joint or overlapping use of facilities. The development of a site with multiple uses such as offices, recreational, shopping, and residential apartments has obvious advantages. The John Hancock Building in Chicago is an example of such combined uses in a "vertical city" concept.

In analyzing how the gross parking supply can be used to satisfy a variety of demands, the hourly accumulation characteristics of each use must be considered. Figure 2.6 shows the accumulation curves for *curb* parking in a single-family residential area (average density of 4 dwelling units per acre) and in a multiple-family area (10 to 25 dwelling units per acre). Because much of the single-family parking was off-street, as was a smaller percentage of the apartment area parking, these two curves do not represent total parking demand. The third curve, marked "apartments," is given for comparative purposes and illustrates actual demand accumulation.

Table 2.24—Proportion of parking during average and low periods in residential areas

Category	At Curb[a]		Total Demand (Multiple Family)
	Single Family	Multiple Family	
Percent average period is of peak	82	72	62
Percent low period is of peak	62	37	17

SOURCE: Paul C. Box, unpublished field studies in Skokie, Illinois.

[a] Actual demand not represented since off-street use not included.

The variation for the three kinds of areas, as related to the peak hour of the day, is given in Table 2.24.

In all cases, the low period of demand is in the midday, while the absolute peak occurs during the early morning hours. An "intermediate" or secondary peak is reached in the early evening. This secondary peak *coincides* with the absolute peak parking demand for two other uses—regional shopping centers (on a day of late closing) and theaters.

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CHAPTER THREE

ZONING

Zoning provides the community with a means for achieving a balanced, orderly development. It represents a major tool in the long-range treatment of the parking problem. Zoning is directly involved with traffic operation in several respects—street right-of-way dedications, setbacks, development density, and access limits. A sufficient off-street parking and loading supply can permit limitation or prohibition of curb parking. By allowing streets to perform properly their basic mission of vehicular movement and access to abutting property, zoning can materially aid traffic operation and safety.

On the other hand, an inadequate parking supply that results in excessive use of curb space can create more than congestion and hazard. It can result in employee parking spillover from commercial areas into nearby residential streets and thus produce neighborhood discontent. Such conflict may involve both the city and the businessman. Inadequate parking can also directly cause business loss or create employment problems for industrial plants.

Because the purpose of zoning is to aid the total community, sensible parking provisions are frequently supported by both business and industrial leaders. With proper applications, including amortization time limits for nonconforming land uses, a city can actively plan for the long-range treatment of many of its parking needs by private enterprise.

This chapter includes a table of guidelines for parking requirements in zoning codes as well as suggested supplemental specifications. Needs and problems of implementation are also reviewed.

DEVELOPMENT OF PARKING REQUIREMENTS

Demand Factors

Parking needs of all areas depend on the type and intensity of land use and the socioeconomic characteristics of the land users. Precedents, cultural conditioning, and the availability of alternate travel modes also influence parking needs. Although needs vary among and within urban areas, the elements that influence these needs and the manner in which they interact are similar.

Parking demand will reach a maximum if the pattern of land development provides adequate parking and travel conditions, if automobile use is universal, and if

This type of hazardous parking in the sidewalk area of the street right-of-way typically results from inadequate zoning requirements. For small, outlying buildings of this kind, about 50 percent of the area of each lot is usually needed for off-street parking spaces, including maneuver and access aisles.

peak intensity of use occurs. This potential parking demand, however, may be constrained by limitations in the existing supply of spaces, high parking costs, less-than-capacity use of the development, multiple-purpose trips, and the availability of alternative forms of transportation. In reality, basic parking demand is seldom "pure." The following examples illustrate various complexities associated with parking demand estimates.

If a motel is built at a rural location along an important highway, remote from industry, and without any rail, bus, or air connections, its parking demand will be limited to that produced by employees and guests. During any peak period, when all units are rented, the approximate parking demand will be 1 space per room plus 1 space per employee. Some variation will exist among different motels and at different times of the year for a given motel.

If the motel adds a restaurant, the parking demand may change. Motel guests who eat at the restaurant are multiple-purpose parkers requiring but one space to serve the two uses. Persons eating at the cafe and not staying at the motel require added parking spaces if motel spaces are not convenient to the restaurant or if they will be eating at a time when the parking lot is filled with cars belonging to motel guests.

Measurement of the actual parking need now requires detailed knowledge of (a) motel guest characteristics such as arrival times, accumulation trends, eating times, and departure times and (b) cafe user characteristics by time of concentration, size of party, and percent of use by other than motel guests.

If an industrial plant is developed within a few miles of the motel and restaurant, parking needs would again change. Cafe use by nonmotel guests would increase,

which might raise the parking demand. Concurrently, however, motel guest parking needs might decrease. Some out-of-town visitors to the industrial plant might be picked up at an airport by a plant employee and therefore not be driving a car while a guest at the motel.

It is not possible in any of these cases to predict the exact number of parking spaces required for the motel and restaurant. Any zoning code parking specification will result in either a deficiency or surplus of parking space supply at one or more of the "peak" periods. In practice, a typical zoning code might require 1 space per room and 0.5 space per employee for the motel, plus one space per 4 seats and 0.5 space per employee for the restaurant.

Such a specification probably will provide sufficient parking for *most* of the needs. When demand exceeds capacity, one of three conditions will occur: (a) people will drive on to eat elsewhere, (b) drivers will congest the parking lot by stopping in driveways, or (c) drivers will park along the highway. Drivers experiencing congested parking once or twice might go elsewhere in the future. Supply and demand tend to balance, with the property owner or lessee the consistent benefactor when supply at least equals demand.

Regardless of zoning requirements for parking, it should be evident to any owner of a proposed or existing building that employees or customers must have acceptable access to the property by whatever mode of travel they choose. If transit is inadequate, the success of the enterprise will depend largely on the availability of parking facilities.

Handling the Variation of Needs

Ideally, zoning requirements should stem from local studies of actual parking demand for each type of land use. Separate study is needed for the various areas of a city that may have different parking demands for the same type of use. For example, the CBD and/or its fringe usually have distinctly different parking characteristics from other areas. Planned developments, such as large shopping centers, office, industrial, or apartment complexes, may require criteria or specifications that vary from those that satisfy "average" needs in the city.

The findings from numerous parking demand studies were given in Chapter Two. City size was shown to be a particular factor in CBD parking needs. However, parking demand for a specific land use varies not only within parts of a city, but also between cities in the same size grouping due to differences in public transportation, economic levels, local policies, and customs. An illustration may be cited whereby the parking demands of numerous land uses were sampled in six cities of approximately equal size. Considering only one specific land use (medical buildings), the parking generation ranged from a low of 1.1 spaces per 1,000 sq ft of building area to a high of 8.6 (*1*). The average value was 3.8 spaces. Blanket zoning specifications using the average value would evidently result in totally inadequate parking supply in some cases and financially impossible and unnecessary requirements in other situations.

This problem can be handled in several ways. The first technique is the use of locally applicable basic data on *actual* parking generation for at least those land uses having the greatest regional variation. This requires special study. The second technique is the specification of parking as a function of different zoning *districts* within the city. Genuine needs for variations can then be handled via an appeals board. Thus a commercial or even residential development in the CBD of a larger city would be required to supply a smaller number of parking spaces per unit if serviced by public transportation

compared with a similar development in an area of the city less well served by transit.

A third technique—the planned development concept—is available to a limited degree. The parking demand for a specific site in a district is separately considered, based on the particular characteristics of only the land uses being planned in the development. A smaller-scale modification of this is the special (or conditional) use permit. Certain land uses are singled out that may have widely varying parking (and traffic, vibration, or noise) characteristics. These uses receive individual study prior to issuance of a building permit, and developers may be required to supply parking in excess of the district requirement.

Zoning can provide effective long-range treatment for parking needs in older areas as well as prevent shortages from developing in newer areas. However, exceptional conditions appear in all cities where even the wisest and most carefully considered parking requirement is not applicable. For this reason, a method is necessary to handle honest needs for individual variations. This is accomplished by a variation hearing agency, which is often called a Board of Zoning Appeals. In principle, this board should hear requests by developers or individuals for reduction in parking supply and by public agencies for *increased* parking supply, as related to specific building proposals. This is a small-scale application of the planned development concept. Although the administrators of most cities provide for the downward variation, few have as yet applied the upward variation except when considering special use permits.

Method of Specifying Parking

A zoning code must use practical units as a method of parking specification. Thus, a given number of spaces may be required per dwelling unit, employee, bed, square foot of building, or other unit of measurement. The degree to which the zoning requires adequate parking can depend greatly on the aptness of the unit specification chosen.

Residential parking requirements are traditionally related to each dwelling unit. However, the number of bedrooms is an important consideration for multifamily dwellings, because apartments are developed with everything from "efficiency" units having pull-down beds to four-bedroom units. Because requirement of fractional numbers of parking spaces is practical for apartment buildings, the specification can be written as a function of the actual number of bedrooms. The zoning district concept, with separate residential parking requirements, also assists in permitting consideration of these and other factors such as car ownership, income, and public transportation access.

Parking needs for offices are usually stated as spaces per 1,000 sq ft of floor area. Although this system is easy to administer, anything but a minimum requirement can become inequitable because of the wide variations of floor space actually allotted per employee in various offices. The great differences in parking generation between downtown and outlying areas can, of course, be handled by establishing zoning districts.

At retail stores, the parking demand is based on a combination of employee plus shopper demand. There is often no direct relationship between employment and shopper concentration; therefore, total parking needs for retail uses are usually specified as a function of floor area.

When using area calculations for a planned shopping center, the recommended parking measurement is GLA (gross leaseable area). Included are all finished floors. Excluded are service areas outside the stores, boiler rooms, and freight tunnels or corridors. Also excluded

are truck docks, which should be required for each major office or retail store and should have sufficient space to accommodate all simultaneous deliveries.

Another commonly used measure is GFA (gross floor area). When used for office buildings, GLA does not usually include elevators, corridors, utility or rest rooms, or service areas. Because some of these area breakouts can be changed by the owner, it is common practice in zoning codes to use the larger GFA figure in specifying parking.

Seating capacity is an appropriate specification unit for places of public assembly, including restaurants. As shown in Chapter Two, hospitals can best be related to parking demand by using employment, but as a practical matter, the number of beds also represents a good measure.

A summary of typical parking specification units is given in Table 3.1. In several cases, an alternate unit can be considered.

RECOMMENDED REQUIREMENTS

Specific zoning standards can be established once the parking needs of a community are estimated and the specifications for various land uses are resolved. Traditionally, there have been two basic differences between needs and ordinances: The standards used to determine needs were not always the best in terms of the practical problems of administration, and within each standard classification there is a wide range of needs.

These practical considerations often produce a zoning standard that incorporates minimal rather than average needs and a general classification rather than a complex regulation that relates to the specific use or combination of uses for which a building is intended. Separate zoning districts should be used when extreme variations in parking demands occur between different areas within the city.

Table 3.1—Typical parking specification units

Type of Land Use	Parking-Related Unit	
	Preferred	Alternate
Residential		
Single family	Per dwelling unit	Per dwelling unit with range by number of bedrooms
Apartment	Per dwelling unit with range by number of bedrooms	Per dwelling unit
Shopping center	1,000 GLA[a]	—
Other retail	1,000 GFA[b]	—
Office	Per employee	1,000 GFA[b]
Industrial	Per employee	1,000 GFA[b]
Hospital	Per employee	Per bed
Medical/dental	Per doctor	Per office
Nursing home	Per employee	Per bed
Hotel/motel	Per unit	—
Restaurant	Per seat	1,000 GFA[b]
Bank	1,000 GFA[b]	—
Public assembly	Per seat	—
Bowling alley	Per lane	1,000 GFA[b]
Library	1,000 GFA[b]	—

[a] Per 1,000 sq ft of gross leaseable area of building.
[b] Per 1,000 sq ft of gross floor area of building.

Thus, selected standards reflect the minimum acceptable parking needs of the individual community district after taking into account its size, density, growth rate, transportation systems, present design, and future development plans.

When a zoning standard is enacted into law, it should apply to all new buildings. As permits for building remodeling are requested, simultaneous upgrading of parking or loading often is possible. All parking standards used in zoning laws should be reviewed periodically and updated to correct parking deficiencies. Communities using minimum standards should select ones that do not restrict overall development planning of the district. This can be accomplished by including separate standards for the high parking generators within a general classification. An example would be "retail" as a general classification of which "supermarket" is a specific use.

Residential Developments

Parking generation for residential areas varies directly with auto ownership in the area. The trend in newer communities is toward additional cars per household. Therefore, a liberal index of two spaces per unit is usually desirable. However, older communities where residences and businesses were built in an era of few automobiles may find 1.0 to 1.5 spaces to be more realistic in terms of actual ownership. There is also a relationship between income and car ownership.

Single Family—Areas with a significant percentage of two-car families should have two off-street parking spaces per dwelling. Other considerations may be the size of the residential lot, width of abutting streets, and functional classification of the street of principal access. Homes facing onto major traffic routes should have at least two spaces each plus

This community allowed homes to be built with only one parking space per home. In some cases, owners park their second car in the driveway, but this blocks access to the garaged vehicle. A more far-sighted zoning regulation would have required two spaces for each home. (Source: Paul C. Box and Associates.)

driveway width and depth to accommodate two guest cars.

Apartments—Consideration should be given to using district standards for multiple-family developments. Separate provisions for visitor parking are optional if management permits visitors to use spaces vacated by residents who are away from their apartments. Assignment of parking stalls to specific residents is *not* recommended.

Apartments in or adjacent to the CBD of large cities represent a special condition. The parking demand may be quite low (less than one space per dwelling unit) because the convenient location attracts many residents who do not own cars. Local studies and zoning district regulations are essential in order to specify a reasonable parking index.

A relatively recent development, special apartments for young unmarried persons, illustrates the usefulness of the concept of spaces per bedroom for the multifamily residence. In these developments, 1.0 to 1.5 spaces may be needed for an efficiency, 1.5 to 2.0 spaces may be needed for a single-bedroom unit, 2.0 to 3.0 spaces for two-bedroom units, and 2.0 to 4.0 for three or more bedrooms.

The more conventional type of special housing for young people is the lodging house or fraternity. A typical need may be 0.5 space per bed, but local study may show a higher demand.

Commercial

In downtown areas, depending on city size and mass transit availability and use, a very low requirement may be sufficient for offices. For most locations, however, the demand will be three to four spaces per 1,000 sq ft of GFA.

Similar values may be applied to most commercial and isolated retail uses. Beauty and barber shops, grocery stores, and certain other types of commercial uses can have a wide variation in parking requirements, depending on their location. In the CBD, medical and dental offices, indoor theaters, restaurants, cafeterias, specialty shops, drug stores, and department stores are heavily customer-oriented, with low employee density as compared with offices. Yet a very high percentage of patrons will be on multiple-purpose trips or will be office employees of the area. It is therefore appropriate to set lower levels of parking requirements in specified CBD areas, particularly those that have well-developed transit systems.

Another factor concerns hours of demand. Restaurants and night clubs may not need to provide extensive parking if peak occupancy occurs when other downtown commercial developments such as offices are closed. Public parking spaces provided for these latter uses may then be shared by the restaurant or night club.

Parking indexes for shopping centers should be adjusted to fit specific developments. A neighborhood shopping center with a supermarket as the major tenant would require a greater number of parking spaces, such as 7 to 9 spaces per 1,000 sq ft of GLA. On the other hand, furniture stores have low parking requirements, such as 1 or 2 spaces per 1,000 sq ft. A regional shopping center may need only 5 to 6 spaces per 1,000 sq ft of GLA when demands reflecting the wide diversity of uses do not peak simultaneously. If office space exceeds 20 percent of GLA, additional parking should be considered. A rate of 2.5 spaces per 1,000 sq ft of GLA devoted to offices (beyond the 20 percent limit) is suggested.

Initially, larger shopping centers should be designed with provision for future expansion and ample parking spaces to meet seasonal shopping demands at Christmas and Easter. As expansion of the center occurs, it quite often is very expensive to acquire additional land for parking. Expansion may simultaneously add leasable area and reduce parking. Another consideration is the quality of public trans-

portation service; good transit access reduces the peak parking requirements by as much as 10 percent.

Historically, downtown hotels provided little or no parking but depended on customers using commercial parking, taxis, and nearby transportation terminals. Suburban motels have always provided one space for each rentable room. Today, many motels in or near the city center are providing the same amount of parking space. Many older hotels are building or leasing nearby parking lots or garages; they have found that complete parking accommodations are necessary for both guests and hotel visitors who are attending luncheons and conferences. Employee parking, truck facilities, and taxi standing areas are also needed.

Industrial

For most industrial plants, 0.5 space per employee for the combined employment of the two largest overlapping shifts is a normal minimum need. Many large employers use a more liberal parking index. For example, a major automobile manufacturer has used 0.8 space for each employee. Other industries have used 0.75 space per employee.

Additional spaces should be provided equal to the peak number of visitors on the premises at one time plus the number of company vehicles stored on the premises during the day. These additional needs often increase parking space requirements by as much as 15 percent.

Auditoriums, Stadiums, and Theaters

Parking needs for theaters, stadiums, auditoriums, convention halls, and other places of public assembly or entertainment such as movies, gymnasiums, roller rinks, private clubs, and lodges will vary with the remoteness of the facility, the availability of public transit, and the type

This neighborhood shopping area in Little Rock has proper parking setbacks and an efficient layout and provides use of the common facilities by several stores. Progressive zoning encourages such developments. (Source: Arkansas State Highway Department.)

of performance or meeting involved. Truck facilities may be required, particularly for convention halls that cater to exhibitors. Special parking areas should also be provided for charter buses.

Schools

As discussed in Chapter Two, parking generation at colleges is affected by such factors as population, proportion of resident students, parking fees, and availability of transit. Parking needs vary inversely with the availability of convenient alternative transportation. High campus parking fees tend to increase car occupancy and reduce actual demand for spaces. As campus population increases, the number of spaces per student declines.

Campus stadiums and auditoriums generate additional parking needs, particularly when scheduled events coincide with classes. Many high schools embody a campus type of design that exhibits similar but lesser parking needs, with the differences being the unlicensed, nondriving students that arrive by bus or someone else's car. A minimum requirement for all secondary schools is 0.5 space per employee.

Churches

For parking needs, churches are considered a special place of public assembly. Peak demands do not coincide with high parking requirements for other land uses. Therefore, the parker may use spaces provided for other developments, such as a nearby school. Parking needs are affected by family size and scheduling of both services and church classes. A typical suburban demand for two morning services and Sunday school is 0.3 space per seat.

Table of Guidelines

A schedule of minimum requirements for parking spaces is given in Table 3.2. These guidelines should be compared with previously discussed needs and adjusted in accordance with local conditions. Standards for other types of uses should be derived directly from local field studies.

These basic standards are intended to reflect generally the best (but not necessarily the highest requirements) of past and current practices. The area of greatest parking growth is residential, and these standards are an attempt to anticipate the needs for the foreseeable future.

SUPPLEMENTAL SPECIFICATIONS

To be effective, a zoning code not only must specify the number of required spaces but also must contain sufficient controls to ensure that all the parking becomes a practical and safe reality. Examples exist where architects have shown impossibly narrow or inaccessible spaces on their plans and where developers have proposed remote parking sites beyond any reasonable walking distance. Cities and plan commissions have drawn zoning and building ordinances requiring screening fences or shrubbery that produce dangerous view obstructions at driveways or intersections. Some codes specify inefficiently narrow driveways or inadequate radii that actually promote the street congestion and hazard that the framers were attempting to avoid. Others put such restrictions on pole height or efficiency of lighting arrangements that parking lots cannot be adequately illuminated.

The following specifics have been tested in practice and are recommended for consideration in zoning codes.

Relation to Site and Joint Use

Zoning can aid sound community development if it causes every owner to provide adequate off-street parking and loading facilities for his property. This does

Table 3.2—Zoning standard guidelines

Use of Building or Site	Minimum Number of Parking Spaces Required
Residential	
Single family	2.0 per dwelling unit
Multifamily[a]	
Efficiency	1.0 per dwelling unit
One or two bedrooms	1.5 per dwelling unit
Three or more bedrooms	2.0 per dwelling unit
Commercial	
Offices[a] and banks	3.3 per 1,000 sq ft GFA
General retail[a]	4.0 per 1,000 sq ft GFA
Shopping centers	5.5 per 1,000 sq ft GLA
Restaurants[a]	0.3 per seat
Hotels, motels[a]	1.0 per rentable room plus 0.5 per employee
Industrial[a]	0.6 per employee
Auditoriums and theaters[a]	0.3 per seat
Churches	0.3 per seat
College/university	
Good transit access	0.2 per student
Auto access only	0.5 per student
Senior high school	0.2 per student plus 1.0 per staff member
Elementary and junior high school	1.0 per classroom
Hospitals	1.2 per bed

[a] Exceptions permitted in CBD if adequate public transportation is available.

not mean that each building should have its own parking lot or garage. In a business area, the development of consolidated, common-use parking facilities is clearly more practical and desirable than individual sites. However, zoning should apply to business districts (including the CBD) to the extent that each developer is required to contribute his fair share of the acquisition and development cost for the parking needed to serve his property. This can be done by cash contributions to an area parking fund in an amount equal to the estimated cost of providing the specified number of spaces.

A common method for avoiding small individual parking facilities involves "exclusions." Under this type of specification, an arbitrary floor area is assumed to have zero parking demand, even though it otherwise constitutes usable office, sales, or manufacturing space. For example, one large city has excepted floor space "equal to twice the lot area" in certain districts. Such techniques may be considered undesirable because they do not realistically relate to actual needs of each development.

Leasing of parking space is necessary when the developer does not own adequate land. A recommended practice is to specify that leased parking spaces be no more than 400 ft away from the use that they serve. Codes should require that the lessor of the parking space provide the city with a suitable covenant to prevent sale or development and to guarantee the continued offer of lease to the affected building.

In a business area, the code may specify a lump sum payment to the city equal to the cost of providing off-site parking.

Such a payment is recommended only if (a) the city has an active parking program, (b) the funds will be applied to the program, and (c) the program provides spaces that are at least equal in number to the individual development code specifications for parking.

The law should also permit cooperative parking when one or two buildings share parking space on an adjacent facility, providing there is not a reduction in the spaces required for either building. Cooperative parking allows the community to exercise some control over the number of exits and entrances located on major routes without restricting building development or forcing the developer to provide either undesirable or inefficient parking within his property boundaries.

The zoning ordinance for Fairfax County, Virginia, was drafted with a provision for combined parking that covered the cooperative development of parking (*2*). This ordinance also contained a provision that the "planning commission may reduce the amount of space required for a church or for a meeting place of a civic, fraternal, or similar organization under the provisions of this ordinance by the amount of space available to it in such a combined parking area by reason of different hours of normal activity than those of other uses participating in the combination."

Double uses of nonconcurrent demand spaces warrant consideration. The possibility should be kept in mind, however, of changes in future business hours (for example, expanded Sunday shopping).

Reservoir Capacity

Zoning code requirements should call for adequate reservoir capacity so that cars waiting for entry to a facility do not obstruct the adjacent street. This is most significant when associated with such land uses as drive-in banks and theaters, car washes, and attendant-park garages. Reservoir requirements should reflect the differing peaking characteristics of individual facilities.

The location of the facility, the capacity available on adjacent streets, and the acceptance rate of the facility also affect the needs for reservoir capacity. Reservoir capacity is more critical at a downtown bank during the rush hour than at a car wash on Sunday morning. Typical examples of observed inbound parking reservoir needs are given in Table 3.3.

Stall Sizes and Access

For all auto parking, the minimum acceptable stall dimensions are 8.5 ft wide and 18.5 ft long. The stall width is related

Table 3.3—Typical inbound reservoir needs

Use	Reservoir Requirement
Drive-in banks	12 to 24 spaces
Drive-in theaters	10 to 20% of theater capacity
Mechanical car washes	30 to 50 spaces
Parking facilities	
Free flow entry	1 space per entry driveway
Ticket dispenser entry	2 spaces per entry driveway
Manual ticket dispensing	8 spaces per entry driveway
Attendant parking	10% of that portion of parking capacity served by the driveway

SOURCE: Paul C. Box & Associates, generally unpublished field studies.

to aisle width, but minimum vehicle door opening space must also be observed. An 8.5-ft stall width assumes a clear space or adjacent stall of the same dimension on both sides. If a stall is located with one side adjacent to a wall or high curb, an additional 0.5 ft of width is needed. The minimum stall width, if walls are on both sides, is therefore 9.5 ft.

The use of minimum width should be restricted to attendant type, employee, or residential garage parking. Customers or visitors to shops, offices, and theaters normally should be provided with 9.0-ft wide stalls. At supermarkets, customers usually have packages to load, and the desirable stall width is 9.5 ft. Some stores are using 10.0 ft as a standard in recognition of customer convenience needs. The basic stall dimensions are in addition to the required maneuver and access aisles. The aisle width decreases slightly as stall width increases. Table 6.1 in Chapter Six contains basic dimensions that may be directly incorporated into a local zoning code.

Back-in parking requires substantially less aisle width and, hence, less total area than the pull-in parking. Unfortunately, pull-in parking operation must be assumed as the norm for most activities. An industrial plant may occasionally be found where management can require employees to park by back-in maneuver. Residential and employee parking off alleys may be assumed and designed for direct back-in parking, provided the number of spaces thus served is small. With these exceptions, it is recommended that parking aisle width requirements be specified for pull-in type parking.

Although cars are generally no higher than 63 inches, headroom must be provided for pedestrians in garages. Hoods of cars at pull-in stalls under a ramp may enter restricted height areas. Except for such areas, a minimum vertical clearance of 7.0 ft is recommended.

Good driveway design is particularly important for the higher volume commercial driveways. In areas with high pedestrian activity, it is good practice to restrict driveway widths and radii and meet sidewalk grade a short distance in from the curb, thus creating a hump. Such measures ensure vehicular entry and exit at low speeds. In all other areas, use of greater widths, large radii, and flat driveway slopes (frequently requiring step-down curbs) is desirable to speed up the entry and exit of vehicles. The suggested specifications for zoning codes have been drawn to recognize both areas, as well as the different kinds of driveways and land uses served. These data are given in Table 6.3 in Chapter Six. All driveways with traffic exiting across public sidewalks should also have a clear sight triangle inside the property measuring 8 ft by 8 ft to allow driver visibility of pedestrians on the sidewalk.

Construction Details

The paving of all parking lots is highly desirable to prevent blowing rock dust, provide all-weather use, control drainage, and allow marking of stalls, aisles, and no-parking areas, and for aesthetic reasons. Parking areas requiring night use, such as shopping centers, theaters, restaurants, and apartments, should have security lighting. Glare or excessive light beyond the property should be reasonably restricted, but height limits for poles are not desirable.

Boundary protection along exterior property lines is needed to prevent parker encroachment onto adjacent property or on public sidewalks. Poured-in-place curbing or precast wheel stops are most frequently used because of low cost and good appearance. The disadvantage of low curbing or blocks concerns bumper overhang, since they act as wheel stops only. Front bumper overhang is usually

Although this wide, isolated exit on a one-way street has little detrimental effect on traffic, the blind corners create a dangerous condition for pedestrians. A clear sight triangle inside the property, measuring at least 8 ft by 8 ft, would increase safety. (Source: New York State Department of Transportation.)

not more than 3.0 ft beyond the wheel, but rear overhang may exceed 4.5 ft. In a 90-deg lot layout, it is possible to set the wheel stops for either type of operation. If some drivers will pull into spaces, the aisle width must be set for this condition. Parking plans must give special attention to wheel stop placement if bumper overhang of an additional 2 ft poses a problem. Wheel stops controlling angle parking adjacent to such areas should be butted to form a continuous line. Despite its cost and questionable appearance, the best form of protection probably is the highway guardrail. This rail affords direct bumper contact, is durable, and is low enough to allow adequate sight distance above it.

Zoning codes should not require wheel stops for interior stalls. Such blocks usually are not needed and can create a potential pedestrian hazard, trap blowing debris, and interfere with snow plowing in northern climates. The blocks should be allowable, however, since a useful purpose is occasionally served.

All boundary controls should be constructed to avoid creating blind exit drives or blind corners at adjacent street intersections. Zoning codes that specify screening boundary controls should set 24-in. height limits or 8-ft setback lines to minimize hazard.

The following summary of parking specifications can be incorporated in zoning or building codes.

1. Each parking stall shall have appropriate access to street or alley.

2. Maneuver and access aisle area shall be sufficient to permit vehicles to enter and leave in a forward motion, except that residential and employee parkers may back-in from alleys.

3. The full width of an alley, but no part of a public street, shoulder, or sidewalk, may be used in calculating the access aisle portion of a one-side parking module.

4. Parking layouts shall use as guidelines the dimensions given in Table 6.1 in Chapter Six.

5. Lots parking five or more vehicles shall be paved with a dustproof, all-weather surface.

6. The lot shall be graded so that it will drain as required by the city engineer.

7. All boundaries of the lot directly abutting public or other private property shall have a landscaped setback of at least 8 ft or shall have a suitable barrier to prevent vehicle encroachment beyond the property line.

8. Neither the required boundary of Item 7 nor any landscaping shall block the visibility of drivers exiting across a public sidewalk or entering a public street. If located closer than 8 ft to the nearest sidewalk line or 20 ft from the nearest roadway edge, any closed fence, wall, or hedge line shall not exceed 24 in. in height along any side having a driveway exit to a street.

9. Parking facilities available for night use by customers of retail stores or patrons of theaters, restaurants, night clubs, and similar uses shall be lighted as required by the traffic engineer.

10. Driveways shall be paved and shall conform to the specifications in Table 6.3 in Chapter Six, unless very high volumes or other special circumstances warrant variation by the traffic engineer.

Loading

Nonresidential land use generally requires off-street truck loading facilities. The number and size of truck docks depend on the nature of the activity rather than the number of employees or visitors. Every new industrial plant requires at least one off-street dock for an over-the-road tractor-trailer combination plus one shallower dock for small local pickup and delivery trucks.

It is difficult to determine exact truck loading needs for each land use. For this reason, common zoning practice is to set a minimum requirement. The requirement varies with the square feet of building space and declines relatively as the size of the building increases. A typical requirement is one truck loading space for every 10,000 sq ft of gross floor area but no more than a total of two spaces up to 40,000 sq ft of GFA, one space for each additional 40,000 sq ft up to 160,000 sq ft, and one space for every 80,000 additional sq ft. Truck-unloading spaces must be provided at the site or be directly accessible to the site by some freight transfer system.

Zoning specifications for off-street unloading facilities for over-the-road tractor-trailers include a 12-ft stall width (14 ft is preferable), 60-ft stall depth, 60-ft maneuvering apron (giving a total depth of 120 ft), and 15-ft vertical clearance. For city delivery trucks, a 12-ft stall width, 30-ft depth, 30-ft apron, and 12-ft vertical clearance are recommended. Loading facilities should be designed so that trucks do not back in or out of major streets or use any street for parking. Truck facilities should include off-street parking areas for trailers awaiting pick up or arriving after hours. Future provisions for container storage also are suggested. All areas used by trucks should be graded, properly drained, paved, and maintained.

In some instances, communities have cleared obsolete structures and sold or

Strip commercial development with inadequate parking setbacks results in hazardous and inefficient operation. The zoning code building setback provisions should be based on parking dimensions, and the layout of stalls should be controlled by the local government agency so as to achieve a safe and efficient operation.

leased the cleared land to the remaining adjacent industries for off-street loading facilities. In industrial urban renewal projects, group use of off-street loading facilities may be planned, but the total number of truck positions should not be less than the sum of individual loading requirements. Group facilities may, of course, be less than the sum of individual requirements if the participating industries stagger their use of the docks.

Driveways having relatively high volumes of large trucks should be provided with radii of 20 to 25 ft plus widths of 30 to 40 ft, so that entry and exit can be made without encroachment beyond the curb lane of the abutting public street.

IMPLEMENTATION

The administration of a modern zoning code can be handled in a number of ways. The particular methods are more dependent on state laws and the type of city government than on any special merit of one form over another. The sequence of steps presented here and the names given to the agencies must therefore be adjusted to fit the local "table of organization." The conceptual approaches and broadness of review are what are important, and in many of these areas a large number of cities may be very deficient.

A "weighting" or scoring system for rating community desirability was developed by Nelson and Aschman (*3*). It is significant that three of the five total points they allotted to the zoning ordinance had to do with the quality of enforcement or implementation.

Building Plan Review

One test for conformance of parking to zoning requirements occurs when a devel-

Modern zoning, properly implemented, will prevent this condition of loading docks at the sidewalk line, which forces trucks to block the sidewalk and usually a portion of the street.

oper submits building plans to the city. The initial submission to the building department is for the purpose of securing a building permit. The building department should review plans with the fire department (for fire code compliance) and the city engineer (sewer, water, and drainage). It is also highly desirable that site development, loading, driveway, and parking plans be reviewed by the city planner and the traffic engineer. The school board may need to review plans for major residential developments.

In some instances a preliminary submission to the Director of Planning is desirable for a development permit prior to the preparation of the detailed plans required for a building permit. The Director will then circulate the plans to the appropriate city departments. This provides an excellent opportunity to check needs for added right-of-way or street widening that the developer should be asked to provide. A development permit is granted only after reviewing the department's comments or recommendations with the developer and determining that the application conforms to both zoning requirements and probable actual needs. Next, detailed building plans are prepared in accordance with the permit, for detailed review of conformance with the building code. Many traffic and parking problems can be avoided if the traffic engineer is involved at all stages of a project. Beneficial changes often may be made without significantly increasing the cost of the project. Numerous cases exist where competent traffic review has resulted in greater efficiency of parking layout and hence reduced project cost.

All site plans should include the north point, the scale, and the location and dimensions of all buildings, driveways, paved areas, parking and loading layouts, fences, and roof overhangs. The legal de-

scription and survey of the property is necessary, as are all critical dimensions. A topographic plan also is desirable showing poles, signs, fire hydrants, trees, and other objects on public property along the site boundaries, plus existing street and sidewalk elevations. Other details that should be shown include outside building dimensions, materials used for external wall finishes and roofing, lighting, drainage, and finished grades. Also attached should be statements of (a) the use of the building, (b) the ownership of the land and interest of the applicant, (c) the estimated completion date, and (d) the number of employees, if a commercial structure.

It is important that special restrictions be observed when preparing for submission of plans. A typical problem occurs when property abuts a state or county highway and that agency has more stringent driveway standards than the local ordinance. Permit applications must then be made to each agency, and the design may be required to incorporate the most restrictive conditions. The driveway regulations of many states and counties specify widths that are too narrow and radii that are too small. In such cases, the city may be able to encourage better design practice through insisting on application of its own ordinances.

In some instances, drainage district approval must be received. Applications also must be accompanied by written approval of any utility company whose gas or power lines pass through the property.

Inspections

The proper construction of a building and the development of its site to follow approved plans should be verified by field inspections. A final inspection by the traffic engineer is desirable for driveways, parking, and loading facilities. It is recommended that issuance of an occupancy permit be *conditioned* upon completion of the site improvement in substantial accordance with the plans.

For existing businesses, checks of parking and loading facilities are often desirable prior to *license* approval. Some communities provide an annual fire and traffic inspection for compliance with regulations. Businesses sometimes obstruct part of their legally required parking area with temporary storage or refuse cans. Such problems can be reduced with periodic checks by building inspectors.

Rezoning Applications

A rezoning application is necessary when a proposed use is not in conformance with existing zoning. This is usually submitted before any building plans are prepared. Applications normally are for adjustment of the zoning to accommodate a new development, which means that all future buildings within the classification would be affected. The community or the developer normally makes the application to the Planning Commission (sometimes to the Zoning Appeals Board). The Commission should have the authority to order special studies that will enable it to evaluate the application. These studies include traffic, parking, road, land use density, and urban renewal considerations.

The Planning Commission that reviews applications typically is composed of appointed officials. Many cities assign a city planner to review the application, and he often meets with the applicant during his review. Next, a public hearing is held at which the planner, the applicant, adjacent property owners, and other interested parties may testify. The Commission approves or rejects the application. Approval may be conditioned with certain modifications and revisions, or the Commission may suggest that an amended application be filed.

Prior to the hearing, there is need for a review and reporting to the Board or

Commission by the city staff. The traffic engineer should review the layout of parking spaces, street access, and influence of proposed building on vehicular and pedestrian traffic. More and more frequently, codes specify that projects involving large parking facilities or high traffic generators be preceded by a traffic survey.

In evaluating a rezoning application, the Planning Commission may apply the principle that the final development be no less desirable than under existing zoning. Quite often, the Planning Commission may make an exception if the applicant satisfies special requirements to avoid adverse effects on the immediate area. These include provision of additional parking spaces when warranted, right-of-way dedication and/or street widening, or special off-site street improvements needed because the applicant is increasing residential or employee density or street use in the area. Sometimes a proposed use will actually result in less traffic generation than development under existing zoning. The service station is often an excellent example of this because it typically generates only a fraction of the traffic that a neighborhood business would if built on the same size lot.

The Planning Commission recommendation is customarily sent to the elected local governing body such as the city council, aldermen, or the county or town board of supervisors. These political bodies may approve the zoning change, reject it, or refer it back for additional study and possible rehearing.

Special-Use Applications

A well-written zoning code includes provision for special- or controlled-use applications that are not allowable as a general use due to problems that they might produce. Each application should be considered separately on the basis of traffic generated, available parking facilities, and whether or not the architectural treatment of the buildings and land is compatible with that of the neighborhood. A well-written code will permit only those special uses that do not substantially change the neighborhood and, of equal importance, will require special uses for the actual (rather than imagined) hazardous types of development. An example of a special use would be a drive-in theater in a commercial area. Special-use permits usually include restrictions. Thus, the theater might be restricted as to the number and location of connections between its parking lot and major routes.

A special-use application may be processed like a rezoning request, and the opportunity exists to obtain additional improvements from the applicant such as special architectural treatment, roadway widenings, channelization, and signal control of high-volume driveways.

Variances

Variation requests may be handled by the Planning Commission or by a separate Appeals Board. Variances typically involve reduced setbacks and parking supply. Theoretically, variances are to handle logical exceptions to the law such as a request by a furniture store for a reduction in customer parking space requirements. Review procedures are similar to those used for rezoning applications, and involvement of the traffic engineer is essential. Special-use and variance applications must not be approved in a wholesale fashion or the usefulness of the code will be lost.

Ownership Changes and Remodeling

The zoning code is generally applied to existing buildings only when there is a substantial improvement or alteration. Improvements that increase the assessed value of a structure more than 20 percent

or 30 percent should subject the site to the parking requirements for new buildings. Similar requirements may apply when the use of the building changes and a different parking generation rate occurs.

Code compliance should be the continuing responsibility of each successive owner. For example, a computer center with relatively few employees per 1,000 sq ft may occupy a building. The owner knows that he requires only a small number of parking spaces, and may properly secure a variation to provide less parking. If the computer center moves and a clerical operation desires to purchase the building, then twice the number of employees might occupy the same office space. Therefore, the variation should carry a fixed occupancy limit for the site, which would prohibit resale to an operation with higher parking generation. Added occupancy should not be allowed until the new owner provides the needed additional parking spaces.

Court Appeal

When applications are denied at the local level, appeal may be made to the civil courts. Recourse to court action is particularly necessary when elected officials take a stand contrary to their own administrative staff or the self-evident public good. The staff may thus find themselves under subpoena and testifying against their employer when a zoning change is rejected by the elected body. Professional integrity may produce this conflict, because in the court proceeding both sides must present factual testimony.

A court ruling may, of course, be appealed by either side and ultimately be taken to the state supreme court. Sometimes a principle is involved, whereas at other times local citizen pressures are responsible.

Parking requirements of zoning codes may rank in importance with the basic land use and bulk regulations. The legal status of specific requirements is still not entirely clear, however, because of the small amount of case law (some of it conflicting).

Williams has prepared a list of selected citations, 15 of which deal with appeals from parking requirements of zoning codes (*4*). Another five cases deal with related problems or screening provisions.

Revision of Zoning Ordinance

The type and intensity of urban land use changes as a result of the dynamics of economic, political, and cultural forces. New programs and projects are constantly being developed. Zoning ordinances are the basic tools of land-use policy implementation, and should be reviewed and revised every 5 to 7 years, depending on the nature of urban growth and change.

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CHAPTER FOUR

PARKING PROGRAMS

Parking programs in most cities are oriented almost exclusively toward the provision of additional parking in the CBD. There are only a few examples of municipal parking programs that also consider the needs of outlying business areas. Even fewer consider the critical parking needs of high-density residential developments. Comprehensive parking programs aimed at the total needs of the community, including the provision of adequate off-street parking in residential areas, along commercially developed major traffic routes, and in outlying business centers, have yet to be fully implemented in any U. S. city.

This chapter deals primarily with the methods of development, administration, financing, and land acquisition for CBD parking programs. Special reference is made to a few specific or classic examples of parking programs relating to the needs of older outlying business centers and high-density residential areas. Legal aspects, case citations, and model parking laws are provided in the Appendix.

ESSENTIAL GOVERNMENTAL INVOLVEMENT

The issue of the involvement of public agencies versus private enterprise in the provision of parking has been, and will continue to be, controversial. When viewed objectively, however, the pros and cons of private versus public parking are somewhat academic. Each community must make its own decisions as to the type of parking program most suitable to its particular needs. In many communities, the types and patterns of parking development have long been established. The interaction of many local factors—the size and economic characteristics of the area; the political, business, and civic interest in the problem; the magnitude of the parking demand and the willingness of parkers to pay; the extent of free parking provided by competing business areas; the ability of private enterprise to cope with the problem—determines the development and administration of a parking program.

Policy

Public policies on parking development should be based on *how* a parking program can best be developed and administered rather than on *who* has the responsibility for providing and operating individual parking facilities. The provision of adequate parking is not an answer unto itself. A program of parking development must be viewed as an essen-

tial element in the total urban development scheme and must be effectively integrated with plans and programs for land development, major routes, freeways, and public transportation systems. In view of the urgent need to revitalize and strengthen our urban centers, it can be unequivocally stated that both government and private interests must assume forceful roles in a comprehensive program of parking development.

Traditionally, government participation in transportation has developed when private approaches have been unable to meet specific community objectives. This philosophy should also apply to parking. Private enterprise should have priority in the development of facilities that relate to specific land uses or can be developed through normal investment procedures. A significant part of downtown parking needs can often be met by private interests either as adjuncts to business or office developments or as speculative commercial ventures. Where parking needs cannot be met effectively by private interests, municipal agencies, concerned with the overall welfare of the city as well as the downtown, may be justified in assuming a role in parking development. The municipal program should supplement rather than compete with private parking facilities. The extent of municipal participation will vary widely, depending on the pattern of land development and the deficiency in parking requirements. It should be recognized that government agencies participate in most aspects of urban transportation, and public participation in off-street parking programs is a natural extension of this practice.

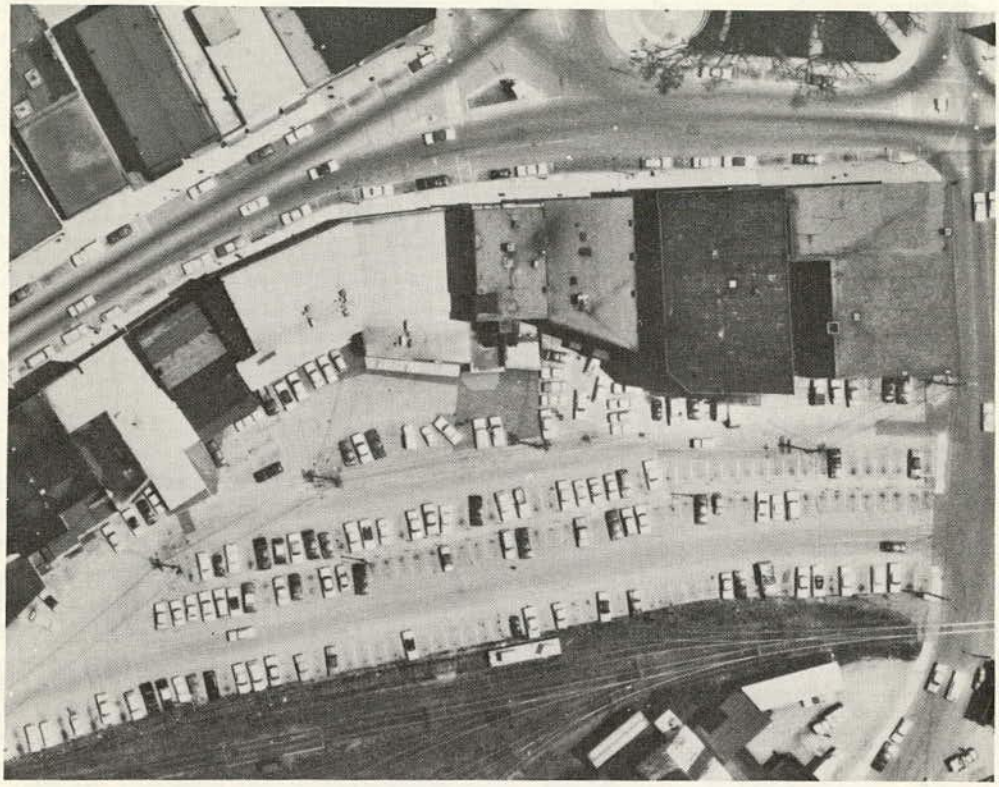
The Municipal Role

Regardless of who assumes the primary responsibility for the development, financing, and operation of off-street parking facilities, municipal government must assume a basic role in *program administration*. Parking facilities should complement other transportation elements in stimulating downtown economic development and in expanding its competitive position within the urban region. Furthermore, the overall parking needs of the community should be identified and included as part of a comprehensive program for urban development.

To accomplish these objectives, local governments (municipal and regional agencies) should perform certain essential administrative and regulatory services relating to the development of a comprehensive parking program. These are described in the following sections.

Transportation Improvements—Public agencies must continually establish goals, policies, and plans to guide the growth and development of the city and its CBD. Comprehensive plans relating to land use potential, street system development, public transportation requirements, and parking terminals are needed. The interrelationships among these elements are the keys to stimulating a coordinated development of the city and its business center.

Public capital improvement programs should be coordinated with private development projects to gain maximum return from investments. As an example, street improvement projects should be coordinated with the access and circulation requirements of existing and planned parking facilities. Priority programming of public projects that stimulate planned development of buildings and parking facilities should be undertaken. This approach upgrades the center and expands the economy and tax base of the community. Moreover, parking terminals must be planned in conjunction with major street and freeway projects and located so as to intercept traffic and minimize unnecessary travel through congested business and commercial centers. The urgent need to upgrade existing street systems to



This metered parking area, financed by parking fees, helps preserve the CBD. It is located at the rear entrances to retail establishments and also allows truck unloading to be kept off the main street of the CBD. The retail stores have improved their rear entrances for customer use. (Source: Vermont Department of Highways.)

improve efficiency and safety of traffic movement will necessitate the extensive prohibition of curb parking. This objective can only be practical if street improvement programs are coordinated with programs to provide off-street parking adjacent to major traffic routes.

Land-Use Regulations—Zoning ordinances, subdivision regulations, and building codes that include specific requirements for the quantity and design of off-street parking and loading spaces are an essential long-range approach to the resolution of the overall urban parking problem. Although parking requirements apply primarily to new and substantially reconstructed buildings, these requirements can stimulate dramatic changes over a relatively short span of years. The downtown skylines of most major U.S. cities currently reflect great change and progress through demolition, new construction, reconstruction, and renewal.

Needs Studies—Public agencies should continually acquire, maintain, and disseminate current data on transportation and parking conditions and needs. This includes inventories of land use, economic trends, traffic volume trends, and parking supply and demand. Factual and up-to-date information is essential to both the private and public sector as a basis for the

decision-making process relating to land development and parking programs.

Parking Regulation and Control—Private parking facilities are found in practically every city, ranging from unimproved lots developed on vacant land to well-planned, multi-million-dollar parking complexes. Because many parking lots occupy land on a temporary basis, operators are often reluctant to finance physical improvements. This type of operation often produces poor parking arrangements, encroachment on public rights-of-way, overcrowding, poor service, and damaged vehicles. Municipal regulation through licensing is necessary to establish minimum standards for physical improvement, design features, and operating procedures for the protection of the public safety and welfare. Requirements should include:

1. Control of physical development to prevent poor layout, unsuitable surfacing, and inadequate drainage;
2. The installation of barriers to prevent parking encroachment on public sidewalks and roadways or adjoining lots;
3. The provision of adequate illumination for personal safety and to minimize vandalism and theft;
4. The establishment of operating requirements for public protection, including the conspicuous posting of parking rates and the issuance of parking claim checks; and
5. Regulations pertaining to maximum parking capacity, transfer of vehicles to other facilities, and the control of entrances and exits to minimize vehicle damage and property loss and to avoid unnecessary conflicts on the public streets and sidewalks.

The State and Federal Role

State Enabling Legislation—Comprehensive state parking legislation is needed so that municipalities can institute and implement their parking programs without recourse to special legislation or court decisions. Otherwise, parking action may be seriously delayed pending convening of the state legislature and the adoption of measures delegating the essential authority.

In action contesting the constitutionality of the procedure used in providing parking facilities, courts usually rely heavily on the intent of the legislature as indicated in the statute under which the municipality proposed to act. Provisions in the parking law should therefore cover all pertinent matters and be clearly stated.

Generally, the powers needed for municipal provision of parking facilities are also required by autonomous parking authorities. If it is desired that the city retain certain powers and that a parking authority have other powers, the specific functions to be performed by each should be indicated in the law.

Comprehensive parking legislation should include the following factors:

1. Public purpose to be served;
2. Body to be vested with authority;
3. Planning provisions;
4. Financing, land acquisition, and construction authorization;
5. Accessory and commercial uses;
6. Parking fees and charges;
7. Taxes;
8. Operation and maintenance; and
9. Records and reports.

Model bills for state general enabling statutes dealing with parking facilities have been prepared under the auspices of the Bureau of Public Roads and the Highway Research Board (*1*).

Because the requirements for the provision of parking facilities may depend on the size of the city, two model statutes have been drafted, a highway or public works department form and a parking agency form. These are given in the Appendix.

Each model is a composite of the best portions of existing state enabling legis-

lation. In drafting suggested language for state and local consideration, it was contemplated that the states or any subdivision thereof would adopt variations and elaborations to suit their respective needs. The purpose of the model legislation is to present the essentials that should be considered in drafting new laws so that the need for amending the law periodically will be kept at a minimum.

Citations to some comprehensive parking laws are also given in the Appendix.

Federal Urban Planning Programs—The Federal-Aid Highway Act of 1962 required a continuing, comprehensive, cooperative transportation planning process in all urban areas of more than 50,000 population. Parking and terminal facilities were included as one of the ten basic elements to be evaluated in developing a comprehensive transportation plan. This federal program, administered by the Department of Transportation through the state highway departments, has provided the means to measure terminal needs in concentrated areas of all metropolitan regions and to develop programs to meet these needs.

The federal "701 Program," administered by the Department of Housing and Urban Development, has provided community planning funds. This program has also included the means to determine parking needs and to develop local plans and programs that encompass off-street parking requirements.

The Federal-Aid Highway Act of 1968 authorized demonstration programs, using federal-aid funds for the acquisition of land adjacent to the right-of-way on any federal-aid highway system and the construction of outlying parking facilities to serve urban areas of more than 50,000 population. The primary purpose was to improve service by reducing the number of vehicles using the highways to the downtown area and therefore to reduce the need for extensive improvements on these facilities. The program was intended to study and demonstrate the potential benefit of such a parking plan approach to the overall transportation program for urban areas.

METHODS OF NEW FACILITY DEVELOPMENT

There are a variety of approaches to the provision of off-street parking facilities and any discussion of the various methods is bound to indicate the complex interrelationships that affect parking programs. There are few clear-cut examples where the resolution of traffic and parking problems has been consolidated into a planned and logical development for a downtown area. In many cases the provision of parking has been a matter of expediency—a system that grew on the chance availability of sites (in either public or private ownership), having little relationship to parking needs or a coordinated plan of development. In other cases, comprehensive parking improvement programs have been developed through cooperative action involving municipal government, commercial operators, and businessmen.

Private Enterprise

In a nation devoted to the private enterprise system, parking is a proper business for exercise of the skills of the private entrepreneur. Commercial parking was well established in a number of cities long before government agencies entered the field. Private developers of parking facilities should be encouraged to the fullest extent, even though the propriety of government action or regulation in the interests of the public has been generally accepted.

The term private enterprise as used here describes the parking facilities financed, developed, and operated by individuals, associations, and corporations.

Private development of parking facilities can take several forms:

1. Lots and garages developed and operated by commercial parking operators;

2. Parking facilities developed by nonprofit or limited-profit corporations formed by commercial groups such as property owners and business and retail trade associations; and

3. Special-purpose parking facilities developed by commercial and retail establishments, primarily as an accessory use and often as a result of zoning requirements.

The major disadvantage of complete dependence on private enterprise has been its inability to provide enough properly located parking to satisfy overall needs. The provision of parking by private developers naturally follows the law of supply and demand. Because investors tend to be conservative, the parking supply normally lags behind the demand.

Without powers of condemnation, it is difficult—often impossible—for private developers to assemble segments of land of adequate size for efficient parking development, especially in the city centers.

Commercial Operations—There are a number of cities whose downtown centers depend primarily on commercial enterprise to provide and operate the necessary supply of parking space. The method of operation is varied, including independent operators, large parking chains, or parking corporations that control the primary supply of parking. In such cities as Atlanta, Baltimore, Dallas, Houston, Indianapolis, Tulsa, Los Angeles, and many others the principal parking supply is in commercial facilities.

This parking garage for a department store in Anchorage is a fine example of private-enterprise development of needed parking. The entry ramp is designed so as to avoid pedestrian driveway conflict, and the skywalk connection reduces pedestrian conflict with street traffic.

This pedestrian skywalk connects from a parking garage (on left) to a commercial building in the CBD. Private enterprise is often responsible for such creative techniques.

A competitive market encourages strong initiative in the optimum location and operation of commercial parking facilities. Private investors have played an important role in developing the parking supply in a majority of U.S. cities. Under private ownership, property remains on the tax rolls—an added source of tax income that is important to local governments.

Because commercial facilities are operated for profit, the owners necessarily favor that segment of the demand that produces the highest income. Private-enterprise parking programs do not ensure a balanced system of parking facilities related to both short-term and long-term parking needs and to the street transportation requirements of the community.

Commercial operation of parking lots often does not guarantee the permanence of the parking supply. In many cases, parking lot operation may be an interim use until the property can be used for a more profitable development.

Business Associations—Retail trade associations or downtown parking corporations have been the prime movers in providing parking facilities in the downtown centers of a number of communities.

The Park and Shop program in Allentown, Pennsylvania, was developed as a community enterprise with 300 local stockholders and operated by a board of directors with a paid general manager. Practically all major merchants in the central city became members and participants. Park and Shop Incorporated owned or leased 80 percent of all central city commercial parking operations as of 1968 (*2*).

In Flint, Michigan, the Greater Flint Downtown Corporation was developed as a nonprofit organization of retail business, property owners, and banks. The operator of the facilities, Mid-City Parking System, was reported to manage six parking facilities in the downtown area with a combined capacity of 2,000 cars. In 1967, more than 1½ million cars were parked (*2*).

Minneapolis is a classic example of a comprehensive parking program developed by a downtown corporation. The following summary of this program is from a study prepared by a transportation consulting firm (*3*).

> The city commenced action to develop a municipal parking agency after studies identified three locations where needed parking facilities were economically feasible. A committee of the Chamber of Commerce had worked closely on the project. Downtown businessmen asked for a postponement of city action, formed a corporation with $600,000 provided by retailers, banks, building owners, newspapers, and some parking companies. A revenue bond issue was floated, which allowed the corporation to acquire land and build on two of the original sites. Additional facilities have subsequently been planned. At least six other private parking developments are believed to have been stimulated in part by the corporation's activity.
>
> The parking is profitably managed by contract with a private operator. The corporation pays income and property taxes.
>
> The director of the Downtown Council, speaking for the downtown merchants, reported that they could provide parking cheaper and better than the municipality with no loss of tax revenue. He cited three basic elements needed for success:
>
> 1. Interest on the part of downtown businessmen.
> 2. Financial support from businessmen to get the program started.
> 3. A willingness of executives of many of the downtown interests to contribute time to the affairs of the private corporation.

Special-Purpose Parking—Development of off-street parking facilities by private interests also includes provision of customer, private, and employee parking spaces by individual merchants or property owners. Although many such facilities have been built to conform to zoning requirements, a number have been built on the initiative of larger business organizations that understand the importance of adequate parking to the economic welfare of their business.

The prime examples of full provision of parking facilities for employees, customers, and visitors are the planned regional shopping centers found in most metropolitan areas. Although some centers only provide parking in accordance with minimum zoning requirements, most have been planned to provide for the seasonal peak (Easter and Christmas) parking demands.

An outstanding example of planning is the Country Club Plaza Shopping District in Kansas City, Missouri. This venture, developed and operated by the J. C. Nichols Company, was initiated in the 1930s as a community shopping center. In the early stages curb parking was heavily relied on; later it was supplemented and replaced by parking lots. More recent developments include the renewal of older commercial buildings, the construction of parking garages on the surface sites, and the construction of integrated parking and commercial structures.

Examples of parking facility development by retail stores in older downtown areas include the Joseph Horne Company in Pittsburgh, J. L. Hudson Company in Detroit, F. & F. Lazarus Company in Columbus, and Davidson's in Atlanta.

Public Parking Administration

Municipalities have several ways of administering their off-street parking programs. The four basic organizations are as follows:

1. Assignment of the function to an existing department such as public works, city engineer, or traffic engineer;
2. Establishment of a separate municipal agency responsible only for parking programs;
3. Appointment of a parking board or commission to coordinate the efforts of several city departments providing services for the parking program; and

4. Creation of an autonomous parking authority.

Each administrative method has advantages and disadvantages. The one best suited to a particular community depends on many local conditions, including community size, public interest and attitude, government organization, and administrative precedents.

The strengths and weaknesses of these arrangements are summarized in the following sections.

Function of an Existing Department—The simplest and most expeditious method of establishing an off-street parking program is to assign the responsibilities to an existing department. This approach is often used in smaller communities. Off-street parking activities thus become an added staff function. However, parking can be subordinated in priority unless adequate staff and budget are provided for the program. An example of parking administration under a public works department is presented in the Cooperative Programs section in this chapter.

Separate Department—A separate department has the advantage of direct lines of authority, and its duties and responsibilities can be clearly defined. In addition, capable management personnel can be attracted by the prestige, salary, and authority of a city department head. The limitations are that changes in political leadership of the city government can disrupt the continuity of management and the efficiency of parking program administration.

An example of a parking bureau is given in Case Studies of Municipal Programs in this chapter.

Parking Board or Commission — A parking board or commission is often composed of civic-minded citizens who serve without pay and whose role is primarily an advisory one. This appointment often appeals to civic-oriented, experienced businessmen whose decisions will be motivated by the public interest. The commission type of organization gives a voice to representative members of local groups interested in improving parking conditions. A weakness is the limitation of its powers to act. In most cases the final authority rests with the mayor or the city council. In addition the decision-making process of a large group can become cumbersome and time-consuming.

An example of a parking commission is given in Case Studies of Municipal Programs in this chapter.

Parking Authority—The parking authority is a separate entity, usually autonomous in the planning, financing, construction, and operation of the off-street parking program created by the municipal government. It combines the public responsibility of government with the potential efficiency of private enterprise. Parking authorities are directed by a governing board appointed by the mayor. Normally there are five board members, and the tenure of members is staggered to provide for continuity of management. The primary advantage of an authority is that it can provide an agency of the size, staff capabilities, and legal authority necessary to deal with the scope of the parking problem. Its powers are normally broad and flexible and it can plan and initiate a parking program suitable to the overall needs of the community. Critics point out that coordination of parking programs with other city activities relating to planning, transportation, and traffic is minimized by the autonomous character of an authority. The authority may also duplicate the work or even conflict with the development plans of existing city departments. The functions and power of parking authorities typically include the following (*4*):

1. Conduct detailed factual studies to locate sites and determine suitable size

This free parking lot was designed by the engineering department and is maintained by the public works department of the municipality. It was financed by local sale of revenue bonds pledged by on-street parking meter revenue, with details handled by the finance department of the community. (Source: Paul C. Box and Associates.)

and type of parking facilities to meet requirements;

2. Make the results of those studies and conclusions available to private individuals as a means of stimulating their interest and investment activity;

3. Assist organized groups of merchants, businessmen, and others in off-street parking activities;

4. Acquire property and finance, construct, and operate off-street parking facilities;

5. Control the location, operation, servicing, and maintenance of parking meters at curb and off-street locations;

6. Administer minimum operating regulations for both public and privately owned parking facilities;

7. Prepare a rational master plan of off-street facilities to meet present and probable future parking needs; and

8. Periodically reevaluate parking needs to update the master plan for changing parking needs and desires.

Two examples of authorities are given later in this chapter.

Cooperative Programs

Parking facilities can be developed through public and private cooperation. There are a number of devices that cities can use if they want to assist private enterprise in the provision of needed parking facilities. One method is the development and operation of parking facilities on pub-

lic lands by private capital. Cooperation may also take the form of tax relief agreements, urban redevelopment programs where land is to be developed by private enterprise for parking purposes, technical services, data, and surveys. This approach has been used to overcome some of the obstacles that often face private enterprise or municipalities working alone. Some of the cooperative programs offer the efficiency and experience usually associated with private development and the powers of eminent domain and lower interest rates of municipal financing.

In Baltimore, the Off-Street Parking Commission can arrange for parking facilities to be built and operated privately (*5*). The city will loan up to 85 percent of the project cost at reasonable interest rates if certain requirements are met. The Commission can acquire land by condemnation and then make it available to private operators.

Oak Park, Illinois, presents an example of outstanding planning and cooperation among business interests, property owners, and the village government. Off-street parking at one time consisted of fragmented parcels of land under mixed public and private ownership, operated under a variety of methods and rates having little relationship to the total parking demand. Preliminary planning and studies began in 1956 when a group of local businessmen conferred with village officials on the development of a parking *system* in the major business district. The plans were realized in 1964 when the village passed a $1,650,000 revenue bond issue to finance land acquisition and construction costs. The properties were a combination of lots owned by the village, merchants, bank and business interests, and several building sites. The combined parking facilities were operated on a validation basis with a majority of the business interests participating in the validation plan. There were 905 spaces reported in the business area as of 1968 (*2*). The program is under the administration of the Village Public Works Department. Responsibilities include planning and design of new facilities, supervision of construction, operation of facilities, leasing of lots to private operators, maintenance of parking lots and equipment, and parking meter maintenance and collection.

Another example of public-private cooperation is the program of the San Francisco Parking Authority, created by the City and County of San Francisco in 1949 (*6*). The Authority was established for three compelling reasons: (a) the inability of private business to carry the entire parking load unaided; (b) the concept that parking facilities must be developed as an integral part of the street and highway system; and (c) the need to concentrate responsibility for parking in one agency established for this purpose. The Parking Authority envisioned the potentials inherent in private-public cooperation. Policy statements and results as of 1965 are summarized as follows:

1. Stimulation of and cooperation with private enterprise to finance and construct the facilities required under the off-street parking program. Facilities developed under this phase of the program have provided 17,000 parking spaces.

2. Public cooperation with private enterprise to provide off-street parking by public acquisition of sites and private financing of construction. Parking projects completed under this joint arrangement have provided a total of 8,200 parking spaces.

3. Direct public financing, construction, and site acquisition where private development was not or could not be undertaken. The 8,500 parking stalls at Candlestick Park were developed under this phase of the program. In addition, 28 public parking lots and garages were programmed for 15 neighborhood shopping districts, providing nearly 1,500 spaces,

critically needed to serve these older secondary business areas.

ELEMENTS OF A MUNICIPAL PARKING PROGRAM

Planning

Site selection for parking should be based on measurements and projections of parking needs. Techniques for determining the magnitude and location of parking deficiencies are described in Chapter Five. Of equal significance is the consideration of planning policies and goals in parking facility location. Plans for parking must be an integral part of a community's long-range development program. Parking terminal location and planning must therefore be directly related to transportation-system and land-use planning.

Parking facility design must also be considered in the planning stage. The type and design of a facility is influenced by a number of variables: the magnitude of parking demand and site size and shape; the socioeconomic characteristics of the neighborhood as they relate to the parking rate structure; and the costs of construction and operation. Chapter Six contains detailed discussion on several of these factors.

Financing

The financing of a municipal parking program is perhaps one of its most important elements. Many types of financial arrangements are possible. The specific arrangement that would be best in a given situation should be developed cooperatively by a multidiscipline team, including a public administrator, an investment or financial counselor, a legal counselor, and a parking consultant. Working cooperatively, the team can develop a number of alternate financial approaches to aid the municipality in selecting the one that is economically, legally, politically, and operationally the most appropriate.

Certain principles apply to most of the potential financing arrangements. Inves-

Parking lots developed as part of municipal programs can often be attractively landscaped without detracting from efficiency. (Source: Public Parking Authority of Pittsburgh.)

tors generally consider that as the term of financing increases the risk becomes greater, and therefore the potential interest rate would increase. Another situation that affects the potential rate of interest is the proportion of the proposed annual debt service that would be underwritten by historical or existing system revenues. Minimum interest rates are experienced when the annual debt service would be covered entirely from *existing* system revenues. As the proportion of revenues from *proposed* facilities increases, the percent of interest normally increases.

As a rule, the minimum rate of interest may be anticipated when money is borrowed for the shortest practical period of time and where repayment would be from revenues of an existing system supported by attractive historical records. On the other hand, many communities have arranged satisfactory financing over a long period of time—up to 30 years or more—with the revenues from new facilities providing a large proportion of the anticipated system revenue. Approaches to financing municipal parking systems that have been successfully utilized in various communities are outlined in the following paragraphs. Obviously, other methods can be used, and it would be possible to combine the methods in various ways.

General Revenue Financing — Some municipalities finance parking projects from their annual operating or capital improvement budgets. This method is primarily used by smaller communities where the required parking projects are limited in scope. General revenue financing is also appropriate in cases where parking lots can be developed on public land or where property can be purchased or leased at a low cost. Some communities have adopted the policy that the provision of free off-street parking is a government responsibility, similar to the provision of streets and sanitary systems.

Pay-As-You-Go Method—Many cities develop off-street parking facilities from funds accumulated from parking revenues. The net revenues, or a fixed percentage of gross revenues, derived from curb parking meters and existing parking facilities are deposited in a reserve fund for acquisition and development of additional sites. The limitation of this method is that it is a lengthy process, and funds may not accumulate as fast as the growth in parking demand.

Parking Revenue Bonds — Financing through revenue bonds is popular in many communities. Only the parking system revenues are pledged to the retirement of the indebtedness, and as a consequence the borrowing ability of the community for nonparking purposes is not affected. The parking system indebtedness is paid off solely from system revenues. Because of this limitation, which leads to a higher risk, the rate of interest becomes correspondingly higher. An additional safeguard normally required with revenue bonds is that the debt coverage ratio for future years must be demonstrated through a parking feasibility analysis to be 1.5 or greater. Generally speaking, as the debt coverage ratio increases above 1.5, the issue becomes easier to sell and/or the rate of interest becomes lower.

Local Parking Revenue Bonds—A variation on the revenue bonds technique has been successfully employed on occasion. A bond issue similar to the parking revenue bonds is used to underwrite the new facilities. The principal difference between this and the conventional parking revenue bond issue is that the bonds are not offered for sale on the general market but are pledged (purchased) by local business interests that have a desire to strengthen the downtown area. Usually, persons subscribing to this type of bond have a vested interest in the CBD and consider this to be "insurance" to protect their other in-

vestments. Under this arrangement it is possible to obtain financing for a greater number of years, at a lower rate of interest, and with a lower requirement for the debt coverage ratio. These factors all act to permit the municipality to borrow more money with the same amount of annual net revenues. The principal disadvantage to this method of financing is that there may not be a market for these "local" bonds.

Parking Authority—In states where the necessary enabling legislation has been enacted, the parking authority is empowered to issue bonds for the construction of new parking facilities. In turn, the authority enters into a lease agreement with the municipality wherein the municipality agrees to pay the authority an annual rental equivalent to the annual debt service required by the bond issue. The municipality would plan to obtain the money for this annual payment from the revenues derived by operating the parking system, but in any event would be liable for this amount each year. In such cases, there would be no risk on the part of the potential bond buyers, and as a consequence the rate of interest would be lower and there would be no specific required debt coverage ratio.

General Obligation Bond Issues—The principal advantage for general obligation bonds is that a low rate of interest can be obtained because the full faith and credit of the community (taxing body) is pledged to the redemption of the bonds. In view of the relatively low risk involved, a low rate of interest is normally available. If the financial details are carefully appraised before entering into this kind of an arrangement, it rarely becomes necessary for the taxpayers to meet the parking system debt payment. Whereas a conventional parking revenue bond issue would normally require a debt coverage ratio of 1.5 or greater (the ratio of net system revenues divided by the debt service level), such a coverage is not necessary with general obligation bonds. If, for example, the estimated debt coverage were 1.1 or 1.2, it would not affect the salability of the general obligation bonds. The principal disadvantage in using general obligation bonds is that the potential credit available for nonparking uses in the community—such as parks and public buildings—is reduced by the amount of the bond issue used for parking facilities.

Assessment District—Under the assessment district arrangement, properties within the trade area of the proposed parking facilities are assessed in accordance with their benefit, and the moneys so derived are used to underwrite the improvements. Either of two methods may be considered:

1. As in the case of other assessments, the city administers and works out the details, and, in effect, the amount of money required to underwrite the proposed project is borrowed with the annual assessments being used to guarantee the retirement of the debt. Normally, this type of financing is set up for a period not to exceed 10 to 15 years.

2. An alternate approach is the use of the annual assessment to enhance or guarantee the amount of "net revenues" available to the parking system for the retirement of conventional parking system revenue bonds. The disadvantage of this approach, however, is that theoretically these assessments could be levied for the entire life of a bond issue, which might range up to 30 years.

Assessment districts have been used successfully in a number of communities where authorized by law. The principal disadvantage of this approach is that objectors may slow down the process with costly court suits. Occasionally, the procedure or formula used to spread the assessment comes under fire. Assessments may be spread through the use of simplified or highly sophisticated procedures

that include distance from the new facility, parking generation attributable to the benefited property, assessed valuation, and credit for the number of parking spaces that may already be provided by the commercial property. However, a logical case may be presented for spreading assessments solely according to the assessed value of land, on the theory that the entire downtown benefits from adequate parking.

Land Acquisition

Acquisition of the necessary lands and properties is an important element in the provision of off-street parking facilities. Inflexible and restricted enabling legislation has sometimes been an obstacle to the establishment of needed facilities. The high cost of land, particularly in and near the downtown central areas of the city, has also posed problems.

When sufficiently broad legislative powers exist, a variety of land acquisition techniques may warrant consideration. The more common of these techniques are reviewed in the following paragraphs.

Purchase—The most frequently used method of acquiring lands is through negotiations with private property owners. Neither party to the acquisition is prejudiced because a value presumably satisfactory to both parties is voluntarily agreed on. The use of the option in negotiations is highly recommended. Such an instrument, upon a small payment, grants the city the right to purchase the lands described within a specified time period. In cities, a fee simple title is generally acquired. An efficient land acquisition organization will utilize prenegotiation appraisals of the value of the property involved, employ skilled personnel, and maintain adequate records.

Lease—Outright purchase of property for a public purpose ordinarily removes it from the tax rolls. Under some circumstances, it may be more expedient to lease properties needed for off-street parking facilities for a stipulated period of time and under designated terms and conditions. Such an arrangement will obviously require a much smaller immediate outlay of capital funds than outright purchase and is an appropriate device for cities that are financially constrained by legal debt limitations. A disadvantage, however, is that when such leases expire or are terminated the use may be changed to other purposes. The advantages of convenient parking places will then be lost to an area that may have become dependent on the facilities while the lease was in operation. To avoid this situation a lease may be drawn to contain an agreement for purchase of the property at a stated price at the termination of the lease.

Condemnation—When negotiations with a property owner have not produced a reasonable compromise, a city must ordinarily resort to an exercise of its power of eminent domain as authorized by law. For technical reasons, such as to clear title, court proceedings are sometimes necessary. Forcible acquisition should usually be considered a last resort because it tends to be costly and time-consuming and sometimes disrupts good public relations. Many cities, however, particularly the larger ones, are often compelled to resort to this device to obtain strategically located sites in the interest of the public health, safety, and welfare.

Dedication by Land Developers—Sometimes the original developers of property will agree to dedicate, without cost to the city, lands needed for off-street parking facilities, in the same fashion as lands are now dedicated for highway rights-of-way. The cost of such lands is absorbed by the remaining lands that benefit by the provision of such facilities. Zoning ordinances in most municipalities require parking facilities to be provided in new developments or as part of major remodel-

ing of existing buildings. As an alternate to partially or completely fulfilling this obligation, developers may dedicate land to be used jointly by the city to provide centralized parking for several properties.

Donation—Lands useful for off-street parking may be donated to the city by public-spirited citizens during their lifetime, or afterwards by means of specific provisions in wills.

Perhaps the most valuable donation from which parking has profited was made in Pittsburgh. Three foundations established by the Mellon family combined to make the city a gift of $4 million to acquire a mid-downtown block and to build a park on its surface. The city leased the subsurface rights in the block to the Public Parking Authority, which constructed an underground garage with capacity for more than 1,000 cars.

Reclamation—Reclamation may often be a successful alternative to other methods of land acquisition and should be considered where conditions permit and the cost is not prohibitive. Many cities have "created" land along the shores of rivers, harbors, and lakes. Chicago's excellent system of parks and express highways on the shores of Lake Michigan is the result of reclamation activities. Two large parking lots in the vicinity of Soldier Field were built on reclaimed land.

Multiple Use of Existing Public Lands—Cities have sometimes utilized land that was originally acquired for other public purposes, such as for market areas, parks, or public squares, and converted them to serve as off-street parking places.

An example of successful use of the area underneath a public park is in the downtown area of San Francisco, where a 1,700-car garage has been developed under Union Square. A hundred years ago this area was dedicated in perpetuity as a park. The garage is leased by the city for operation by commercial enterprise. Similar garages have been constructed under the Boston Common, Pershing Square in Los Angeles, and the Auditorium Plaza Park in Kansas City, Missouri. The Chicago Park District has constructed two parking garages under Grant Park providing space for approximately 4,200 cars near the downtown center of Chicago.

The experience of the city of Cleveland is also of interest. In 1936 the Great Lakes Exposition was held along the lake front on city-owned property. The land was converted into a parking lot for 435 cars, with parking free and transit service provided to the downtown area for a fee. The lot has been enlarged to accommodate 2,500 cars.

Air Rights—The construction of parking facilities is sometimes practical above highways, streets, or rivers. The use of such air rights is another example of multiple public land use. However, it is also sometimes practical to consider air-rights development above or below privately owned facilities such as rail stations and railroad track areas. Both the Illinois Central Terminal proposal in Chicago and the Grand Central Station development in New York illustrate forms of intensive building development above rail areas that may or may not include parking facilities.

Marginal Land—Marginal land acquisition is the taking of property along the borders of a public project in addition to that required for immediate physical improvement. Such marginal lands may sometimes be suitable for off-street parking facilities.

A 1945 enactment in one state provided that, in the acquisition of property or property rights for any controlled-access highway, the public agency may acquire an entire block or tract of land, even though the land is not immediately needed for the right-of-way but is otherwise useful to the public. Similar authority has been granted

by the statutes of numerous other states in connection with the acquisition of land for controlled-access highways.

Where feasible this type of authority could well be used to facilitate the acquisition of off-street parking areas in conjunction with the establishment of express highways.

Operation and Maintenance

There are numerous methods of operating municipally developed and financed parking facilities. These include the following:

1. Municipal operation and maintenance using municipal employees.
2. Contract with a private management firm to provide management for a fixed fee. Employee, maintenance, and operating costs remain the responsibility of the municipality.
3. Contract with a private management firm to provide management for a percentage of the gross or net profits. Within prescribed standards, the private firm can be responsible for employee, maintenance, and operating costs.
4. Direct lease with a private operator, who supplies personnel and maintenance. Standards relating to parking rates, quality of service, and maintenance are usually specified by the municipality.

Each method has advantages and disadvantages that will relate more to local conditions than to generalizations. There is no one "best" method.

CASE STUDIES OF MUNICIPAL PROGRAMS

The types of municipal parking administrations have been described in the preceding sections. The following case studies of selected cities illustrate several types of organizations and scopes of parking programs being conducted. The material is excerpted from the referenced publications and is used with permission.

Chicago's Municipal Parking Program (City Parking Bureau)

Chicago's municipally sponsored parking program (7) has been acclaimed by traffic and urban experts as an outstanding example of farsighted planning. The program was started in September 1952 with $41,000,000 in bonds issued. As of January 1967, $13,403,000 in bonds had been retired. The sinking fund continues to retire bonds at 6-month intervals.

At the end of 1966, Chicago's Bureau of Parking had in operation 76 parking facilities that provided space for approximately 14,600 cars. The Bureau also managed the 35,000 on-street meters. The parking program operates as a division of the municipal government and was established in 1952 within the Department of Streets and Sanitation. The city leases facilities to private operators on a contractual basis.

Chicago's coordinated attack on the parking problem involved consideration of a number of interrelated elements, including (a) city operation and maintenance, plus the role of the private operator; (b) state and local legislation; (c) financing; (d) selection of suitable sites in relation to community and city-wide needs; (e) continued studies and analyses to determine present and future needs; (f) functional design to meet the needs of the specific area; (g) sound architectural and structural design; (h) correlation of street traffic regulation and enforcement with the planning of off-street facilities; and (i) cooperation with industry and commerce, outlying business center leadership, and influential civic groups.

Chicago had 13 multilevel facilities in operation in 1966. The six ramp-type facilities feature both self-park and attendant parking and range in capacity from about

200 cars to more than 1,200 cars. They can be converted from either type of parking to the other as necessary for most economical operation.

Four self-park type facilities are located in areas where rates could not permit attendant handling. Split-level construction is used with one-way ramps and, for economy of operation, all can be operated with only one person on duty. Automatic ticket-issuing devices, sometimes combined with gates, reduce personnel requirements.

Three mechanical garages in Chicago have a capacity of over 1,600 cars. They are of the "Bowser" type, where the attendant drives the cars on and off the lifts and the cashier controls the delivery of cars.

The city also developed more than 60 parking lots located in 25 outlying shopping or business areas throughout the city. Cashier-controlled or attendant lots are used wherever possible because they are flexible and can permit monthly parking, long- or short-time parking, and several types of merchant subsidy or validation programs and can more easily accommodate sales or special events. Such a lot generally has a capacity of 90 or more spaces, and the location has a good turnover. This type of operation is supplemented with automatic ticket dispensers and remote entrances with dispensers and gate controls.

Parking meters are used on lots that have a high turnover rate but are too small to permit economical cashier operation. One attendant is assigned to several lots and usually cleans them in the morning and patrols them for violations in the afternoon and during evening shopping hours.

The city also has several gate-operated lots that are mostly located within or close to congested areas and where the parking demand is largely for long-time parking or all-night residential parking. Gate operation permits the lots to be in service 24 hours every day. Transients can be handled by coin operation with fees both in and out. Monthly parkers use a card control that is changed monthly. The lots feature automatic coin counters that close the lots to transients after a certain number but permit the monthly customer access and guarantee him a space. These lots have been economical to operate, although vandalism has sometimes posed a problem.

Milwaukee's Parking Program (Parking Commission)

The Milwaukee Parking Commission is an advisory body of seven citizen members (*8*). The parking program, commencing in 1951, has developed facilities in the CBD, outlying business areas, and residential areas. Facilities open to the public as of 1968 are given in Table 4.1. The facilities were developed using parking income—in some cases supplemented by a benefit district assessment to owners of commercially zoned land. The general property tax was not directly used for parking.

The sources of parking income include parking meters, parking gates, all-night on-street parking permits, and rentals. All of the parking income has been used for parking purposes except for operation and maintenance and a payment to the general fund in lieu of taxes.

All facilities were designed for a 24-hour operation. Residential parking facilities may be used by employees or customers during the day. Business area parking is also available for all-night use.

The capacity of lots and the one structure in outlying business areas as of December 1968 ranged from 12 to 193, with an average size of 60 spaces.

Residential Parking Program—Milwaukee's overnight parking prohibition ordinance is enforced by a 2-hour parking regulation between 2:00 a.m. and 6:00 a.m. However, some sections of the city

Table 4.1—Milwaukee parking projects

Area	Type of Facility		Total Capacity	Total Cost
	Surface	Structure		
CBD	2	3	2,940	$10,000,000
Outlying business areas	45	1	2,670	4,500,000
Residential areas	10	1	780	1,100,000
Totals	62		6,390	$15,600,000

have such a shortage of off-street parking that it is impossible for all motorists to comply with the ordinance.

In May 1950, an all-night, on-street parking permit system was set up on all secondary streets in the city. The permit fee was set at $4.00 per month. All-night parkers were required to use the even-numbered side of the street on even-numbered days and the odd side of the street on odd-numbered days. The system permits easier detection of stolen cars and better street cleaning, snow plowing, and tree spraying. Parking permits were not issued for major routes or narrow streets where parking would be detrimental to traffic movement.

City-wide parking restriction notification signs are posted at all through highways entering the city limits of Milwaukee and at prominent freeway off-ramps. In addition, a special warning notice is posted in numerous hotels, motels, and other business establishments.

Money from the permits is earmarked for off-street parking, printing of permits, and lighting and maintenance of parking facilities. A contribution is paid to the general fund of the city in lieu of taxes.

The residential facilities are in high-demand areas. They are leased to private operators for operation in accordance with state statute. The facilities are within reasonable distance of some areas having need for employee industrial parking. The all-night facilities have therefore helped to alleviate daytime parking problems because there is no demand for short-term residential parking.

A 1954 circuit court decision stated that "the court considers that the issuance of special privilege parking permits and the ordinance permitting such permits constitute reasonable police regulations."

Because of their possible widespread application, the appropriate Milwaukee residential parking resolutions and ordinances, as of January 1970, are included in the Appendix.

White Plains, New York (Parking Authority)

White Plains, New York, is the county seat of Westchester County (*9*). As a

neighbor of New York City, it lies within an area containing the largest concentration of people in the United States. Consequently, it must face a parking problem of extraordinary magnitude.

Every business day thousands of people come into the city to work or to obtain commuter service to their jobs. Other thousands converge on the city to shop at the large number of specialty and department stores, many of which are suburban outlets for major New York City stores. Although the city has an official population of approximately 50,000, its daytime population is estimated at 70,000.

The city first attempted to solve its parking problem by the installation of parking meters at downtown curbs in 1938. In the immediate post-war period, with the rapid increase in automobiles, this approach to the parking problem became inadequate and, in 1947, the state legislature created the White Plains Parking Authority.

The Authority is governed by a five-man board. Board members are appointed by the mayor and serve without compensation. The Authority has power to acquire land by purchase or lease, construct and operate parking facilities, rent lots to concessionaires, and pledge parking revenues to retire bonds. In operation, a contract between the Authority and the city for exchange of services provides that the city agrees "as an independent contractor, to the best of its ability and as economically as possible," to acquire sites and construct facilities; to take advantage of all cash and trade discounts; deposit meter collections in a special account; and maintain records and prepare necessary reports. The city further agrees that it will not "substantially reduce" the number of curb meters, will not grant permission to any other agency or individual to similarly engage in the public parking of automobiles, and will obtain bids for work or materials costing more than $1,000.

The three major methods used for site acquisition include direct purchase, leasing, and "reverse" leasing. Site leasing has been accomplished through three different procedures: (a) by leasing a site at a fixed monthly rental for a fixed period of time; (b) by monthly rental as a fixed percent of revenues collected from meters installed on the site; and (c) by permit from the state for the use of space under a state expressway viaduct. Leasing in reverse has occurred only once. In 1964, White Plains granted to a commercial developer a 99-year lease for the use of air rights over a city parking lot. The lessee built a 12-story hotel over the lot, with attached garage to replace parking spaces lost at the ground level. The Authority operates the first two levels of the deck and the lessee controls the two top decks, which provide parking for hotel patrons. The annual rental for air rights is $17,500 for the first 10 years, with automatic increases for each succeeding decade up to a maximum of $24,500.

In 1961 it became apparent that parking lots were crowding out the businesses they were intended to serve. The obvious solution was to build multilevel facilities. The first parking garage was opened in 1963. Others have been built or are in the planning stage.

The first parking garage was constructed on an Authority-operated parking lot, part of which was owned by the city and part by the R. H. Macy Company. In 1961, the city entered into a contract with Macy's for the city to build a four-level parking structure covering the entire area. Macy's donated all of its land, which originally cost $485,000, to the city. Macy's further agreed to pay the city up to $100,000 annually for 10 years to cover garage deficits. Chargeable costs deductible from income include (a) the equivalent of all real estate taxes that would have been levied against the donated land, based on a fixed assessed value of $427,250, the

1961 figure, which, based on the current tax rate, amounts to just over $26,000; (b) the equivalent of the 1961 income from meters to be displaced, fixed at $40,000; (c) the annual amortization and interest on bonds and notes, amounting to $178,500 for the first year of operation; and (d) all normal operating costs, including policing, repair and maintenance, lighting, material and supplies, insurance, and salaries.

Garage capacity is 1,159 spaces. Electric-eye counters flash a sign at the foot of ramps when the level above is filled. Two banks of elevators carry patrons between floors. In addition, there are pedestrian stairways at each of the four corners. Macy's, at its own expense, was permitted to build a bridge of matching design between the store and the third floor of the garage. Any other nearby business would be permitted to build a connecting bridge under the same terms.

The garage is patrolled by meter maids and police who "tag" cars parked overtime. The tag is not a summons; it informs drivers that they may surrender the tag at the garage office as they leave and pay for overtime at the rate of 20 cents per hour—the regular 10-cent charge plus a 10-cent penalty charge. The meter system avoids delays and traffic pileups at entrances and exits. Instead of having to stop at the entrance to get a ticket from an attendant and to stop again on the way out to pay for elapsed time, the patron drives into the building and directly to the nearest open stall. He exits the same way.

Possible future expansion was considered when the garage was designed. Should it be necessary or desirable, the foundations will support an additional deck over the present level and permit extending the garage over an adjoining connector street for up to six levels.

Most lots and garages in White Plains are meter-operated. But both metered and attendant parking for commuters are provided at rail stations on land purchased from the railroad.

Uniformity is emphasized in all Authority operations. Entrance and interior signs in garages are the same green and white color and size. Coin-changing machines are standard equipment, and a color code indicates maximum time allowed in a metered stall: a silver-colored meter post denotes a 1-hour limit; blue, 3 hours; yellow, 5 hours; and red, 12 hours. Signs at entrances explain the code. Similarly, just as bridge connections are allowed between the garage and stores, ground-level connections are permitted for parking lots. Where interior lots abut stores or offices, the owners may obtain a permit to cut the bumper rail and build a pedestrian walkway from the lot to the rear entrance of the building. The opening is wide enough for pedestrians but too narrow for automobiles. The owner is required to pay all costs, including insurance coverage.

The White Plains Parking Authority has its own funds and budget entirely separate from city funds and budget. A financial report is filed annually with the state, based on an independent audit.

The Authority's objective is to amortize the cost of each facility within 20 years. However, five of the lots paid for themselves within 10 years and one has earned more than four times its original cost. Lucrative investments such as these helped to offset the high prices the Authority had to pay for some of its sites.

Until the first parking garage was built, the Authority operated on a strict pay-as-you-go policy. Technically, it still does, because the city, not the Authority, sold $2,250,000 in revenue bonds to finance the garage project. Because of the city's AA municipal credit rating and the pledge of meter receipts to amortize the debt, the interest rate was only 2.88 percent. Meter receipts pay the bills. Thus, the garages have been built and are being operated at no cost to city taxpayers except for the

money they deposit in meters to park their cars.

The Authority has developed or acquired control of 6,700 parking spaces since its creation. During this period income has increased steadily. In 1954 the total was just over $200,000. By 1967 the annual revenue was in excess of $1 million.

The city and Authority have made it a policy to provide parking where the need is determined by careful study to be most urgent in order to maintain business property values and ensure a sound tax structure. Also as a matter of policy, parking meters are not regarded as revenue producers but as parking and traffic controlling devices. If the removal of meters on a congested street and the banning of curb parking will speed flow of traffic, meters are taken out.

Pittsburgh (Parking Authority)

The majority of parking spaces existing in the downtown area of Pittsburgh at the end of World War II had been developed by private enterprise, but such efforts had not provided a sufficient supply to meet the post-war parking demand (*9*). The first positive step toward the solution of Pittsburgh's parking problems was taken in 1945 when the city's Bureau of Traffic Planning conducted a parking survey of the downtown business district in conjunction with the state highway department. Using the results of this survey, and through other research, the Pittsburgh Regional Planning Association, an unofficial citizens' planning agency, in cooperation with the Allegheny Conference on Community Development, prepared a comprehensive parking study for the downtown business district.

The basic recommendation of the study was that a Public Parking Authority for the entire city should be formed. Pittsburgh's leading civic and business leaders, along with public officials, recognized the importance of this recommendation. Through their combined efforts, the Public Parking Authority of Pittsburgh was created through state and local legislation in 1947 with the goal of planning and developing a permanent and coordinated system of parking facilities.

The Authority was established by the city as a public, nonprofit corporation possessing certain definitive powers under the Parking Authority Law of Pennsylvania. The agency is authorized to plan, design, locate, acquire, construct, maintain, operate, or lease facilities devoted to the parking of vehicles of any kind.

A most important power given the Authority, and which is basic to its operations, is the power to condemn property for parking development. However, it cannot condemn the usual public uses such as places of worship, cemeteries, or parking facilities that were in existence when the act was passed. Through this power of eminent domain, the Authority is able to acquire land at the proper locations without being blocked by unreasonable demands for payment or complete refusal to sell. If it is necessary to condemn, a fair price for the property is determined by a court of law. Actually, the Authority has exercised this power in only a few isolated instances where one or two owners held out and otherwise would have prevented the assemblage of a complete site for garage development. In other cases, the Authority has acquired its sites through negotiation.

Power to issue nontaxable revenue bonds is an essential element in the effectiveness of the Authority. Through this method of financing, additional parking facilities can be provided now and be paid for over a period of years from parking revenues produced by the facilities. Each new project is given very careful scrutiny by investment bankers and other lending

institutions. Because the bonds must prove to be a sound investment in order to be marketable, there is little chance that the Authority will provide an oversupply of parking spaces.

The Authority also has exclusive power to establish the rates to be charged in its facilities. These rates must produce sufficient revenues to maintain and operate the facilities and meet all other financial obligations, including the principal and interest on the bonds.

The Authority, by law, was declared to be exempt from taxation on its real estate and parking facilities, except for first-floor commercial space that it can develop in its garages. A 1963 amendment to the law permits parking authorities in Pennsylvania to sell or lease air rights above their facilities for commercial uses other than parking. Such commercial space, of course, is subject to real-estate taxes. A Pennsylvania Supreme Court decision in 1966 resulting from a suit involving projects of the Philadelphia Parking Authority required that air rights be leased or sold only on the basis of competitive bidding. An amendment to the law was sought in the legislature that would permit leasing of commercial space and air rights, or sale in the case of air rights, on such negotiated or competitive basis as the Authority shall determine. In the Authority's opinion, this provision would hold unlimited possibilities for far more intelligent planning and intensive development of future multipurpose facilities, both downtown and elsewhere in the city. The Authority intends, wherever possible, to design its future garages to accommodate air rights development and not build any more "free-standing" structures.

The Authority is governed by a five-member, nonpaid board, appointed by the mayor to serve for alternating terms of 5 years. A full-time professional staff is employed by the board to carry out its policies and decisions and administer the day-to-day activities of the Authority's operations.

As of 1967, the Authority had nine garages in and near downtown Pittsburgh with a total capacity of more than 7,800 self-parking spaces. A 333-car addition to an existing above-ground structure was completed in late 1967. This addition was designed to provide for a maximum 13-story building in the air rights above at some future date. Seven of these facilities are multilevel, ramp-type, open-deck structures and were financed, including the addition just mentioned, under six separate revenue bond issues. All of the garages have been leased to private enterprise, either directly to experienced parking operators or, in three instances, to major local department stores. In the latter cases, the security of these prominent business establishments standing behind the bonds enabled the Authority to obtain more favorable interest rates when the issues were sold. Lease agreements have terms ranging from 6 to 40 years and all are carefully controlled as to operational, maintenance, and general housekeeping practices, including the determination of parking rates. Rates, however, are only fixed after consultation with the prospective lessee or operator.

The eighth garage is a 1,040-car, 6-level underground facility located in a central downtown block called Mellon Square. The structure is surmounted by a beautiful city park that provides greenery and open space in an area where it is sorely needed. The Parking Authority entered into an agreement in which Mellon Square Garage, Inc., a private corporation, would design, construct, and operate the garage for a period of 38 years. Upon completion, title to the structure was vested in the Authority by the city, and the garage corporation operates it under a lease-hold for the entire period. By a joint government-private enterprise effort, a costly underground garage was provided in a high-

demand location. It is not likely that this could have been realized through private enterprise alone.

The ninth facility is a three-level, 2,750-car, semi-underground garage built under a 750,000-sq ft shopping-commercial complex in a major urban renewal project area located on Pittsburgh's North Side, a short distance from the Golden Triangle. The garage was financed by a $13 million bond issue of a private, nonprofit corporation that operates the facility under a long-term lease from the Authority.

During the 1960s, the Authority expanded its activities into the city's several neighborhood shopping districts that had seriously felt the impact of suburban shopping centers. A network of metered and gate-operated surface lots was developed. The lots were financed in part from curb meter revenues that the Authority received as a grant from the city and partly from funds loaned the Authority by businessmen and merchants in these neighborhood districts. These facilities have been producing revenues generally sufficient to meet operating expenses and other debt obligations.

All of the Authority's existing downtown garages have been sound financial ventures. Retirement of the first bond issue was accelerated by about 3 years. Rate schedules have been designed to attract the short-term parker to those facilities that are primarily shopper-oriented and the all-day, employee-type parker to the

This multiple-use structure has a portion of the first floor serving retail sales and the remainder used for parking. Such joint uses often improve the economic feasibility of a facility in high-land-cost areas. (Source: Public Parking Authority of Pittsburgh.)

more peripheral locations where walking distance is not a critical factor. The Authority's system of downtown garages is providing a skeleton network of permanent off-street parking locations giving good coverage to the Golden Triangle and effectively supplementing private parking operations.

The Authority's experience indicates that private interests, by themselves, had not undertaken to provide adequate public off-street parking, in both the central and smaller business districts. The greatest portion of the permanent off-street spaces developed in downtown Pittsburgh since World War II has been created by the Parking Authority. Only in recent years has there been significant private construction of off-street parking, and that mostly in connection with new office and high-rise apartment building projects.

PROGRAMS FOR OUTLYING AREAS

In addition to Chicago and Milwaukee, there were 54 cities of over 50,000 population that reported development of municipal facilities in outlying areas (*10*). Of the 529 facilities, 76 percent were located in business areas; 16 percent were in residential areas; 3 percent served employees; 3 percent served commuters; and the remaining 2 percent served hospitals. This survey did not include any parking privately supplied as part of zoning requirements, parking publicly supplied to serve government operations such as airports, libraries, parks, and civic centers, nor parking developed by public bodies other than parking agencies or a local government.

Those cities reporting outlying parking developments (*10*) in residential areas or for commuter, employee, or hospital uses are as follows:

Residential

Evanston, Ill.
Milwaukee, Wis.
New Haven, Conn.
New Rochelle, N.Y.
Philadelphia, Pa.
Tampa, Fla.

Commuter

Alhambra, Calif.
Chicago, Ill.
Philadelphia, Pa.
Washington, D.C.
White Plains, N.Y.

Employee

Columbia, S.C.
Inglewood, Calif.
Los Angeles, Calif.
Miami, Fla.
Milwaukee, Wis.
Philadelphia, Pa.
Pittsburgh, Pa.
Rochester, N.Y.
Santa Monica, Calif.
Washington, D.C.
Worcester, Mass.

Hospital

Miami, Fla.
Oakland, Calif.
Philadelphia, Pa.
Pittsburgh, Pa.
Pontiac, Mich.
Sacramento, Calif.

Philadelphia reports a fully subsidized residential area program. The parking is free, and all development costs are paid from city-wide capital funds.

In New Haven, the city used urban renewal funds to construct residential lots. A nominal parking charge is levied, with operation and maintenance being performed by the City Parking Authority.

Another method of financing off-street parking for residential areas—the use of special assessments—warrants consideration, but examples of its application were not found. If the benefit district method is proposed (with levies against all

properties in the block when allowed by state law), "credit" allowances should be given for existing owner-supplied off-street parking. The potential for this allowance may encourage sufficient self-improvement to solve the parking shortage. Many apartment lots have rear or side yard areas that could be converted to parking space. This would be a substantial savings to the owner when compared with a special assessment to buy land and tear down a building for a central parking lot in the block.

If the total parking requirements of urban areas are to be met, a large-scale effort is clearly needed. Programs could take several forms, depending on the type of parkers (industrial, institutional, business, or residential). In many cities, the widespread shortages in residential areas seem far too vast to overcome through use of general tax funds. The Milwaukee street parking permit system is an interesting approach, and its application in other cities appears warranted.

Other equally innovative approaches should be considered. For example, very high automobile license fees (such as $200 or $300 a year) might be levied against vehicle owners lacking off-street parking at their place of residence. License fees for businesses or industries might also reflect the degree of their off-street parking supply, as measured by some local scale of unit generation.

This municipal parking lot in a residential area features boundary protection and special lighting. Note, however, the inadequate driveway radii.

Whatever the tools used, treatments will be expensive, controversial, and less than ideal. The problems should spur cities to use progressive zoning controls to ensure adequate parking in new developments.

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CHAPTER FIVE

PARKING STUDIES

Studies have been made in many cities to analyze parking needs and expand or develop programs for improvement. Some cities have performed several studies, and many cities review their parking needs periodically. Early studies were generally conducted for city agencies and business or civic associations, whereas many recent studies have been done as part of comprehensive transportation planning for metropolitan areas.

In general, studies may be made to identify parking inadequacies or to develop proposals to improve parking supply in a specific area such as the CBD or along certain traffic corridors. In any case, the study should be designed to provide the information needed to develop a program for obtaining the basic objective. A parking study may have to determine not only where motorists can and do park but also where they would like to park and how their parking practices affect the use of other transportation modes.

This chapter includes a brief discussion of the types of studies, the kinds of information that can be gathered, and the typical applications of these data to business, industrial, and residential areas.

TYPES OF STUDIES

Parking studies can generally be classified into three major types: comprehensive or full-scale, limited or partial, and special-purpose. The type of study needed depends on the scope and purpose, the area to be surveyed, available information, and financial considerations.

There are five basic elements essential to any parking study:

1. Preparation—planning and organizing the study.
2. Data collection—surveying existing parking conditions.
3. Data analysis—determining needs and developing alternatives.
4. Evaluation—examining the effects of each alternative.
5. Implementation recommendations—selecting a program of improvement.

The nature and type of study depend on how each of these elements is developed. The successful initiation of a study depends on the development of the study objective and a method of achieving the desired results. The necessary facts must be gathered and existing conditions correctly reported. The analysis of the data

should be designed to yield answers to basic questions and to provide insight into present and future needs. During the analysis phase, various program alternatives may be developed. These alternatives should be evaluated, the effects of each examined, and the desirability of each determined. The final step produces recommendations for a program offering optimum parking improvement.

Comprehensive Study

The comprehensive study is the most complete of the three major types of studies and the most costly because of the extensive data collection and detailed analysis required. This type of study is designed to investigate and analyze the parking problems of the CBD, to appraise trends in parking use, and to establish a sound base for future plans.

The study normally should provide information on the capacity and use of existing facilities, the location and extent of parking demand, the influence of large parking and traffic generators, future parking needs, the adequacy of existing laws and ordinances, limitations of administrative responsibility, financial capabilities, and possible future parking programs.

The most difficult and expensive information to gather usually relates to *location of parker demand*. In almost all areas with a parking shortage, people are forced to park at locations that are not their destination. The determination of where they actually want to go normally requires some sort of direct contact, i.e., interviews. The interview may be conducted at a parking facility, at a generator, along the road, or even in the home. The location and extent of the interview sample is a prime factor in how comprehensive and expensive the study will be and also in the usefulness of the findings.

Other techniques to collect information on parking demand and parker characteristics include the use of origin-destination home interview data, postcard questionnaires, and license-plate surveys.

Limited Study

The limited or partial study is usually conducted in cities of less than 25,000 population that do not need the detailed information of a comprehensive study. The limited procedures will still include the five basic parking study elements. A complete inventory of all parking spaces within the study area is also required.

The major difference between a comprehensive and a limited parking study lies in the parker interview data. Smaller cities may eliminate the interviews and merely use hourly accumulation counts of parkers or facility occupancy checks to

An interview provides essential data on the parker's destination. Parker interviews may be conducted at the curb (as shown here) or within off-street parking facilities.

measure use. They may also conduct some interviews on a selected sample basis to help determine trip purposes, durations, walking distances, and turnovers. A limited study might also use origin-destination home interview data, postcard questionnaires, or license-plate surveys.

The lack of complete interview data from the limited study poses a problem in estimating demand on a block-by-block basis. A knowledge of parking demand is important when selecting the optimum facility site location. In large cities this is critical; in smaller cities, a familiarity with the area and its principal parking generators will often allow reliable judgments to be made of deficiencies.

One type of limited survey produces demand data during the period of maximum accumulation. This is the "peak-hour" study, which involves interviewing all parkers during 1 hour. Parking occupancies in a business area are fairly uniform for several early afternoon hours, and interviews are typically conducted between 2:00 and 3:00 p.m.

The peak-hour study provides a limited but fairly adequate source of information on block-by-block space deficiencies at less than half the cost of a comprehensive study. Although the procedure will not produce all the valuable data of the comprehensive study, it may be entirely adequate to define the extent of space needs and where spaces should be located, which are the primary functions of a parking study. It does not, however, give representative data on illegal parking, overtime parking, trip purpose, or truck requirements for loading zones. Data may not be sufficient to allow development of a financial feasibility report.

Special-Purpose Study

The special-purpose study is generally designed to answer a specific question rather than investigate and analyze overall parking needs of a CBD. A special-purpose study may be conducted to determine the feasibility of installing parking meters on local streets or the results of removing parking spaces along a major traffic route. This type of study may also be used to check on the collection of parking fees, illegal parkers, enforcement of parking regulations, or the parking requirements in a selected area such as a proposed industrial park or shopping center, at a university or hospital, or in a residential neighborhood.

A relatively simple special study that cities of nearly all sizes should consider is the specific generator type. The purpose is to secure appropriate local data on which to base zoning code parking requirements for the area's specific land uses.

PROCEDURES

The first step in a parking study is the clear definition of the *objective*. The extent of work required to meet this objective will then indicate the general kind of study needed (comprehensive, limited, or special). A review of procedures for the comprehensive CBD type of study will include the elements of the limited and special-purpose studies, since a major difference is in the amount of interview data collected.

A rudimentary knowledge of parking survey procedures will assist the administrator. It will help him to (a) formulate the objective, (b) determine the extent of local technical staff contribution, (c) review the cost factors, and (d) develop local interest and sponsorship. The discussion of procedures is intended to orient the administrator but is not intended to be a working manual. These manuals are available nationally, and certain states have prepared their own (*1, 2, 3*).

Organization

The preliminary organization steps include a detailed specification of study objectives; consideration of the types of field

studies to be conducted; evaluation of existing data; determination of personnel requirements; selection of personnel; design and preparation of forms, manuals, and maps; arranging for equipment and supplies; and training of personnel.

The director of the parking study is usually an engineer with considerable traffic and planning experience. For the larger studies it is often appropriate to employ an assistant study director who will select and train the personnel and supervise the field studies and coding of data.

Manpower requirements vary widely, depending on the scope of the project and the method used. A limited parking study or inventory and occupancy counts of parking facilities within a study area require only small field crews. Conversely, a comprehensive survey of a large area may employ as many as a hundred field and office personnel.

The comprehensive study is typically performed with local manpower, utilizing some staff assistance from the traffic or city engineer's office, but largely depending on people especially hired and trained for the project. The work is usually under the direction of the state highway department or a consultant.

It is important that the director develop survey techniques to obtain the necessary data economically and to process it effectively. The following major elements are involved in the cost estimate: (a) preparation and printing of survey forms, manuals, and maps; (b) parking inventory; (c) land use, employment, and travel mode surveys; (d) parking occupancy counts; (e) license-plate surveys; (f) interviews; (g) coding and tabulating of survey data; (h) keypunching and computer programs; (i) study of alternatives; and (j) preparation of report.

Data Collection

Parking surveys should be conducted at times when favorable and unbiased results can be obtained. This excludes days of extreme inclement weather or days preceding holidays.

Inventory—A parking survey necessarily must include the inventory of all parking facilities within the study area. By means of an inventory, information is assembled about the location, capacity, and other pertinent characteristics of existing parking facilities both at the curb and off-street, including alleys (Fig. 5.1).

The inventory is a prerequisite to occupancy studies and interviews. A land-use survey is also desirable. These are useful in working out changes in parking regulations and in determining areas or locations for potential development of additional parking facilities.

If a study objective is to recommend sites for additional parking, data are often gathered on assessed valuation of existing parking lots, vacant tracts, or highly depreciated buildings. This work follows completion of the basic land-use and off-street facility inventories.

Information on employment and building square footages (by type of use) of selected major generators is secured as part of the land-use survey. Data are collected on transit use, including trends in patronage, when appropriate.

The checking of local ordinances, state enabling legislation, finances of existing parking operations (including curb parking, meter costs, and revenues), and similar administrative-type studies may be conducted during any stage of the project. They are most closely related to the inventory.

Accumulation Counts—Checks of parking accumulation are needed at each curb and off-street parking facility on various days to include the hours of weekly peak parking demand. (Heaviest use is typically found on Thursdays, Fridays, or Saturdays.) The trends of total parking accumulation within the study area are usually determined from checks taken periodically

across an entire business day.

Aerial Survey — Aerial photographs may often be used to check and verify occupancy of lots and curb spaces. Ground checks must be used in garages.

By means of color photography, accurate data can be obtained on accumulation, duration, and turnover. No information on trip purpose is obtained but where these data are not required aerial photography can be a very useful tool in determining parking characteristics. This technique has been used successfully in Ohio and is reported to have reduced costs

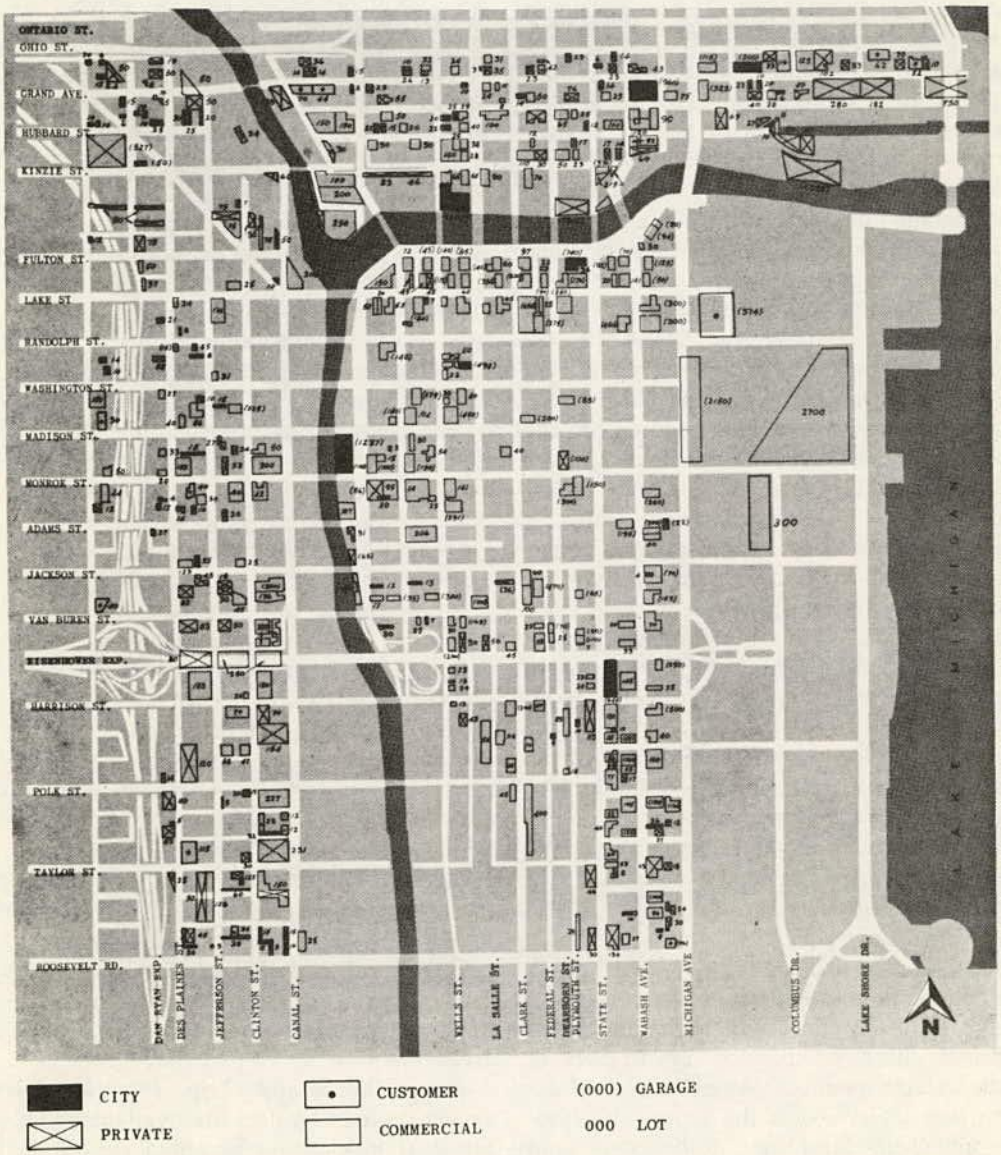


Figure 5.1. Parking inventory map. (Source: Barton-Aschman Associates for the Chicago Central Area Committee.)

by 72 percent and time requirements by 85 percent when compared with the more conventional technique using observer-recorders on the ground (*6*).

Cordon Count—A cordon count will yield data on traffic volumes and the accumulation of vehicles within a study area. All inbound and outbound vehicles on each street crossing the boundary of the area are counted. The cordon count should run from 6:00 a.m. to 6:00 p.m. in order to include both rush hours. Certain control stations must be operated 24 hours a day throughout the study as a means of expanding the data to full-day volumes. It is also good practice to conduct some sampling of car occupancy.

The cordon count is expensive because it requires a very large number of persons. The count has been extensively conducted in the past to gather data on CBD traffic volumes, by route of entry and exit to the area, and on the accumulation of vehicles by hour of the day within the area. However, prior surveys often have secured a good data base on traffic volumes, types of vehicles, and numbers of persons per car. Newer techniques such as aerial photography also may be coupled with ground control checks within structures to give ample information on parking accumulation.

The cordon count continues to have application in transportation studies and gathering of data on annual trends such as mode of travel into CBD areas; however, it is no longer considered essential to a comprehensive parking study.

Parker Interviews—Interviewing can be successfully accomplished upon either parker arrival or departure. An advantage of arrival interviewing is the reporting of driver intentions that led him to park at the specific location. An advantage of departure interviews is the reporting of accomplished facts on destinations and lengths of stay.

Interviews may be conducted more easily at off-street facilities than at the curb. If all patrons pay daily or hourly fees, interviewing at the cashier's stand is easiest and has least influence on traffic operations. In all instances where interviews are to be conducted, advance arrangements with operators of the facilities are mandatory.

In an area of relatively stable parking patterns, parkers at different facilities may be interviewed on successive, similar days. Thus a smaller force can accomplish the work over a longer period of time, and results are more consistent because the interviewers become more experienced and any peculiarities in technique are spread through the data rather than concentrated in observations of a single facility. It is extremely important, however, to omit days of special events or inclement weather.

The amount of curb space that one interviewer can cover is limited by his ability to watch all spaces and to reach a driver before he leaves his car (in arrival-type interviews) or drives off (in departure-type interviews).

Some people are reluctant to answer questions, and others are frightened by an unexpected contact. Curbside interview of women drivers is particularly difficult. It is very helpful to get broad publicity for the proposed study, and it is mandatory that interviewers have identification, such as an insignia or badge, that is readily recognizable. Careful screening of interviewers for both manner and appearance is essential. Excellent results have been obtained by women interviewers (particularly school teachers and women with census experience), but special provisions for their security are required in some areas.

Origin-Destination Trip Interviews—Origin-destination data are available from urban transportation planning studies in areas of over 50,000 population. These surveys, which collect information on trip

purpose, destination, times, type of parking, and various socioeconomic characteristics of the trip maker, may provide some of the data needed in a parking study. Optional questions asked during the interview can produce data on parking location, parking cost, and walking distance.

The use of these data reduces the cost of a parking study by eliminating the CBD parker interviews. Data from home interviews were found to be a valid substitute when checked in a Sioux Falls parking study (*4*). Although previous origin-destination surveys rarely collected information on CBD parking location, and only a few collected data on cost and walking distance, these and other optional questions as discussed in the procedural manual for collecting travel data might be included in future surveys (*5*). A detailed discussion of the procedures involved with this technique is available (*4*).

Postcard Survey—Postcards are distributed to determine the characteristics of parkers whose vehicles are found in the study area at the time of peak occupancy. They are placed on car windshields by the field crew, and the serial numbers are recorded for each facility. The parker is requested to fill out the card and return it by mail. Information gathered includes trip purpose, origin, destination, and length of time parked (Fig. 5.2).

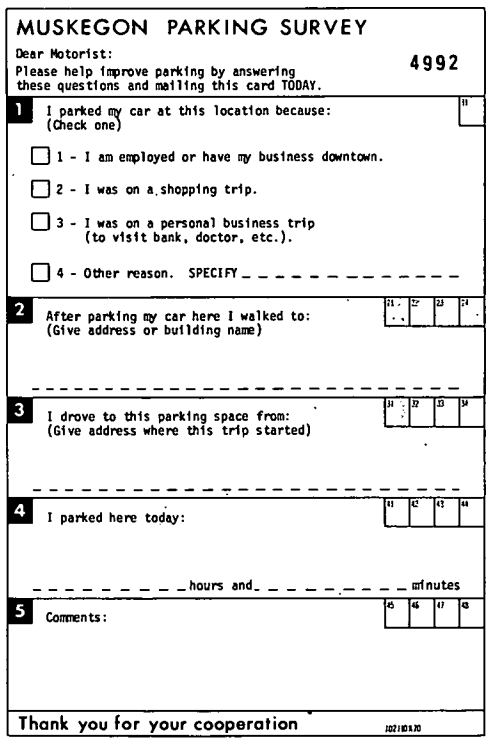
Shortcomings of the postcard distribution survey are the possibly biased returns that can result in statistical slanting of results and a generally low percentage of response.

License-Plate Survey — Parking turnover and space occupancy data may be obtained by periodic checks of license plates on parked vehicles. The necessary interval for observations depends on the character of use. Posted or metered time limits, thoroughness of enforcement, and prevalence of "meter feeding" all influence the selection of a proper interval.

A license-plate study yields excellent occupancy and turnover data plus insight into parking irregularities and degree of enforcement. Origin, destination, trip purpose, and walking distance, however, cannot be learned from this type of survey. It does *not* measure or identify location of parking demand.

Major Traffic Route Studies—Parking restrictions may be warranted along major routes during as many as four different time periods: the morning rush hour, midday, the evening rush hour, and overnight.

Surveys of existing supply and demand are made by taking accumulation checks during the study period. For potential 24-hour restrictions, checks at hourly intervals from 5:00 a.m. to midnight are suggested. Separate tabulation should be made of the number of cars parked in lots, on each curb side of each block, and on local cross streets for about 200 ft from


MUSKEGON PARKING SURVEY

Dear Motorist:
Please help improve parking by answering these questions and mailing this card TODAY.

4992

1 I parked my car at this location because: (Check one)

☐ 1 - I am employed or have my business downtown.

☐ 2 - I was on a shopping trip.

☐ 3 - I was on a personal business trip (to visit bank, doctor, etc.).

☐ 4 - Other reason. SPECIFY _ _ _ _ _ _ _ _ _ _ _ _ _

2 After parking my car here I walked to: (Give address or building name)

_ _

3 I drove to this parking space from: (Give address where this trip started)

_ _

4 I parked here today:

_ _ _ _ _ _ _ _ _ _ hours and _ _ _ _ _ _ _ _ _ minutes

5 Comments:

Thank you for your cooperation

Figure 5.2. Postcard survey questionnaire.

each side of the major route. Trucks should be tabulated separately from passenger cars. Checks should be made on the sections of cross streets to determine the number of legal curb spaces. The parking capacity of lots serving properties along the route should also be determined.

In making a direct comparison of the demand versus reduced curb supply for each block face, due allowance will be needed for any surplus capacity in private lots. In many cases, however, people will park at the curb even though ample space exists in a free parking lot serving the same business. It is generally impractical to conduct interview studies as part of major traffic route parking surveys. In a few critical blocks, direct observations of parker destinations may be advisable to check out possible shortages.

Residential Area Studies — Special studies in residential areas should be made during the hours of peak demand, which usually occur between 1:00 a.m. and 5:00 a.m. The work should include an accumulation check, performed separately for each block face and in the rear or side off-street parking facilities (if any) of each separate building. The number of illegally parked cars along streets and in alleys should be noted. A day check is also necessary to determine the number of available legal spaces at the curb and off-street at each property.

Specific Generator Studies—Studies to determine the parking generation of specific land uses are simply accumulation counts. For the data to be used in zoning code specifications, the demand must be related to some unit of size. Applicable units for typical land uses were suggested in Chapter Three.

Hourly, daily, weekly, and seasonal variations in demand must, of course, be considered. Helpful guides were given in Chapter Two, but care is required to assess correctly the local conditions.

Analysis of Comprehensive Study Data

Upon completion of the field work (inventory, occupancy counts, interviews, postcard distribution, or license-plate surveys), the data are compiled and analyzed to determine the characteristics of the existing system. The precise significance of tabulated data and particularly the relationships between variables are often difficult to isolate. To this end graphic analyses are often helpful.

In the more comprehensive studies, summaries are prepared to give comparisons of parking supply and demand in each block (sometimes also for specific generators) and to express characteristics of parkers by trip purpose, duration, walking distance, parking charge, and kind of facility used.

The analysis of data yields answers to questions of what changes are needed in existing facilities (such as curb parking time limits), how much additional parking is needed, and which blocks it is to serve.

Trip Purpose—The purpose of a trip affects four important characteristics of the parking system: the time of parking and duration of stay, percentage of vehicles entering or leaving facilities during a given period of time, acceptable walking distances, and acceptable parking fees. In determining the total quantity of parking required, time of occurrence and duration of stay are paramount.

Parking Duration and Turnover—Parking duration and turnover data are obtained from the interviews, the license-plate survey, general surveillance (except for parking within structures), or postcard tabulations.

The length of time parked is an index to the type of parking facility that should be provided to serve the parking needs of motorists. The proportion of short-time parking (the absolute number, not the total occupancy time) is particularly significant in setting up time restrictions at

the curb so the greatest number of parkers may be served.

Parking turnover is the rate of use of a facility and is determined by dividing the number of available parking spaces into the number of vehicles parked in those spaces in a stated period of time (the typical business day or study period).

Walking Distance—Although accumulations, parking durations, and turnover rates of a parking system identify the quantity of parking available, they do not clearly establish the quality. One index of quality is the relationship of the space location to the parker's actual destination. Data are gathered from interviews or postcard tabulations. Comparing the amount of parking supply and trip destinations per block will illustrate apparent parking shortages or surplus. In any decision on location of additional parking facilities, the factor of walking distances must be considered.

Forecast of Overall Parking Demand

Present parking needs depend on the daytime population of workers and other visitors, the proportion of CBD trips made by automobile drivers, the parking supply, and parking regulations. The total demand in the business district may be regarded as consisting of (a) the demand evidenced by the drivers now parking there legally, (b) the equally evident demand of the illegal parkers, (c) the demand of those drivers who may now park just outside the district and walk in, and (d) the demand of those who use some other mode but would drive if parking were available. When the available supply is used to capacity in both core and accessible CBD fringe areas, factor (d) may be substantial. The extent to which total actual and potential demand is to be met is governed partly by economics and partly by local public policy.

By normal standards, when 85 to 90 percent of the spaces available to the general public are occupied, the system is considered to be used to capacity. Some spaces are always unoccupied because drivers are maneuvering to park in or leave spaces and because some spaces may be preempted by construction, special events, or careless parking that encroaches on adjoining spaces.

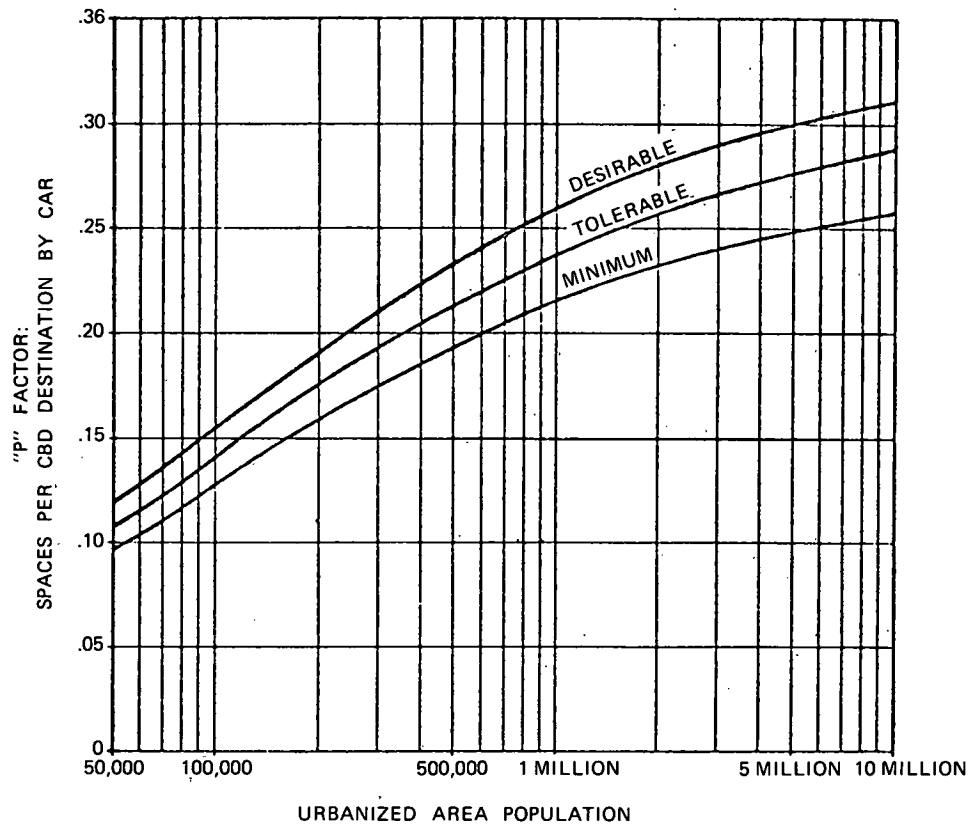
The total supply should be corrected to reflect surplus private spaces not available for public use. A calculation of overall use, based on the number of private spaces actually occupied rather than the number available, frequently increases the occupancy rate by as much as 10 percent.

In general, forecasting overall CBD parking demands for a future year will involve one or more of the following factors:

1. The anticipated increase in the urban area population;
2. The total CBD person-trip generation, including the number of persons coming downtown for work and nonwork purposes;
3. The economic growth and market forecast for the CBD;
4. The proportion of total daily travel to and from the CBD that occurs between 6:00 a.m. and 6:00 p.m.
5. The future "modal split" (proportion of trips by car and transit), from which the number of downtown person trips by automobile may be estimated; and
6. Future average car occupancy.

Figure 5.3 shows the general manner in which overall CBD parking space requirements tend to relate to urban population. This figure shows the parking space factors ("P" factors) that can be applied to the proportion of total downtown person-trip destinations by automobile. Once the total downtown trip attractions and modal split are determined, these curves may be used to provide a first approximation of either present or future overall parking requirements.

Curves shown in Figure 5.3 indicate "desirable," "tolerable," and "minimum" demand levels. The desirable demand curve reflects both average and seasonal peak needs. The tolerable demand curve provides sufficient space for a typical weekday, giving consideration to concentrations of demand in the core area (it recognizes that certain spaces are beyond acceptable walking distance). The minimum demand curve does not include the concentration factor.



APPLICATION OF CURVE

1 - ESTIMATE CBD PERSON TRIP DESTINATIONS

2 - ESTIMATE PERCENTAGE OF DOWNTOWN PERSON TRIPS BY CAR

3 - CALCULATE THE DAILY CBD PERSON TRIP DESTINATIONS BY CAR (MULTIPLY 1 BY 2)

4 - READ THE APPROPRIATE "P" FROM ABOVE CURVES

5 - CALCULATE THE CBD PARKING SPACE REQUIREMENTS (MULTIPLY 3 BY 4)

6 - CALCULATE ADDITIONAL PARKING SPACES REQUIRED BY COMPARING SPACE DEMANDS WITH AVAILABLE SPACES

Figure 5.3. Parking space demand factor. (Source: Wilbur Smith and Associates, "Parking in the City Center.")

Other methods have been developed for estimating future parking demand. The simplest method requires historical data for the development of parking supply or demand trends. More detailed studies take into account population changes, socioeconomic indicators, and alternative transportation systems. Land-use projections and total square feet of floor area may also be used in conjunction with parking generation rates to estimate future needs. The more sophisticated technique uses the forecast CBD auto driver trips based on comprehensive transportation planning studies. This may involve the development of peak parking demand ratios or a parker distribution model.

Estimating Specific Parking Needs

Business Areas—Comparisons of survey data on supply and use versus demand, on a block-by-block basis, will identify the individual locations of deficiency. The blocks with surplus public parking capacity will tend to be at unacceptable walking distances to satisfy the class of parker for which service is deficient. Therefore, the blocks of greatest shortage will form the center of one or more areas, with the boundary of each area being limited by average walking distance.

Possible future deficiency of any block is determined by making reasonable projections of proposed or planned changes in the immediate area. Important types of changes include gain or loss of parking supplies and major generators and possible adjustments in curb parking regulations.

Major Routes—Specific parking improvements may also be needed along major traffic routes located outside the CBD. A block-by-block comparison of supply and demand is often necessary to determine whether a particular curb parking prohibition would result in a critical parking problem during any hour of its application. In making such calculations, the engineer should give due consideration to parking lots that serve only a single land use and are not available to other owners, even though surplus capacity exists. There have been cases where curb parking restrictions have encouraged adjacent businesses to share in use and maintenance costs of a common lot. Such cooperative possibilities constantly warrant exploration.

Residential Areas—Parking shortages and needs in residential areas may be directly checked on a block-by-block basis. The number of cars parked in the night check exceeding 90 percent of the total available legal spaces may be considered to represent the minimum parking shortage. A severity index, developed by the Pennsylvania Economy League for Philadelphia considers 71 to 90 percent to be "serious" and over 90 percent to be "critical," in terms of residential area planning priorities (*7*).

Development of Parking Improvements

Upon completion of the parking study and the determination of present and/or future deficiencies, a parking improvement program should be outlined. The elements of plans include the selection of alternate sites for new facilities, changes needed in regulations or operating procedures, and development of a short- and long-range program. General types of programs and methods of financing were presented in Chapter Four and need not be repeated here.

Potential locations for new facilities include vacant lots, city-owned land, blighted areas, interior block space, and air rights. Sites for additional parking must be readily accessible and convenient if they are to fulfill their primary purpose. They should serve to promote a land-use improvement that is consistent with community goals and objectives. If a

traffic circulation and proposed land development plan is available, it will also help to identify general areas where new facilities should be located.

Parking facility capital costs include land, legal and engineering services, construction, and financing during construction. An economic analysis of each alternate site should be made to determine the feasibility of the facility, including revenue and operating cost estimates. Workable sites are those that satisfy the identified deficiency and are economically practical.

The types of additional parking facilities needed will depend on both current and future deficiency estimates. In some extreme cases, "temporary" parking facilities may even be warranted. In the past these have been surface lots, but the development of demountable parking structures has opened an expanded opportunity for erection of ramp structures that can serve one location for 5 to 10 years and then be relocated to a new site (see Chapter Six).

Other parking improvements may be developed by changes in curb parking regulations such as time limits, added or extended special-purpose zones (freight, passenger, and taxicab), installation or removal of meters, changes in meter rates, or increased enforcement.

In the development of the program, zoning requirements should be carefully considered and the need for any updating evaluated. Guidelines are given in Chapter Three.

A parking study may also produce recommendations for changes in operating or financing procedures. Examples exist where direct municipal operation of parking is less efficient than leasing the facility to a private company or executing a management lease. Examples of the converse undoubtedly exist. Measures such as better audit control or consolidation of administrative responsibilities may warrant adoption. In short, the study may delve in depth into existing operations. The municipality should not lose the opportunity thus afforded of securing an outside appraisal of its existing facilities, even though staff resistance may occur.

Continuing Evaluation

Parking studies should result in a parking plan and program, but to be effective they must also be continually updated and evaluated. The analysis and publication of the report of a parking study may take as much as 6 to 9 months. Even where public interest is already aroused, there almost inevitably ensues a period of several years before action is decided on, the necessary legislation enacted, and the financing arranged. If the program is extensive, the decision may be in favor of a progressive or stage construction plan covering several years.

In any event, in view of the rapidly changing traffic and transportation patterns and resultant physical changes throughout urban areas, it usually will be desirable to reappraise periodically the parking situation in the problem area. This may be done without undertaking a complete and extensive restudy. Applicable work includes maintenance of a current inventory of existing parking facilities and revisions in the long-range plan based on the periodic reevaluation of growth forecasts. The changes in the demand for space may be approximated from the changes in use by comparing the present peak parking accumulation with that of the previous study. Some parking demand may have been met in other ways, such as provision of more effective transit service or multi-use residential and commercial building complexes. Adjustments may be made where important traffic generators have been enlarged, added, or removed. The continuing study not only appraises changing needs but also the effectiveness of past actions and programs.

APPLICATIONS

Parking studies are not limited in their application. They may be performed wherever an analysis of parking is desired. Studies may be conducted to determine the needs of an area or of a specific development. The more extensive studies are required for the downtown area, regional shopping center, or planned community.

The most comprehensive study is conducted in the CBD of a city. Such a study is performed in the public interest because the downtown area normally has acute traffic congestion as well as critical parking problems. The economic vitality of the CBD is of great importance to the entire community.

Other areas include secondary or local business districts, small retail trade centers, or small communities outside the center city. These locations frequently have parking and traffic congestion problems that merit study. The studies are of a smaller scale, but through them the local communities are often able to develop and implement parking programs that significantly improve existing conditions. For example, a limited study made in one of eight such older districts in Kansas City, Missouri, resulted in the establishment of a local association, development of two new parking lots, and a special financing program (*8*).

Institutional and industrial areas may have critical parking problems that warrant special study. Many urban universities have started expansive parking programs; college administrators cite student parking requirements as one of their most pressing needs. Industrial areas that are experiencing unpredicted growth may also develop severe problems. Older high-density generators, such as hospitals, may require special study and programs of parking facility construction.

This metered municipal lot illustrates the kind of facility that may be developed as a result of parking studies in local business areas.

Residential areas that have extensive land development and high population densities comparable to older sections of cities usually have a parking shortage resulting from insufficient off-street spaces. Crowded curb parking causes local street traffic congestion, presents a serious safety hazard to vehicles and pedestrians—especially children—and interferes with the access of fire equipment and other emergency vehicles. Although the basic parking studies for these areas are simple, the implementation of a program that is financially feasible is extremely complicated.

Change-of-mode terminals require special analysis to determine the extent of parking demand and the number and type of spaces needed. Perhaps the greatest single concentration of parking outside the CBD is an airport. Other generators requiring special study include downtown bus and rail terminals. Suburban commuter rail and rapid transit stations are also likely to develop parking congestion. In many locations, the community development was initially due to the suburban railroad station, and the local CBD may adjoin or overlap the terminal area. In any case, specialized parking studies are needed, and the projection of future demands is a challenging task.

Recreational areas, public parks, and sport centers all have high peak-demand periods for parking. Although land is usually available, a study is required to determine the number of spaces that should be provided and the possible design of an overflow area.

Other specialized parking studies may be conducted along major urban routes. These often may be performed as part of a TOPICS (Traffic Operations Program to Increase Capacity and Safety) study. (TOPICS is a program administered by the Federal Highway Administration through state highway departments.) The development of outlying parking facilities also requires some type of study to determine numerous site parameters such as location, size, service, and use. These facilities are receiving increasing federal emphasis.

Almost every city needs a continuing check of parking generation for different types of land uses in the various zoning districts. These special accumulation studies will materially assist in developing and maintaining reasonable and proper off-street parking requirements in the zoning code.

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CHAPTER SIX

LOCATION AND DESIGN

The broad elements of parking facility location and design range from the very limited alternatives at the single-family residence to the complex multi-access and multi-use developments feasible only in a large city CBD or at a major airport. Because of the high land cost and great variety of parking developments potentially needed to serve downtown areas, most of this chapter is concerned with the "centralized" kind of facility. However, much of the material also has relevance in designing parking lots and garages in other areas or of a lesser scale.

GENERAL CONCEPTS

A private motor car will usually be parked at or near the owner's residence for over half its life. For convenience, safety, and access, this private parking should be as close to the residence as practical. For the single-family home, duplex, or row house, the best location is on the building lot. Off-street parking for visitors, however, usually does not exist or is limited to one or two spaces in the driveway.

In larger residential developments, such as apartments or hotels, a common parking facility becomes mandatory—it serves residents, employees, and visitors and is usually integral with, or adjacent to, the basic development.

Individual commercial or industrial enterprises should have their own parking to serve employees, shoppers, and visitors. This private parking is also best located on the site.

In all three of these general cases, the parking is owner-supplied, is usually free, and is not available to the general public. It is a form of private, self-contained parking. Admittance is normally free-flowing, and the need for attracting parkers, collecting fees, or controlling revenue does not exist.

Most of the so-called public parking facilities represent a more centralized and general-purpose use. Parkers usually have a choice of several destinations. Much of the time they also have a choice of alternate places to park. A public facility usually needs to attract parkers if the investment in its construction is to be justified. When the facility is intended to be self-supporting or is a commercial investment, the need for adequate revenue is obvious. Even when the parking is free, justification is needed for the expenditure of benefit district assessment funds, park-

ing meter revenue, or public money used to acquire land and to construct and operate the facility.

Methods of Operation

The design of a general-purpose parking facility must take into consideration the type of proposed operation—with attendants, by self-parking, or with a combination of the two. The most economical operation occurs where the patron parks his own car. In heavily used facilities where patrons pay for parking, it is sometimes feasible to utilize attendants to park the cars after the patron pulls into the lot. This type of parking is best suited to small lots in highly congested areas where the larger spaces required for self-parking are not available. Criteria on which the attendant versus self-park decision is made also include the level of service and required revenue. Attendant-parking garages are not able, because of high labor costs, to compete successfully today except in a few areas where the parking rates are especially high.

Some parking facilities can operate on both systems, with certain areas reserved for self-parkers and other areas served by attendants. This frequently occurs in older parking garages that were built for smaller cars.

The advantages of self-parking over attendant parking are considerable and appear to be controlling in most situations. These are reviewed in detail in Chapter Seven. For self-parking, the unit space must be larger, and double parking or aisle parking cannot be allowed. This reduces total capacity and hence possible revenue. These factors apply, however, only when the facility is used to capacity. It is likely that the very substantial saving in labor cost achieved through self-parking will more than offset the difference. Also, the single rows and clear aisles of self-parking facilities permit faster and safer vehicle movement. Insurance costs are usually lower with self-parking. Other advantages of self-parking are that the owner may lock his car, that it will not be handled by anyone but the owner, and that, with delays eliminated, the net time demand on the owner will often be less than under attendant operation. Experience in Chicago's Grant Park Garage has shown that about 87 percent of parkers prefer to park their own cars when facilities are adequately designed (*18*).

Parking Charges

In a revenue-producing parking facility, the charges levied can strongly influence use. A remote facility may be used by office workers (some walking as much as 2,000 ft) if the rates are attractively low. The phrase "low rate" is, of course, relative and depends usually on the size of the city and economic conditions of the area. All-day parking rates within 6 blocks of the major generators in Detroit have been one-fourth to one-third what are charged in New York. Yet the Detroit rate may be double the charge in Winston-Salem. Furthermore, the Winston-Salem parker would likely expect to park closer to his job than 6 blocks.

All parkers naturally prefer free space, and lacking this they look for the low rates generally charged at curb parking meters. When short time limits or other restrictions of such parking cause the driver to look to off-street facilities, his first choice is an open parking lot with the lowest prevailing rate that can readily be found near his destination. Rates and walking distances are strongly related.

A garage tends to be the last choice of drivers (other than regular parkers). There are several reasons for this reluctance. Garages in a given area tend to charge higher prices, for obvious economic reasons. Garages appear to be more complicated and less secure than open park-

ing lots. The ramps may be difficult for some drivers to maneuver. Time and effort are required to use stairs and elevators. This is particularly true for strangers and occasional users, since regular patrons soon become familiar with the facility. Garages also have an unfortunate history of delays in car delivery, which stems from older, attendant-park facilities having inadequate staff.

Because of the basic differences between garages and lots, any consideration of parking fees and the effects of competitive charges needs to be related to type of facility as well as to method of operation.

LOCATION OF CENTRALIZED FACILITIES

Proper locations for general-purpose parking facilities are essential if optimum use is to be gained. Whether free or commercial, the public purpose of the parking is to enhance local economic values, increase production, reduce street congestion, or attain combinations of these goals.

Factors that determine appropriate locations for individual facilities include degrees of parking shortages and types of nearby generators, facility user considerations (walking distances as related to parking charges, security, and convenience of access), development costs (land values as related to costs of alternate facilities), and street system elements such as capacity, directional flows, and turn restrictions. In addition, the total parking *system* of an area should be considered as it relates to overall needs, balancing of supply, and the street access network.

Areas of Parking Shortage

A comprehensive survey, as described in Chapter Five, develops information on local parking habits, parking generators, and existing parking facilities. It indicates the blocks of demand, the strength of the demand for each block, the geographical limits within which shortages exist, and the magnitude of the shortages. Detailed location and economic feasibility studies, however, may still be required for specific sites.

Location of a new facility too far from the actual area of shortage can result in limited use. In an eastern city, for example, one facility close to a shopping and office area has been regularly filled all day long, whereas another only two blocks away in a manufacturing zone reported only 50 of its 650 spaces in use.

The location and type of major traffic generators must be strongly considered if a new facility is to be of maximum service. Some centralized facilities serve a number of different generators, such as office buildings, stores, restaurants, hotels, and theaters, that produce use during the day and also the evening. Others, such as for auditoriums, sports facilities, and factories, receive more limited and special use. Facilities on the periphery of the CBD frequently perform only a single function —all-day parking for the downtown office workers—and are virtually empty at night.

The location of potential new generators also warrants careful attention. Consideration of any plans to provide parking for the new generators is needed as well as of any existing parking supply that may be displaced by the new development.

Facility User Considerations

Experience and studies quoted in Chapter Two have shown that the size of a city has a definite influence on the distance a parker is willing to walk to his destination. The smaller the city, the less distance the parker will walk. In very small cities, the business district usually is confined to the main street, the square around the courthouse, or, at most, two parallel streets and is not more than four or five blocks long.

In large cities, where the CBD represents a sizable area, fringe parking is less attractive and may be used only if there is adequate transit connection with the downtown area. Frequently, there are separated subdistricts of widely different characteristics such as shopping, theaters, market area, and wholesale district. In any case, there will be a substantial percentage of shoppers and other short-term parkers who will patronize only those establishments within a few hundred feet of the place where they can park.

In commercial districts, every potential parking site tends to have a "trade area" for short-term parkers produced by acceptable walking distances. The primary area is limited to a short block in all directions, whereas the secondary area may extend one block further. The possible area for employee parking is greater yet. As previously noted, however, any rates charged, the characteristics of the generators within the trade area, the kinds of parkers, and the location of other parking facilities must be considered. These elements affect both the size and shape of the trade area.

Where parking facilities are to be built in hilly terrain, locations are preferred that will allow pedestrian exits to be positioned uphill from major generators. It is also desirable for as many generators as possible to be visible from the pedestrian exits.

Locations that allow direct pedestrian connections to major generators are uncommon. The ideal form of connection is via enclosed bridge or tunnel. Such connections shelter the users from adverse weather and avoid conflict with street traffic. Pedestrian bridges offer more security than do tunnels. Adequate lighting and elimination of turns or blind corners are desirable for both types.

At-grade pedestrian routes also warrant consideration as a factor in parking facility site selection. Security needs may require special attention to be given to sidewalk lighting. From an accident standpoint, changes in traffic signal operation may be needed at nearby intersections to provide for an unusually heavy pedestrian movement. Midblock pedestrian crossings may be justified, and in some cases pedestrian signals are needed for control of the crossing. The feasibility of such traffic control measures depends on the type of street to be crossed, and this in turn may affect the desirability of a particular parking site.

Pedestrian considerations are so important and potentially critical that one of the objectives in parking system development, as well as in individual site selection, should be to minimize the conflicts to which the pedestrian will be exposed between the time of parking his car and the time of reaching his destination.

Relation to Street System

Location for a parking facility should include consideration of the major routes over which traffic approaches the area as well as the streets immediately adjacent to the proposed site. Major routes are usually located close to the business district serving both through and local-access traffic. Off-street facilities logically may be placed on the business district side of such routes.

New routes constructed to bypass the CBD often are freeways. Although location near a freeway generally means less driving time to a parking facility, consideration must be given to the precise route to reach the facility. Street systems near the freeway exits or entrances may be complicated or aided by one-way operation or turn restrictions. Figure 6.1 shows an arrangement where the operation is aided by the one-way streets.

Within a business district, corner locations are generally considered to be higher rent-producing locations and often should be reserved for business and shopping es-

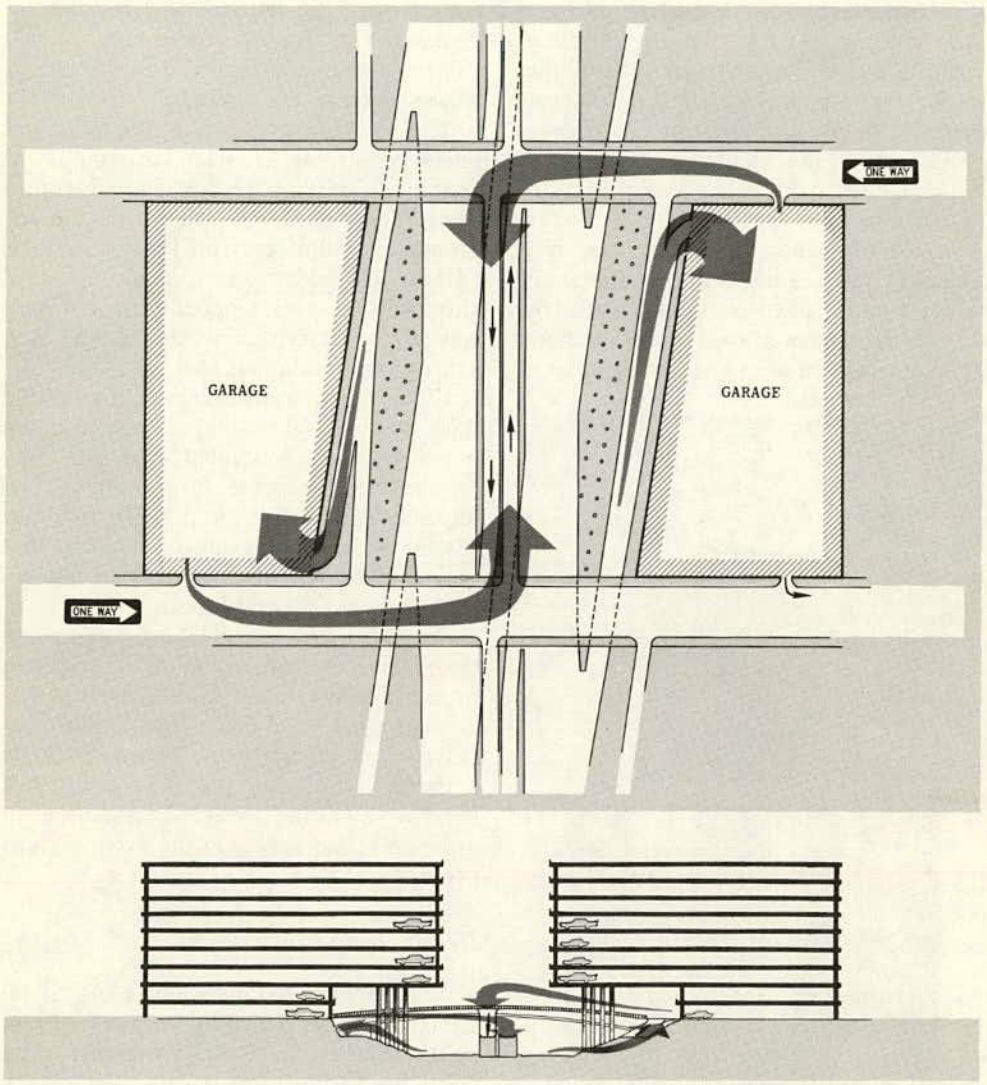


Figure 6.1. Example of how a long-term parking garage might be connected to a freeway. (Source: Barton-Aschman Associates for the Chicago Central Area Committee.)

tablishments. The less desirable midblock retail locations or the interior of the block often can be developed for parking facilities. However, corner locations have certain advantages for parking facilities because they offer alternate possibilities of locating entrances and exits on different streets. A disadvantage of a corner garage site is the difficulty of getting in and out caused by other vehicles at the intersection.

In locating entrances and exits, it is necessary to consider not only the traffic volumes and capacities of each street but also the capacities of nearby intersections. It is generally not in the public interest to allow construction of a parking facility whose access requirements would overload the adjacent streets and intersections. In this respect, the number and location of access points are of prime importance. (These details are discussed in the Driveways section in this chapter.)

The Court-Franklin garage in Buffalo's CBD has access on two separate one-way streets to facilitate ingress and egress by avoiding turning conflicts. (Source: New York State Department of Transportation.)

The location of existing and potential one-way streets is also an important factor. A parking facility should (other things being equal) be placed on the approach direction of streets leading into the CBD. An ideal arrangement involves entry into the parking facility from a one-way street carrying inbound traffic and exit onto an outbound route.

Changes are sometimes made in traffic flow patterns. Two-way streets become one-way, and directional reversals may be required at some future date. The location and design of parking facilities should be kept sufficiently flexible so that they may be operated even when unforeseen street changes take place.

Another street regulation subject to change is the prohibition of intersection turns. The left turn is usually the one that is controlled, and such restriction may strongly affect either the approach to or departure from the parking facility. A flexible operating design is essential in order to retain access in the event of turn prohibitions.

Development Cost Factors

Construction—It typically costs $1.00 to $2.00 per sq ft to fully improve—pave, light, mark, construct driveways and boundary protection—a lot. Multistory facilities cost $6.00 to $8.00 per sq ft to build, or $2,000 to $3,000 per space for conventional ramp garages and $4,000 to $5,000 per space for mechanical garages.

Underground garage construction often exceeds $4,000 per car space and may reach $7,000 or more. One such garage, projected for 1974 construction to include

a park on top, was estimated at $9,500 per car space. Ventilation and fire sprinkling systems usually required for underground garages add 20 to 30 percent to basic construction costs. Special waterproofing problems associated with a fully landscaped top increase costs still more. An additional factor concerns the cost of building the heavy load-bearing roof, which, unlike the conventional garage, is not used for parking automobiles. Typically, the cost of an underground garage is not optimized until at least four or five parking levels are constructed.

Land—Land costs for parking generally reflect competitive uses of surrounding properties. Where land is abundant and relatively inexpensive, surface parking lots are usually developed. At costs of over $5.00 to $10.00 per sq ft for land, multideck garages may be more economical per car space than open lots. For very high land costs, combination facilities with vertically mixed land uses (or with the ground floor leased to commercial or retail business) may be the most feasible.

Many cities have regarded public parks in the CBD as prime locations for underground garages. Because such garages are so much more expensive to construct than above-ground facilities, however, the "free land" advantages may be outweighed.

Use of Air Rights—Land costs may also be reduced or eliminated by building parking facilities in air rights above or below freeways. When an elevated freeway is to be built on a structure, the air rights below can often be economically developed for parking. When an elevated freeway is proposed to be built on fill, the

The famed Mellon Square in Pittsburgh illustrates how an underground garage and a park can be attractively combined. San Francisco's Union Square and Kansas City's Auditorium Plaza garage are of similar concept. Unfortunately, the problems of ventilation and waterproofing add considerably to the construction cost. (Source: Public Parking Authority of Pittsburgh.)

A garage utilizes air rights over this Omaha street to gain capacity and reduce pedestrian movements across the busy traffic route.

increased cost of building a highway structure with usable parking area below may be justified. When a depressed freeway is built through an area of high land value and high parking demand, the air rights may often be used economically for parking garages spanning the highway.

A study of 65 cities of over 150,000 population found that about half had freeways within 1,000 ft of the edge of the central parking demand area (*1*). However, only one city (Hartford, Connecticut) had the freeway within 1,000 ft of the CBD focal point of peak parking demand. It appears that most developments of air rights parking over CBD-area freeways would be for supplying parking to employees who are willing to walk the longer distances.

Public streets may also have parking facilities constructed above or below them close to areas of high demand. Furthermore, such structures may complement or tie together existing means of access and primary generators. An excellent example of such a concept is in Ann Arbor, Michigan, where the city constructed a 300-car garage over Maynard Street (*2*). The structure is anchored on one side to a department store and on the other side to an older 500-car garage. The reported cost was $4,300 per car space, which included major revisions to the older garage.

Railroads, canals, and rivers may also be spanned to provide parking. Janesville, Wisconsin, connected two existing parking lots on opposite sides of the Rock River by a 237-space deck in the CBD area. The parking bridge not only tied separate sections of the business area together but also was reported to have stimulated remodeling of the backs of adjacent buildings (*3*).

Multipurpose Buildings — In recent years parking facilities have increasingly been incorporated into multipurpose build-

This small city had a parking shortage, and its CBD had historically developed on both sides of the river. A treatment for both problems was supplied by this parking "bridge".

ings. Frequently large portions of the ground floor are devoted to retail establishments, and parking is located above or below ground level. Other floors may contain offices, clinics, hotels, or apartments. In such developments, the land cost chargeable to parking is greatly reduced. A severe penalty may be introduced, however, in the layout and operating efficiency of the garage. Practical column spacings for parking may not be economically acceptable for other building uses above or below the parking levels.

Such problems can be minimized by careful consideration of structural needs. A Howard Johnson Motor Hotel in Chicago was designed for 396 units to be located on top of a 10-story parking garage having 340 spaces (*4*). Furthermore, the self-service garage was designed for clear-span (column-free parking and aisle area) construction.

SURFACE PARKING DESIGN

Most of the basic principles of parking layout can be illustrated by a review of surface lot design. Stall and aisle dimensions and arrangements, horizontal circulation patterns, reservoir needs, and entry-exit revenue controls are similar for lots and garages. The special elements introduced by garages (columns, ramps, vertical circulation patterns, daytime lighting, and ventilation) are covered separately in the Parking Structure section in this chapter.

Relationship Between Design and Operation

The operation of a parking facility is greatly influenced by its design. The design elements and their associated operational features may be identified in successive steps as follows:

1. Vehicular access from the street system (entry driveway);
2. Search for a parking stall (circulation and/or access aisles);
3. Maneuver space to enter the stall (access aisle);
4. Sufficient stall size to accommodate the vehicle's length and width *plus* space to open car doors wide enough to enter and leave vehicle;
5. Pedestrian access to and from the facility boundary (usually via the aisles);
6. Maneuver space to exit from the parking stall (access aisles);
7. Routing to leave the facility (access and circulation aisles); and
8. Vehicular egress to the street system (exit driveway).

The simplest form of off-street parking is the single stall at a home. Assuming a straight driveway, steps 1 and 8 use the same lane and curb cut opening. Steps 2 and 7 are rudimentary. Step 6 usually involves backing out into the public street or alley, as part of 7 and 8. Herein lies the essential difference between low-volume parking and what generally should be practiced in facilities designed to handle more than two or three cars. Except along alleys, the larger lots should have all parking and unparking maneuvers contained off-street. Frequent backing of cars across sidewalks and into public streets increases congestion and creates hazards.

Stall and Aisle Dimensions

In developing the design of a parking facility, it is customary to work with stalls, aisles, and combinations called "modules." A complete module is one access aisle servicing a row of parking on each side of the aisle. In some cases partial modules are used where the aisle only serves a single one-side row of parking. This arrangement is inefficient and should be avoided where possible.

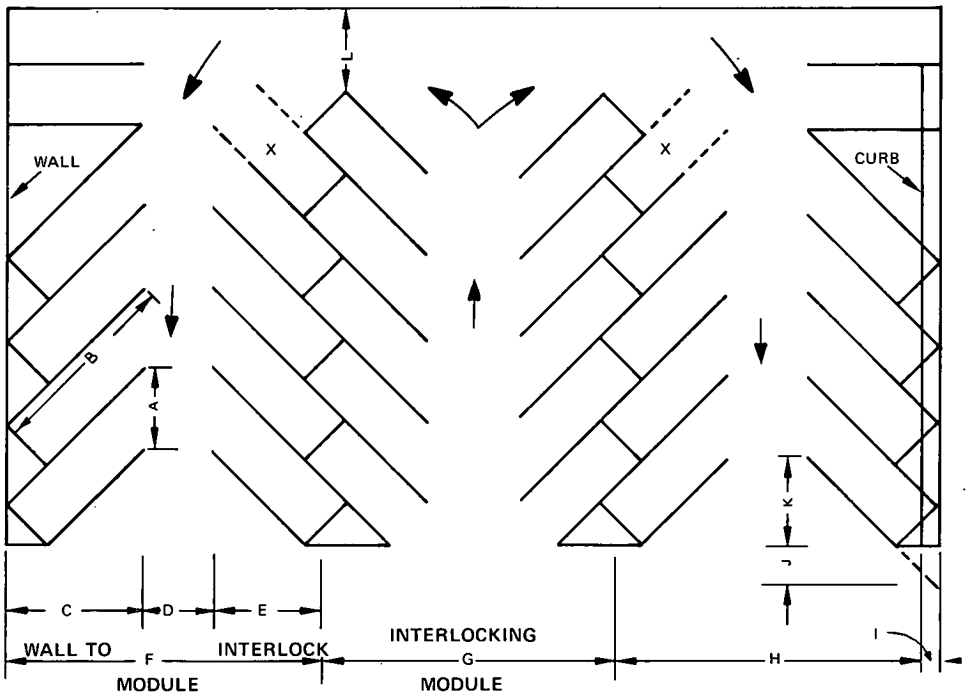
The minimum practical stall width varies principally with turnover (frequency of stall use) and the experience of the parker. Commercial parking attendants can park standard American cars in stalls as narrow as 8.0 ft, but 8.3 to 8.5 ft is a more common width. With self-parking, a width of 8.5 (for industrial or office employees) to 9.0 ft (for other public or residential users) is needed. If packages are customarily being placed in cars, as at supermarkets, stall widths of 9.5 to 10.0 ft are desirable.

The long-term trend in American automobile design has been toward increased width. Thicker doors and increased numbers of 2-door cars have been in vogue for many years. The practical limits needed for door opening space between cars, and driver or passenger access to the vehicles, combine to produce an optimum stall width of about 9.0 ft for most applications.

It is important to note that stall widths are measured *crosswise to the vehicle.* If the stall is placed at an angle of less than 90 deg, the width parallel to the aisle must be increased proportionately.

Many engineers are of the opinion that marking of substandard stall widths represents false economy. For example, an 80-ft row will typically park about 9 cars at 90 deg to the aisle. If the row is marked for 10 stalls of only 8-ft width, overriding tends consistently to take one or two stalls out of service. Although there is no increase in capacity by the substandard marking, there is opportunity for delay, confusion, irritation, and fender-bending.

The length of stall should be appropriate to the overall length of almost all cars expected to use the space. A length of



X = STALL NOT ACCESSIBLE INCERTAIN LAYOUTS

PARKING LAYOUT DIMENSIONS (in feet) FOR 9-FT STALLS AT VARIOUS ANGELES

Dimension	On Diagram	45°	60°	47°	90°
Stall width, parallel to aisle	A	12.7	10.4	9.3	9.0
Stall length of line	B	25.0	22.0	20.0	18.5
Stall depth to wall	C	17.5	19.0	19.5	18.5
Aisle width between stall lines	D	12.0	16.0	23.0	26.0
Stall depth, interlock	E	15.3	17.5	18.8	18.5
Module, wall to interlock	F	44.8	52.5	61.3	63.0
Module, interlocking	G	42.6	51.0	61.0	63.0
Module, interlock to curb face	H	42.8	50.2	58.8	60.5
Bumper overhang (typical)	I	2.0	2.3	2.5	2.5
Offset	J	6.3	2.7	0.5	0.0
Setback	K	11.0	8.3	5.0	0.0
Cross aisle, one-way	L	14.0	14.0	14.0	14.0
Cross aisle, two-way	–	24.0	24.0	24.0	24.0

Figure 6.2. Stall layout elements.

18.0 ft has served this purpose in past years, but a value of 18.5 ft is recommended by some engineers on the basis of increased automobile sizes.

These lengths refer to the *longitudinal dimension* of the stall. When rotated to angles of less than 90 deg, the stall depth perpendicular to the aisle increases to a maximum of nearly 20 ft and then decreases.

Most parking aisles serve for both circulation and access to stalls. Exceptions concern crosswise or "end-loop" aisles. The access aisle width required to allow single-pass parking and unparking maneuvers varies principally with the angle of parking and secondarily with the stall width. It is obviously also related to the stall length. When dealing with large facilities, most parking designers work directly with the combinations of stall depth plus aisle width, or modules.

For 90-deg parking, the aisle width can also be related to the practice of pull-in versus back-in parking. Typically, a driver backing into a stall requires about 4 ft less aisle width. Furthermore, the maneuver is easier to perform. Unfortunately, the majority of drivers (both male and female) are reluctant to back into parking stalls. For this reason, pull-in design is the norm for practically all facilities.

The total dimensions required for a parking module are produced by adding together the aisle width plus the stall depths (perpendicular to the aisle) on both sides. However, the *effective* stall depth depends on the boundary conditions of the module. If car bumpers contact a wall or fence on one or both sides, the maximum total module requirement is developed. If there is no boundary barrier of bumper height, but tires of parked cars contact wheel stops or curbing, the vehicle overhang must be considered. The curb must be set back. For 90-deg pull-in parking, the setback to the inner face (wheel side) of the curb should be about 2.5 ft. For back-in operation, a 4.0- to 4.5-ft setback of curbing is needed because of the greater rear overhang of typical automobiles.

These setback dimensions are not adequate to furnish complete protection to any fences or decorative walls located on the perimeter. Unusual overhangs may be found (such as "Continental" rear ends), and it is also possible for tires to ride up on or over the blocks or curbing. When positive limitation is required, a bumper contact barrier such as a structural wall or highway guardrail should be used at the end of the stall.

For parking at angles of less than 90 deg, front bumper overhangs are reduced in proportion to the angle and, for example, reach 2 ft at a 45-deg angle.

Another type of module, the interlock, is possible at the flatter angles. There are two types of interlocks. The more common and more preferable is the bumper-to-bumper arrangement shown in Figure 6.2. The other is the "nested" interlock; it can be used at 45 deg and is produced by adjacent aisles having one-way movements in the same direction. This arrangement requires the bumper of one car to face the fender of another car. Wheel stops are necessary for each stall, and, even with their use, the probability of vehicular damage is much greater than for other parking arrangements.

Table 6.1 lists desirable design dimensions for typical parking angles, stall widths, and modules. In practice, a more rapid parking operation will be achieved if the dimensions are increased. Slight reductions in the dimensions are also feasible for low-turnover parking such as by employees, apartment dwellers, and home owners. In garages, the modules are often reduced by 2 or 3 ft to minimize construction costs.

Narrowed stall width for parking angles of less than 90 deg is not desirable (*5*). There is a relation between stall width and

Table 6.1—Typical parking dimensions

Parking Angle (degrees)	Stall Width Parallel to Aisle (ft)	Stall Depth to Wall (ft)	Stall Depth to Interlock (ft)	Aisle Width[a] (ft)	Modules[b] Wall to Wall (ft)	Modules[b] Interlock to Interlock (ft)
45						
8.5-ft stall	12.0	17.5	15.3	13.0	48.0	44.0
9.0-ft stall	12.7	17.5	15.3	12.0	47.0	43.0
9.5-ft stall	13.4	17.5	15.3	11.0	46.0	42.0
60						
8.5-ft stall	9.8	19.0	17.5	18.0	56.0	53.0
9.0-ft stall	10.4	19.0	17.5	16.0	54.0	51.0
9.5-ft stall	11.0	19.0	17.5	15.0	53.0	50.0
75						
8.5-ft stall	8.8	19.5	18.8	25.0	64.0	63.0
9.0-ft stall	9.3	19.5	18.8	23.0	62.0	61.0
9.5-ft stall	9.8	19.5	18.8	22.0	61.0	60.0
90[c]						
8.5-ft stall	8.5	18.5	18.5	28.0	65.0	65.0
9.0-ft stall	9.0	18.5	18.5	26.0	63.0	63.0
9.5-ft stall	9.5	18.5	18.5	25.0	62.0	62.0

NOTE: These dimensions are for 18.5-ft long stall, measured parallel to vehicle, and are based on results of a special study to evaluate the effects of varied aisle and stall width for the different parking angles shown. The study was conducted in December 1970 by the Federal Highway Administration and Paul C. Box and Associates.

[a] Measured between ends of stall lines.
[b] Rounded to nearest foot.
[c] For back-in parking, aisle width may be reduced 4.0 ft.

aisle width, as shown in Table 6.1, but the stall width needs are basically determined by door-opening clearances. Only at very flat angles of less than 35 deg will doors open ahead or behind the cars in adjacent stalls, and even then there can be little reduction in basic stall width.

Special dimensions for small-car parking have occasional application in the United States. The percentage of such cars varies each year and also somewhat by geographical location.

The most suitable stall length for foreign cars is 15 ft. Table 6.2 gives several design dimensions for this length of vehicle, which may be compared with the recommendations for standard cars. It should be noted that only *very short* American cars (1970 Maverick and Hornet) will fit into such stalls. So-called compact cars such as the 1970 Valiant, Falcon, Mustang, and Nova require 16-ft stalls, whereas the 1970 Dart needs a 16.5-ft stall.

When used in U.S. facilities, substandard stalls for compact cars should generally be grouped, be convenient to use, and have some compelling attraction to small-car drivers (such as reduced fees at commercial facilities). The percentage of small stalls should be less than the percentage of compact cars expected because under most conditions the drivers will use some of the full-size stalls.

Because of the problems in attempting to predict potential numbers of compact cars and to control their parking, it is usually considered good practice to design

Table 6.2—Parking dimensions for foreign-size vehicles (15-ft length)

Parking Angle (degrees)	Stall Width (ft)	Aisle Length per Stall (ft)	Depth of Stalls at Right Angle to Aisle (ft)	Aisle Width (ft)	Wall-to-Wall Module (ft)
45	7.5	10.5	16.0	11.0	43.0
60	7.5	8.7	16.7	14.0	47.4
75	7.5	7.8	16.3	17.4	50.0
90	7.5	7.5	15.0	20.0	50.0

SOURCE: Adapted from "Design of Parking Garages for European Needs" (*5*).

NOTE: These measurements are *inadequate* for average American compacts. Each stall depth should be increased about 1 ft (2 ft total for the module) to accommodate the usual range of American compact sizes.

every stall and aisle to handle full-size cars.

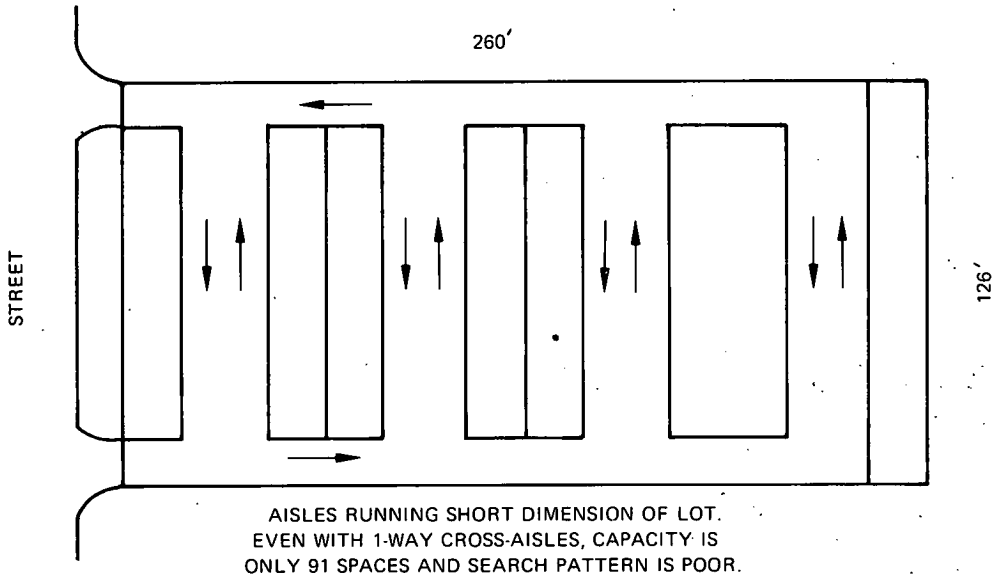
Layout and Circulation

Ideally, parking lots should be rectangular with cars parked on both sides of access aisles. For two-way traffic, 90-deg parking is generally used. This tends to be the most efficient layout if the lot size and shape are appropriate. Furthermore, the wide aisles are more inviting than the narrower ones used for space economy in flatter angle layouts.

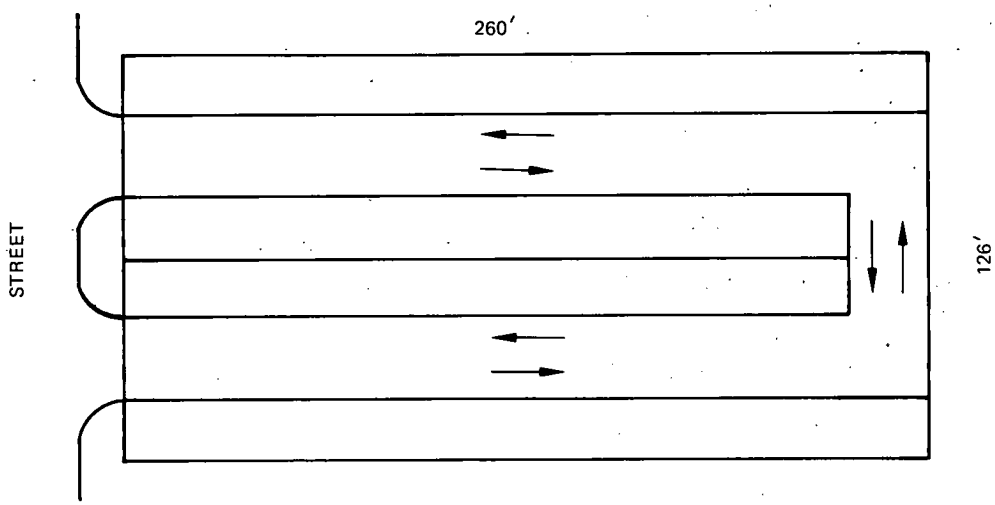
By 1970, the number of licensed women drivers reached approximate parity with men. Much concern has been expressed over difficulties that women have had in maneuvering into 90-deg parking stalls. However, over 85 percent of the cars produced in the United States during the 1969 model year were delivered with power steering. Unquestionably, parking at *any* angle is made easier with this power assist.

Much of the alleged difficulty with 90-deg parking has stemmed from inadequate aisle dimensions. Where proper measurements are used, a smooth and efficient operation can be achieved. As Welch has stressed, there are at least eight advantages in 90-deg layout for shopping center parking (*6*). Half of these advantages deal with the greater convenience to the parker, and the others relate to safety and operating efficiency. For example, at parking angles of less than 90 deg, the aisles are normally one-way. Sometimes this is desirable, but "regimentation" of traffic flow within a parking facility should be minimized. Furthermore, the narrower one-way aisles do not provide room to pass a standing or waiting vehicle. The one-way aisles require drivers to circulate at least once next to the principal buildings during the pattern of entry and exit. This increases conflict with pedestrians in the lot and causes unnecessary congestion. It also requires driving greater distances within the aisles past other parked vehicles and increases the accident potential. Such problems are reduced with 90-deg parking. Other advantages, as compared with lesser parking angles, include better sight distance at aisle intersections, fewer aisles (hence easier locating of a parked vehicle), and better approach vistas of the shopping center buildings because of the wider aisles.

The relative efficiencies of various parking angles may be compared by the number of square feet required per car space (including the access aisle on a full mod-



AISLES RUNNING SHORT DIMENSION OF LOT.
EVEN WITH 1-WAY CROSS-AISLES, CAPACITY IS
ONLY 91 SPACES AND SEARCH PATTERN IS POOR.



AISLES RUNNING LONG DIMENSION OF LOT.
CAPACITY IS 110 SPACES WITHIN SAME AREA,
AND SEARCH PATTERN IS EXCELLENT.

Figure 6.3. Lot layout and circulation alternates.

ule layout). Where the size and shape of the tract is appropriate, a 90-deg parking layout tends to require the smallest area per car space.

In typical lot layouts, the average overall area required (including cross aisles and entrances) will approximate 350 sq ft per car. There is no significant reduction in required area by using narrower stall widths; however, a very flat angle layout is significantly less efficient than other angles.

Many conditions exist where one-way aisles are desirable. With angles of less than 90 deg, drivers can be restricted to certain directions; however, the angle should usually be no greater than 75 deg to avoid drivers going the wrong way. Adjacent aisles generally have opposite driving directions. Any multiple of modules can be used, depending on location of entrances and exits and the size of available land. However, at angles below 45 deg and with interlocking stalls, the module dimension becomes too small to allow U-turn access between adjacent aisles by standard-size cars.

Regardless of the parking angle, the most efficient arrangement is usually found with aisles parallel to the long dimension of the lot. Relative efficiencies of two layouts in the same total area are shown in Figure 6.3. There is a 20 percent difference in capacity.

The most desirable internal circulation is one in which each potentially vacant parking stall within a small lot or segment of a larger lot must be passed once by the incoming patron seeking a space. This ideal is seldom attained, and most lots are arranged so that a driver must circulate on a random basis until he finds a vacant space.

On exit, the driver should have to pass the minimum number of occupied spaces. Entrances and exits should, however, be kept to a minimum, consistent with capacity and circulation requirements.

Having driveways at opposite ends of a parking lot tends to reduce conflicts between incoming and outgoing cars, but complicates revenue control. At entrances, care should be exercised to prevent backups onto the street. Ordinarily, a well-designed parking facility can accept arriving cars as quickly as the street system delivers them. Aside from acceptance rate limitations caused by revenue control measures, the principal causes of entry delay are sidewalk conflict with pedestrians, parking or unparking maneuvers close to the entrance, and conflicting internal circulation, including vehicles waiting to exit.

Because driveway entrances to surface parking lots are at the same grade as the public sidewalks, it is generally impossible to avoid pedestrian conflict. The problem can sometimes be minimized by locating driveways on streets having lower pedestrian volumes and at points upstream from the heaviest pedestrian flow. Pedestrian conflict can be reduced if the driveways are located on peripheral CBD access streets and pedestrian entrances are on the side of the facility nearest the generators.

It is good practice to prohibit stalls so close to the entrance that unparking maneuvers would require backing into the sidewalk or obstructing inbound traffic. Depending on the size and turnover of the facility, several stalls near the entrance may best be kept out of active use; however, this is more of an operational than a design element.

Internal circulation and exit arrangement is a mixture of design and operational elements. As reviewed in the Driveways section in this chapter, narrow driveways may create unnecessary conflict.

Parking lots that charge a fee often control their revenue by issuing tickets at the entrance. If a ticket-dispensing machine is used, a very small (one or two spaces) reservoir within the lot should be ade-

quate. If the tickets are manually dispensed, a larger inbound reservoir is needed; however, this is highly dependent on the size (capacity) of the lot and its parker characteristics. Unfortunately, many smaller, high-turnover self-parking lots have cashier booths located adjacent to the public walk. The one-space reservoir thus provided is often inadequate.

Where parking is done by attendants, an inbound reservoir area of sufficient size to hold 5 to 10 percent of total lot capacity may be needed. Such designs are seldom found, and congestion-causing backups into the street are common experiences.

Construction Elements

Unless stall markings are used, parking layout will be difficult to enforce, and inefficient use of the area will result. Markings typically require some type of permanent surfacing. A paved surface has advantages in allowing proper drainage, reducing dust, facilitating snow removal and sweeping, providing an improved walking surface, reducing maintenance costs, and presenting a more pleasing appearance.

White is normally the best color for marking stall lines, with yellow used only in the nationally accepted "no parking" context. Yellow cross-hatching is most effective, for example, if other lines are white. In a garage with a portland cement concrete surface, however, yellow lines offer optimum contrast.

All lines should be 3 to 4 in. in width. Many owners have painted double lines between stalls and are of the opinion that this causes drivers to center their cars better within each stall.

In general, the ends of parking stalls within lots can be marked in a satisfactory fashion by only a paint line. Wheel stop blocks or curbing in the interior of a lot have many disadvantages; they may interfere with and present a hazard to people walking between cars, provide traps for blowing debris, and interfere with snow plowing in northern areas.

High-demand use for a gravel or cinder surface lot can result in parking chaos. Paving and marking of stalls will help to develop an effective facility.

Raised pedestrian sidewalks are sometimes used in large parking lots to separate rows of cars and to provide more favorable walking conditions. People walking to and from cars most often use the aisles, however, and the value of interior walkways is debatable.

At the ends of parking rows, drivers must circulate toward exit drives or continue searching for vacant stalls. The normal right-angle turn by a typical passenger car driver requires an inner radius of about 18 ft. During the turn, the vehicle sweeps a path some 11 ft wide at its extreme. The ends of parking rows in high-turnover lots can be treated with painted or curbed islands. A design for a 90-deg and a 60-deg parking layout is shown in Figure 6.4. A curbed island serves the following functions:

1. Limits parking encroachment into cross aisles;

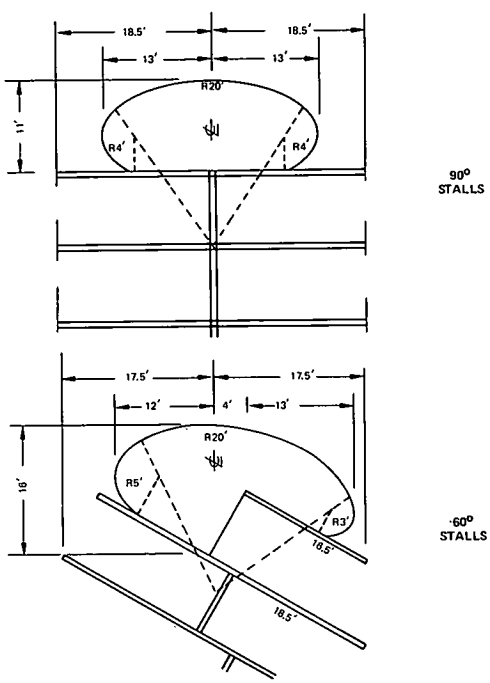


Figure 6.4: Examples of end-islands for 9-ft stalls.

2. Opens up sight distance at intersections of cross aisles with access aisles;
3. Provides a comfortable turning radius;
4. Provides a cart storage area at supermarkets;
5. Stores limited quantities of snow;
6. Protects directional signs and allows light pole locations; and
7. Allows aesthetic plantings to avoid a "sea of paving" appearance.

Where a parking lot abuts a public sidewalk, it is usually necessary to provide some type of boundary barrier. This can be wheel stops, curbing, guardrail, low walls, or fencing. If blocks are placed less than 2 or 3 ft from the sidewalk to restrain parking at angles of less than 90 deg, the blocks should be butted to form a continuous line. Otherwise, wheels of cars parked at incorrect angles can run between blocks and allow substantial encroachment into the public walk.

As discussed under Construction Details in Chapter Three, boundary controls that are higher than about 24 in. should not be allowed along streets having exit driveways or near intersections unless an 8-ft boundary setback from the public walk is used. Sight obstructions to entering traffic, and to that circulating within the lot, should similarly be avoided.

Landscaping is desirable, but should be limited to ground cover, low hedges, and trees whose lower foliage begins at least 6 ft above ground. The positioning of trees should be coordinated with the less flexible locations required for signs and lighting fixtures.

Adequate lighting is of paramount importance. Ample mounting height and proper ratios of spacing to mounting height should be used to distribute acceptably uniform amounts of light to the entire facility. Use of luminaries or spotlights of a sufficient intensity to illuminate all dark corners and areas between cars is desirable but generally impractical. The normal

application is a level of 1.0 to 2.0 foot-candles with a uniformity ratio (average illumination divided by the lowest point) not exceeding 6:1. Poles range from 20 ft to 50 ft or more in height. If spotlights or floodlights are used, care should be exercised to minimize glare in the lot or on the street. Excessive spillover light on adjacent residential property should be avoided.

Pole locations should, of course, be coordinated with stall and aisle layouts. Where practical, poles should be kept at ends of parking rows. This allows flexibility for possible future changes in stall widths or layout. Where pole locations are required within parking rows, they should be at the junctions of adjacent stalls. This usually will not affect the parking capacity of the initial stall width design layout.

In many cases, interior signs giving directions or aisle identification can be attached to lighting poles. Where separate poles are used, the same principles of location apply.

If a parking fee is collected, or if meters are employed, clearly marked and conveniently located signs indicating the conditions should be displayed at the entrance. These signs should be mounted sufficiently high (at least 5 ft to bottom) to allow drivers to see under them.

The lot pavement should have sufficient slope to drain properly. A minimum grade of 1 percent for asphalt and 0.5 percent for concrete is desirable. Grades should not generally exceed 3 percent in directions longitudinal to parking stalls or 5 percent for cross-slopes or aisles.

Maintenance

The principal element of lot maintenance is cleaning. Markings and signs should be repainted as required for good visibility. Light fixtures should be cleaned at least annually, and lamps should be replaced prior to burnout.

Snow removal in northern climates is an additional problem. Snow cannot sim-

Adequate signing is essential to direct parking traffic efficiently.

ply be pushed into the streets; it must be removed by truck, stored in nearby areas, or melted. Storing snow on the lot is doubly expensive in "pay" facilities, because the loss of revenue from spaces devoted to its storage must be added to the cost of moving the snow.

Melting has been successfully employed in some facilities. Oil and gas-fired snow-melting equipment, both stationary and portable, is now available. Electric coils or pipes for heated fluids can be buried in the surface, or radiant heat sources (electric or gas) can be installed overhead. These have optimum application at entrances or exits.

Salt and other chemicals have been used extensively in some areas to lower the melting point of snow and ice and to facilitate subsequent runoff as water. These materials can harm unprotected concrete surfaces. Protective coatings, applied soon after construction, can help to reduce the corrosive effects.

PARKING STRUCTURE DESIGN

Types of Garages

Garages may be classified in three ways. One method involves their vertical location (underground or above grade). Another method concerns the type of vertical vehicular handling (ramps, sloping floors, or elevators), and the third involves the person who parks the car (attendant or car owner).

Within each general classification, there may be several subgroups. A garage may be built into a hillside, for example, and thus have some underground and some above-ground characteristics. A garage may begin several stories above ground and thus use "express" type ramps for entrance as well as for exit.

Numerous means of interfloor travel exist, and the type of ramp system will invite subclassification based on this distinction alone. Some garages use attendants to park cars part of the time, or in one portion of the structure, whereas the balance operates on a self-parking basis. A few garages allow free public parking and thus have different access and egress criteria from the majority, which must use revenue control.

The science and art of *efficient* garage design is far too complex for anything beyond cursory review in this chapter. A fundamental text was developed in 1948 and updated by Ricker in 1957 (7). Trends since then have included wider stall needs, decreased consideration of either attendant park or mechanical type garages, and broader application of clear-span, column-free construction. Portable or demountable structures have appeared, and computerized revenue and traffic control systems are now in use.

Experience has demonstrated that functional design of all but the simplest garages should be handled by specialists. Some knowledge of basic garage features, functions, and limitations is needed, however, by administrators, engineers, and architects.

Underground Parking — Underground garages present special problems of construction that make them as much as twice as expensive per car space as garages built above the ground. Extensive excavation and relocation of public utilities contribute to the higher cost. The artificial ventilation and daytime illumination required, groundwater, and other drainage problems also add to the cost. The greatest single problem in underground garages is usually water. Seepage from the roof (or through a park area) can result in structural and operating difficulties if adequate measures are not taken. Water may also enter from the walls or up through the bottom floor slab due to hydrostatic pressure.

The underground garage may use a variety of ramp or sloping floor arrangements.

This is an express-type exit ramp cantilevered out from the structure. A pedestrian skywalk has also been provided to connect with the fifth floor of the office building at extreme right.

Ramp Garages—Parallel garage floors may be connected by straight or circular (spiral or helix) ramps. These may operate up or down, one-way or two-way. In small, very-low-turnover garages such as for apartment buildings, short one-lane-wide ramp sections can even operate on a reversible two-way basis.

The sloping floor garage has parking on each side of the aisle, which thus acts for circulation, rise, stall access, and stall egress. Separate down ramps are frequently provided for "clearway" or express exit.

Mechanical Garages — Almost every year a new and often fanciful idea for the mechanical handling of automobiles is introduced. Although some manufacturers of parking devices claim 1-minute delivery of a car, few in actual practice achieve this speed. But sometimes mechanical parking garages are the only parking facilities that can be built on narrow, expensive lots; they can make good use of the land by stacking cars as high as 10 or 12 levels above or below ground and they employ fewer people than an attendant-park garage of the same capacity. However, they typically create heavy backups on the streets because of their limited or nonexistent reservoirs. It is almost impossible to erect these garages with entrance and exit reservoirs large enough to handle the large traffic volumes that their very nature requires. The consequences are long delays for the customers and traffic backed into the streets.

It should also be pointed out that these garages have been subject to mechanical failure and high maintenance costs. Replacement or repair of vital parts is often difficult, expensive, and subject to delays. Parts may have to be specially made.

Temporary Structures—One of the recent innovations in the parking field is the demountable structure. One type employs precast concrete deck panels on a steel frame (*8*). Another type is all steel. A third type uses precast, post-tensioned concrete modules (*9*). These structures can be erected as (a) an interim or temporary use of land, where a master plan dictates a denser future use but where demand presently exists for parking in excess of available surface spaces; (b) on leased land; (c) in air rights space; and (d) over existing high-volume parking lots.

Construction Factors

Various methods of construction are used in conventional parking structures. The three most popular methods are

poured-in-place concrete, precast concrete, and steel. All can be used in either long- or short-span construction.

Long-span, or "clear-span," construction is currently the preferred design primarily because of its great efficiency of parking layout and its adaptability to changes in future automobile dimensions. It provides column-free parking and better visibility on each floor.

Figure 6.5 shows two similar parking layouts on a 110- by 300-ft site (exclusive of spiral down-ramp). The short-span structure parks only 98 cars whereas the long-span design accommodates 111, or 13 percent more. Historically, there has been a slightly greater construction cost for clear span, but the difference has been decreasing. One authority has reported over 500 garages planned by his company during the period 1953 to 1970, with *all* of them recommended for clear-span design (*10*).

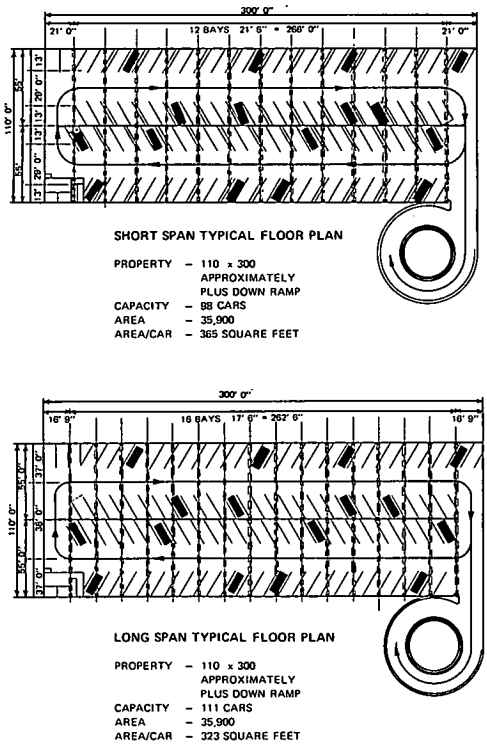


Figure 6.5. Comparison of efficiency, short versus long span. (Source: Adapted from "Methods of Construction and Construction Costs," by Richard C. Rich and Associates, for National Parking Association, 1966.)

One major advantage of short-span construction (30 to 35 ft column spacing) is that it more readily permits the erection of an office building, apartments, or other structure above the parking deck. Short-span construction also allows shallower beam depth and a reduced floor-to-floor dimension. In areas with severe zoning code height restrictions, 1 or 2 ft may be critical.

Precast concrete is adaptable to parking structures of both long- and short-span construction, and its use can often reduce the cost and time of construction. However, there is usually considerable delay at the mill where special forms have to be built, and little overall calendar time is saved. Precast may lose its price advantage to poured-in-place concrete when there are many different shapes and sizes of beams and panels to be cast. Depending on local wage rates or distance from the mill, precast and cast-in-place may be priced almost the same.

In some sections of the country, and under certain height and area restrictions, garages built with structural steel may be advantageous. Oppressive fire codes have been responsible for the relatively higher cost of these buildings in the past, but the codes are being modernized.

Circulation and Ramp Systems

The simplest above-ground garage may be a single deck supported by columns above an existing parking "lot" and with the two levels connected by one or more straight ramps. When the ground-level spaces lost by columns, stairs, and especially ramps are considered, however, construction cost is extraordinarily high if

This garage is typical of modern construction. It has long spans, self-parking, and a readily comprehensible traffic circulation plan. (Source: South Carolina Highway Department.)

expressed on a per-*added*-stall basis. If additional floors are built, with ramps stacked vertically, the per-added-stall cost decreases significantly.

The vertical circulation system for vehicles, regardless of whether it is ramps, sloped floors, or combinations of the two, should be as simple and comprehensible as possible to the driver. In larger garages (over 200 spaces) of sloped-floor design, one-way aisles are often used. Directional signing and circulation to floors having vacant stalls, or to exits, is often simplified by one-way aisles. Counterclockwise rotation is desirable for American drivers, because their left-side seating allows direct view of inner (left) obstructions at ramp turning points.

With one-way aisles, parking angles of 45 to 75 deg are used. These angles need lesser modules (see Table 6.1 for applicable clear-span dimensions), and hence shorter spans can be used.

Sloping-floor garages often use express down ramps for exit. These ramps are sometimes suspended on the structure sides, or spiral loops can be built in separate connected structures as well as within or at the end of the parking decks. Exit traffic can also be handled by other sloped floors with adjacent parking on the floors. This can utilize almost every square foot of the structure for maximum efficiency but is generally avoided in high-turnover garages.

Where parking floors begin some distance above grade, express-type ramps are often employed for both entrance and exit. The parking garage for the New Haven Coliseum is constructed above the arena. It is entered and exited by helical ramps in separate silos. Macy's Queens

department store parking rings the retail core and is also reached by helical ramps in silos.

Ramps may connect to each parking level or to alternate levels. The helical ramp is sometimes designed so that it drops two floors in one 360-deg turn, with access from each floor. Especially in the higher garages, two helical ramps may be constructed concentrically so that one ramp takes cars from the even-numbered floors and the other ramp from the odd-numbered floors with a drop of two floors each per turn. Five complete turns is considered by some designers to be the practical maximum for circular ramps serving self-parkers.

It is possible to build ramps two lanes wide, with one lane handling upward traffic and the other downward. This has the disadvantage that cars may have to cross over the opposing lanes upon entering or leaving the system. An alternative is two one-way ramps, one for each direction, located in the same core.

In the continuous double-floor system, connection is often maintained through crossovers at each floor so that a driver finding one system full or crowded may cross over to the other system and attempt to find a parking place sooner, or to exit without traversing other floors.

A sloped-floor parking structure should be limited to six continuous circuits, or revolutions, or 600 cars per unit because studies have demonstrated that drivers tend to become confused and irritated by repeated turning and driving past occupied parking spaces.

Examples of several possible arrangements for both sloping-floor and ramp-type garages are shown in Figure 6.6.

Layout Dimensions

Much of what has been said about surface parking arrangements applies to garages also. Ease of internal circulation for vehicles and pedestrians is the single most important factor affecting floor and ramp layout. From the standpoint of conceptual arrangements, parking decks should be considered as rectangular areas consisting of multiple modules sized to fit within the site dimensions. Although the parking angle can be adjusted to develop the most appropriate modular sizes, it is not always possible (nor necessary) to use all of the land in a given site. Inefficient structures should not be built merely to cover available land.

Stalls and aisles in a structure should be designed so as to comply with the parking need. In high turnover parking, the structure should have dimensions similar to those of a surface lot. Wide aisles will reduce the car capacity, but easy accessibility can offset this by allowing faster operation. For longer-term parking, aisle widths can be decreased slightly. An efficient parking garage may use a portion for transient parking (it may be the major portion of the structure), and the remainder may be used for long-term or monthly parking.

The maximum preferable grades for sloped floors are 3 percent to 4 percent in self-service facilities and 10 percent in attendant-park garages. A large (60 deg or greater) parking angle is desirable to minimize gravity roll-back if brake slippage occurs.

Ramps should have flat enough grades so that drivers using them do not get a feeling of insecurity. Ramps should be constructed to be skid-free. Grades exceeding 10 percent have proved to be hazardous when wet. Steep ramps slow up traffic because the driver exercises more than the normal amount of caution. Maximum ramp angles for attendant-parking range between 15 and 20 percent.

Where a crossover occurs between two driving paths of a parking deck, or a ramp joins a parking level, a change in driveway surface planes occurs. The angle formed is

called a "breakover." The change of angle should not be too sudden; if it is, the ends of the car or the center section will scrape on the floor. A good rule of thumb is to make the transition grade half the ramp grade, with a minimum blending distance of 12 ft and with the intersection points rounded.

In general, ramp widths of 14 to 18 ft are needed in circular ramps and at entry turns to straight ramps. Along straight runs narrower widths of 11 to 12 ft can be used.

The minimum radius for the outer wall of a circular ramp or other turning path is 32 ft. A greater dimension, such as 35 to

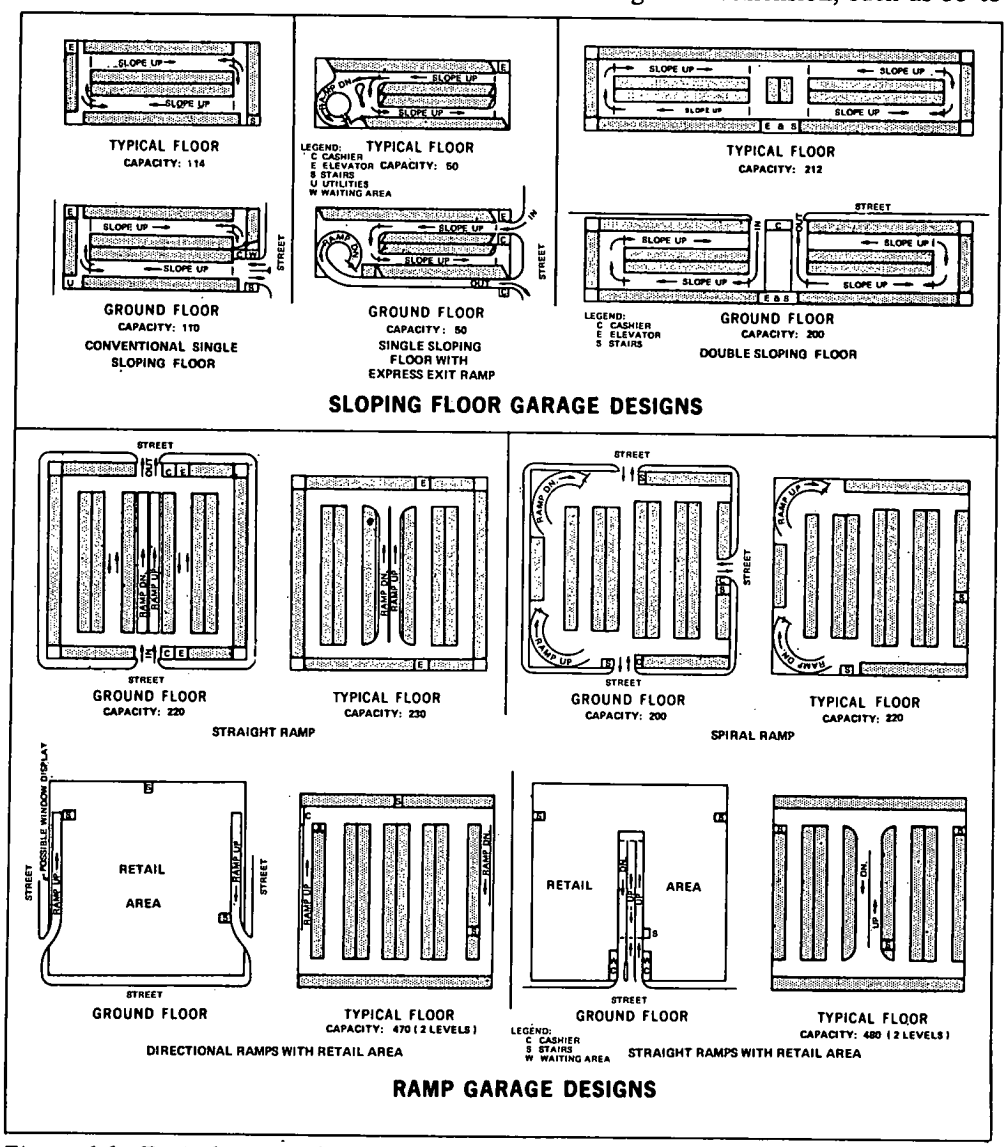


Figure 6.6. Typical garage designs. (Source: Wilbur Smith and Associates, "Parking in the City Center.")

37 ft, is desirable for spiral ramps with many turns. Superelevations of ½ in./ft are used. Grades are measured along the outer wall.

The recommended vertical clearance in a parking structure, including ramps and the first level, is 7.0 ft. This typically produces a 9.5- to 10-ft difference of floor-to-floor elevation.

Reservoir and Access Needs

Facilities that require drivers to stop upon entry should have a reservoir space available inside each controlled entrance so that cars can pull off the street before stopping. If a self-parker is to be issued a ticket, the pause should be made inside the facility rather than on a sidewalk or street outside. Two or three reservoir spaces are usually required per lane.

During heavy peaks cars will frequently line up alongside the curb leading into the attendant-park garage. This can be reduced by providing substantial inbound reservoir space.

Exit reservoir space is also important if the parker must pay a parking fee to a cashier on his way out. This transaction is usually longer than that of picking up a ticket. Therefore, a substantial exit storage area is necessary to eliminate a jam or delay within the parking structure itself. This tie-up can be reduced by installing more attendant booths to speed up the operations; however, this involves higher wage costs and the use of more space within the structure. Exit reservoir space is usually provided by backup within the circulation aisles themselves.

When a garage is built on a sloping site, it is often desirable to locate entrance and

Wide entrance area on a one-way street is a feature of this Buffalo municipal garage. The high capacity afforded by multiple lanes, each with interior reservoir space, reduces probability of backup into the street. (Source: New York State Department of Transportation.)

exit points at various levels. This tends to improve external access and may also reduce internal ramp construction needs. In a cashier-controlled garage, however, it is usually necessary to interconnect multiple exit points to allow collection from a single point during slack hours.

Ideally, garages should be able to fill or empty completely within 1 hour or 60 percent in ½ hour. This rate of flow is most needed for surge-type activities such as sports events.

Well-designed ramps connecting between floors have a capacity of 500 to 600 cars per hour per lane. In fact, as many as 660 vehicles per hour have been counted to enter through automatic ticket dispensers under conditions of constant waiting lines (*11*). A typical maximum design capacity is 400 vehicles per hour. However, *exit* through a cashier operation at a stationary booth has a rate of only 150 to 200 cars per hour per cashier. This can be greatly speeded up by prepayment at remote booths prior to unparking. In this operation, the ticket stub is then surrendered at the exit driveway.

In general, garages need two exit lanes for each entry lane. It is desirable to arrange lanes so that reversible operation can be used at peak outbound and inbound periods. The flow can be facilitated by use of green and red lights over each lane. This arrangement also allows an "all-red" display when the garage is full.

Pedestrian conflict on adjacent sidewalks can seriously interfere with exit from a garage. In areas of high pedestrian activity the cashier booth ideally should be located several car lengths within the structure in advance of the sidewalk.

Pedestrian Travel

Both vertical and horizontal pedestrian movements require attention during the design stage of a garage, just as they do during the location planning. Travel between floors is generally via stairs or elevators. The strictest of the national building codes have in the past required that the nearest exit doorway (which in a multilevel structure may lead only to a stairway) be located no more than 100 ft in the line of travel from any car.

Good design requires a minimum of one elevator in a garage of over two levels, preferably located nearest the major generator. Need for additional elevators depends on several factors: number of floors, number of cars, and type of parking (all-day or transient). Two elevators may be adequate for a 5-level, 500-car deck serving a department store that has a fairly uniform flow of traffic all day, but they could not accommodate the early morning and late afternoon surges in an employee garage of the same size.

Escalators use up a larger floor area than elevators. Because escalators cost more (several times the cost of elevators for the same rise), they are recommended only where there is an extremely high volume of traffic at peak periods.

Direct horizontal connections can sometimes be made by bridging between parking decks and nearby generators. This is a highly desirable arrangement, but it must also have stairs and elevators planned for suitable access from other parking levels.

Services and Equipment

Lighting and User Security—Adequate lighting is essential within a structure to provide for safety (to avoid both vehicular and pedestrian accidents), to gain maximum operating efficiency, and to promote user security. Entrance areas should be provided with 50 footcandles for the first 10 seconds of driving time inside the structure. Aisles should have 10 footcandles and storage areas 5 footcandles.

In the above-ground structure, and depending on distance from adjacent buildings, much of the needed illumination

This parking garage is connected by pedestrian bridge to a department store. The overhead crossing is preferable to a tunnel.

near the perimeter will be provided by natural daylight. To reduce vandalism and theft and for the safety of customers, artificial illumination is needed for inner areas away from sunlight and in all areas during night operation.

Feelings of personal insecurity are particularly prevalent in underground garages. Good lighting is one of the most helpful measures.

Closed circuit television (CCTV) offers a possible measure of security. Monitors mounted in the manager's office or in the cashier's booth are linked to cameras on each floor. The camera may act as a deterrent to the molester and assure the patron that someone is watching out for his or her safety. However, the Garage Design Committee of the International Municipal Parking Congress has reported CCTV to be of doubtful or marginal security value. A high likelihood exists for criminal attacks to occur outside the range of cameras (between cars, or in stairwells or elevators). Problems of monitoring the screens include added labor costs and attendant distractions if a cashier is being asked to monitor as an added duty.

An audio monitoring system can be used as an alternate or supplement for television surveillance. Microphones can be placed about the garage, and the location from which a call for help comes can be noted.

Ventilation and Heating—Because most above-ground parking decks are of open design, they rarely present a ventilation problem. In very large garages it is possible, under certain climatic conditions, to have insufficient circulation of air in the interior portion to diffuse the noxious gases.

In an underground garage care must be taken to see that it is well ventilated and that the air is changed frequently, depending on use and climatic conditions. Typical building codes require four or more air changes per hour with mechanical exhaust-

ing (*12*). Other codes require 1 cu ft of exhaust air per square foot of floor area, plus an equal amount of fresh air to be supplied mechanically.

However, some authorities feel there is no rule of thumb that can indicate how many changes of air per hour are needed for an underground garage because of the different operating characteristics of each building. In some cases three changes of air per hour have been found to suffice, whereas in other locations as many as 14 changes have proved to be insufficient. A standard of eight changes of air per hour has been tried, but this has proved to be inaccurate on many occasions. Proper ventilation must provide for positive exhausting of carbon monoxide and noxious exhaust gases from the garage, and this can only be done by introducing fresh air at one location and exhausting the stale air at another. A simplified flow system of air through the garage has proved most successful. The carbon monoxide level has not proved to be a serious problem as the quantity of noxious foul-smelling exhaust gases usually reaches an intolerable stage long before a harmful amount of carbon monoxide is present. Garage design should prevent accumulation of a carbon monoxide level in excess of 100 parts per million.

Very few structures include heating of the parking area. The modern car is engineered to withstand cold (as contrasted with the cars of the 1920s when the first garages built were enclosed and heated). Some parking garages in extremely cold climates will provide electric outlets and cords at each parking place that can be plugged into the owner's engine heater, but for the most part, the only heat in garages will be found in the manager's office, cashier's booth, or customer waiting area.

Fire Protection—Many building codes require that any storage built beneath the ground surface must have water sprinklers. This blanket provision is made regardless of the use for which the building is intended. More than half of the major underground garages built recently have been built without fire sprinklers. Fire experience has shown that underground garages are extremely safe buildings, and cases of fire are almost unknown. Calculation of the available combustible material in the garage, assuming automobile and gasoline services are not provided, will show that the average underground garage is far safer than the private home. For this reason, many city building boards of appeal have permitted underground garages to be built without sprinklers.

The incidence of fires in above-ground parking structures is also very low. Fire extinguishers at convenient locations are considered sufficient by some designers. Where steel framing is used, most codes call for fireproofing the frame, which radically increases the construction cost.

Most building codes classify an open parking structure as a distinct building and require that at least 50 percent of two sides be open. For this reason, sprinklers (and mechanical ventilation) can be eliminated and distance to exit can be increased for this type of structure. In a sloped-floor design, with an express-exit ramp, the exit ramp itself provides an escape to the outside. It is possible in some cases to include the exit ramp as one of the two required exits.

Unrealistic elements of local building codes have in large part developed from problems in repair garages (with many combustible materials), enclosed parking structures, and, of course, facilities having living or public assembly quarters housed in the same building. Proposed building code provisions for modern structures used *exclusively* for parking cars have been prepared by the American Iron and Steel Institute (*13*).

Signing—There are three general functions of signs for a parking structure: (a)

to guide drivers to the facility, (b) to direct them to parking inside, and (c) to get them out again. Signs located *outside* the building serve to identify it as a parking structure, to inform drivers as to who can use it (general public or only visitors, customers, or employees of specific buildings), and to notify the potential users of the rates charged, if any.

Within the structure, signs are needed in two general categories—directional and informational. The former category includes guidance to specific floors or areas of the garage and to exits. The latter type of signs is used to inform drivers of needs for special actions (no parking in certain areas, one-way aisles, stop for cashier, etc.). Informational signs also are needed for pedestrians to locate stairs and elevators and to aid in stall identification. (This is discussed at length in Chapter Seven.)

Increasing numbers of parking garages are being equipped with automatic counting devices that keep a running count of the traffic, floor by floor, and signal to drivers when certain sections are full. It is especially helpful to the driver using a garage with five or six levels or different sections to be able to avoid full sections and go directly to where he has a chance of finding a place. Internally illuminated "blank out" type signs, coupled with automatic sensing and counting systems, can accomplish this. Guidance can also be achieved by lighted markers mounted in the ramp pavement (*14*).

Automotive Services—The builders of some parking facilities have added various automobile-related services, such as gasoline service stations, diagnostic laboratories, car washes, and tire, battery, and accessory centers. Although some of these services have proved successful and may

Attractive landscaping and setbacks to clear visibility for exiting drivers are part of the basic design features for this municipal garage.

represent an added convenience to the customer, they generally do not contribute to the parking efficiency and, unless very carefully located within the facility, can interfere with internal and external flow of traffic.

In municipally owned or operated parking facilities, state laws may prohibit the sale of gasoline and other items.

Aesthetics—The designer has a responsibility to produce a structure that is compatible in appearance with buildings near it. This sometimes involves the use of semi-open or "Moorish-style" masonry to mask parked cars from outside view and trimming the outer faces of the building with decorative grillwork, such as stainless steel, aluminum, or other metal, to mask the sloped floors and present a vertically rather than horizontally oriented building. Care should be taken, however, to avoid such similarity of architecture along the block that a motorist has difficulty in recognizing or finding the garage.

Odd-shaped site parcels will often provide irregular strips at ground level, which can be landscaped. With rectangular sites, the limited range of modular width combinations will sometimes result in strips not needed for structure and therefore best used for landscaping.

If the structure is at a corner, it is least subject to setback influences of adjacent buildings. Even in areas of high land cost, where other buildings in the block are built to the right-of-way line, a modest garage landscaping setback of 5 to 10 ft may be considered worthwhile.

DRIVEWAYS

Traffic Conflicts and Location Factors

If freeways and parking areas in a highway system can be coordinated through direct ramp connections, an optimum development will be achieved because major movements to congested areas could be routed to their terminal destinations (parking areas) without interference from, or to, nearby surface street traffic and pedestrians. In most cases, however, the entrances and exits of parking facilities require driveways connecting the public street and the facility. In the case of parking lots, the driveway must cross the sidewalk area. Traffic entering and leaving the lot is in direct conflict with pedestrians. The seriousness of the problem depends largely on (a) the volume and approach speed of entering traffic, (b) the volume of traffic and sight distance available to exiting drivers, and (c) the pedestrian volumes during the same time period.

When a parking structure is being designed, it may be possible to avoid all direct pedestrian conflict. This can be accomplished if the ramp is constructed within the sidewalk area, and the sidewalk is relocated inward. If a building rises above the site, the sidewalk becomes arcaded and therefore pedestrians are also afforded some protection from adverse weather.

Ramps may be constructed entirely within the street in those rare instances where surplus space is available. The ramp then curves under or over the sidewalk and into the parking facility. Regardless of whether or not the public sidewalk is set back, ramps may avoid pedestrian conflict and service parking floors above or below ground but (obviously) not at the surface level. Whenever parking garages are constructed adjacent to very high activity sidewalks, the ramped driveway design probably warrants consideration.

The concepts of driveway positioning along streets are closely related to the street system criteria presented under Location of Centralized Facilities earlier in this chapter. The driveway is simply a short connecting link tying the street access into the internal parking circulation system. Factors concerning entry/exit location from intersections, effects of

one-way streets, and types of major routes are all applicable. For example, the location and design of a driveway ramp and sidewalk arcade scheme are strongly related to direction of traffic flow on the street. It may be difficult or impossible to design such ramps to work efficiently with more than one assumed type of directional traffic movement on the adjacent street.

Studies by the Bureau of Public Roads in cooperation with 24 states found driveway capacities to range from 650 to 1,100 vehicles per hour per lane (*15*). The average rate for drivers at familiar entrances (industrial plants, military bases) was 1,000 vehicles, whereas the rate for drivers at "unfamiliar" entrances typical of most parking facilities was only 760. These volumes were developed on relatively level entrances, when a constant arrival flow was maintained and no serious internal parking conflict existed.

In the absence of vehicular conflict on the street, or of pedestrians on sidewalks, somewhat higher rates of *exit* flow could be expected. When the effects of other traffic are considered, however, the capacities of driveways may be only slightly higher than those of ramps within parking structures.

The number of driveway lanes required to service a given parking facility is dependent on the expected rates of flow. As noted previously, capacities of up to 400 vehicles per inbound lane per hour can be expected through ticket dispensers. For design of surge-type facilities, both entry and exit rates of flow per hour should at least equal the capacity of the facility. A minimum of one entering lane is then needed for each 500 to 600 cars that can be stored in such a lot or garage. Street traffic conflict, intermittent arrival rates, and sidewalk conflict with pedestrians may require additional driveway capacity.

The number of required exit lanes will depend on the method of fee collection (if any), sidewalk conflict, and available traffic gaps in the street flow. Studies of available gaps may be warranted. Along two-way streets, the gaps across both directions of flow to accommodate left-turn exits must be checked separately from the near-side flow that is involved only with right-turn exits from the parking facility. If more than one exit lane for movement in a given direction is planned along the

Two views show the entrance and exit as they meet street grade at this modern parking garage. The sidewalk is arcaded under the building, thus avoiding congestion and hazard for pedestrians in this CBD area.

same street, the gap reduction effect of this flow obviously must be considered at "downstream" locations.

Methods exist for calculating the reductions in gaps that may be expected as a result of specific future traffic volumes, if the annual growth factor is known. However, predictions based on free-flow condition gap availability will be unrealistic if nearby traffic controls interrupt the flow.

A more serious effect of nearby traffic control is often the backup of vehicles waiting at signals or stop signs. This backup tends to reach maximum at the same time that peak exit demand occurs at the parking facility. Such conditions indicate that driveways should generally exit onto lower volume streets and at maximum practical distance from controlled intersections.

Sizes

The key elements of driveway configuration include the following:

1. Width—usually measured at the right-of-way line, but alternatively at the throat limit when curbs are constructed;
2. Radii — connecting the driveway edges to the street curb or edge of pavement;
3. Angle—as related to the street line;
4. Directional flow—in, out, or two-way; and
5. Spacing—from nearest intersection, from property corners, and between adjacent driveways.

In general, as driveway widths and radii (on the entering side) are made larger, a more rapid and efficient entry flow can be expected. Thus, in most areas, generous widths and radii are desirable. Particularly good design is needed for high-volume driveways at shopping centers and factory parking lots.

Driveways in areas having very high pedestrian volumes, such as in the CBD of most cities, should probably be designed for lower entry and exit speed. Table 6.3

Table 6.3—Commercial driveway dimension guidelines

Dimension	Urban		Rural
	High Pedestrian Activity[a]	All Other[b]	
Width[c] (in feet)			
Minimum (one-way)	15	15	15
Minimum (two-way)	25	25	30
Maximum	30	35	40
Right turn radius[d] (in feet)			
Minimum	5	10	15
Maximum	10	30	50
Spacing[e] (in feet)			
From property line	0	0	0
From street corner	10	10	15
Between driveways	10	0	0
Angle[f] (in degrees)	75	45	45

[a] As in central business areas or in same block with auditoriums, schools, and libraries.
[b] The remaining city streets including neighborhood business, residential, and industrial.
[c] Measured along right-of-way line at inner limit of curbed radius sweep or between radius and near edge of curbed island at least 50 sq ft in area. The minimum width applies principally to one-way driveways.
[d] On side of driveway exposed to entry or exit by right-turning vehicles.
[e] Measured along curb or edge of pavement from roadway end of radius.
[f] Minimum acute angle measured from edge of pavement.

Designed for right-turn-in and right-turn-out operation, the driveways for this parking garage have adequate radii, and the exit is well set back from the main public sidewalk. (Source: South Carolina Highway Department.)

gives two sets of suggested design values for urban driveway controls.

Other Design Elements

In addition to basic dimensions, driveway approach grades warrant consideration of breakover angles. Adverse angles can be formed, for example, between the downward slope of a highly crowned pavement and a driveway steeply rising to meet the elevation of a sidewalk several feet back of the curb. This problem can often be avoided by warping down a larger portion of the sidewalk, or by depressing the walk with step-down curbs on each side of the driveway. Although some municipalities are opposed to them, step-down curbs do have the merit of clearly notifying the pedestrian that he is crossing a driveway conflict area. For every pedestrian who stumbles on the curb, another may be prevented from suffering vehicular-caused injury of a far more serious potential.

Studies have shown that driveway-pedestrian conflicts in lower density areas are minimal and that conflict with street traffic is the major concern (*16*). The main pedestrian problem that was found concerned blind exits created by building walls at the corner of the driveway and sidewalk.

Exit sight distance can best be established by a building line setback of 8 to 10 ft from the public walk or by funneling the walls. An alternate method is to provide sight triangles by use of openings or corner windows (sills should not be more than 3 ft above sidewalks).

In the mid-1960s, a pedestrian warning system was developed for use at blind drives. The exiting vehicle can actuate a detector that illuminates a "caution" sign and/or sounds a buzzer for a preset interval.

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CHAPTER SEVEN

OPERATION

The most important elements of parking facility operation are economies of operation, service to the users, and effect on the adjacent street system.

There are three basic types of car handling: self-park, attendant direction, and attendant (or mechanical) park. A charge may be levied with each particular type or the parking can be free. When a charge is assessed, it may be imposed on entry (generally at flat rate), on exit (either graduated or flat rate), partially on entry and the balance on exiting, or at the parking stall (parking meters).

Parking operations are generally classed as either attendant-park or self-park. They may be functionally subdivided into facilities satisfying a long-term demand (employee parking) or short-term demand (shopper parking). Facilities can be operated to serve a single purpose (shopping center) or multiple purposes (shopping during the day, theater in the evening, and recreational and church on the weekend).

An intimate relationship exists between design and operation. To design a facility independently of the intended operation is wasteful. To operate a facility without due regard for the intended operation incorporated into the design of the facility may be just as inefficient.

A number of operational characteristics and requirements are reviewed in this chapter. Varied conditions may exist in parking facilities, ranging from the free, self-park lot serving a specific business to the commercially operated charge-type parking garage serving a CBD. The majority of operating problems are associated with the commercial facility and involve elements such as reservoir space needs, employee relations with the public, and audit control. Much of the discussion in this chapter is directed toward such lots and garages, but material is also included on features common to both free and commercial facilities.

SPACE UTILIZATION

Stall Assignment

In the generally free, self-park lots or garages provided for industrial or office workers and for apartments, it is common practice to reserve certain spaces. Stall reservation is sometimes even considered a status symbol. When limited to a group

or particular department, such reservations may be appropriate. However, assignment to specific individuals can produce inefficiency. This can occur when the individual is temporarily absent due to sickness, vacation, or field assignment. A stall freed in this fashion may be used by someone else, if the individual holding the reservation notifies a co-worker of its availability. The degree to which such shared use is made varies widely. There would often be better use made of facilities if they were on a first-come, first-served basis.

Parking at apartment buildings is seldom adequate for guests. The greatest efficiency can be obtained if spaces are available to all users who are oriented to the apartment site, be they residents, guests, workers serving the building, or tenants. The growth in multiple car ownership and prevalence of fractional zoning code provisions (see Chapter Three) such as 0.5 to 1.5 spaces per unit raise questions as to the basic mechanics of stall assignment. Under such conditions, the fairest method may be to make no assignments.

One consistent finding appears for all sorts of developments. Once stalls have been earmarked for individuals, cancellation can be difficult, and awkward at best.

Commercial Facilities

The method of operation of any commercial facility is related to type of service to be rendered, operational cost (primarily labor), income, and facility size. Attendant-park facilities normally have a higher operational cost. In these facilities, however, more cars are parked in the available space because attendants are able to park in smaller spaces than the average parker, blocked (two-deep) stacking can be used, and back-in parking is feasible. Back-in parking can utilize a narrower aisle. On the average, an attendant-park operation can store 25 percent more cars in a given area.

Most parkers (women and men) apparently feel incompetent to back into stalls. They will go through extensive and complicated maneuvers in order to pull forward into stalls. To satisfy this quirk of human nature, the self-parking facility must provide aisles wide enough for pull-in operation and also wider stalls.

Despite the lower efficiency of space utilization and the problems of direction and service, modern facilities are typically designed for self-parking. Disadvantages of attendant-parking include high labor costs, expensive reservoir space, often poor and slow service, customer resentment toward car-jockey handling, and leaving (or forgetting to leave) ignition keys. The effect of various elements on operating economy or efficiency can best be compared for the two types of operation by following the step-by-step parking and unparking stages.

INGRESS AND VEHICLE HANDLING

The first critical phase of the parking operation begins when the parker has left the street and entered the facility. The service and treatment that the customer receives is his first contact with the operation and will, to a large extent, mold his attitude toward the facility. Congestion and delay at the entrance to a parking facility can be just as annoying to a patron as congestion and delay on the street. Every effort should be made to eliminate them.

Attendant-Park

An attendant-park operation can experience excessive backup and delay if an unanticipated surge of parkers arrives in a short time or if the rate of acceptance by car-handling personnel is less than the arrival rate. A short-lived surge will result in minor delays to the parkers, but the surge can be handled and delays eliminated in a short period of time. If the

high rate of vehicle influx continues, however, the queue will lengthen, and a complete failure of the entrance operation will result.

The solution lies in the provision of sufficient attendants and an adequate inbound reservoir area. All employees should be instructed on how to help clear the reservoir area in an emergency. However, this reserve force can be of only limited help because of the small number of nonparking personnel working at an attendant-park facility. For example, a parking report by the Eno Foundation (*1*) showed the following distribution of personnel for a 700- to 800-car attendant-park garage:

Manager	1
Assistant Manager	2
Attendants	23
Cashiers	3
Maintenance	2
Secretary-Bookkeeper	1
Total	32

During a period when a surge of arrivals could occur, it would be expected that, at best, only the manager, assistant manager, one cashier, and two maintenance men would be available to help. Assuming a maximum of 15 attendants on duty at any one time, this 5-man addition would increase the force to 20 and increase the number of vehicles that could be handled by up to one-third.

Another solution to the problem, as mentioned before, is the provision of adequate reservoir space. This is a design consideration and should be provided despite the high cost of land and construction. An adequate reservoir area properly

This attendant booth is located too close to the street. The simultaneous arrival of two vehicles will result in the second one having to stand across the sidewalk while the driver of the first car stops, gets out, and receives his ticket stub, and until the attendant then enters the car and drives it into the lot to park.

utilized can result in a given level of service to the customer with fewer attendants. Hence higher construction costs may be offset by reduced operating costs.

A concurrent inbound and outbound peak creates a severe problem. Normally, an effort is made to handle both demands, with the major effort being made to handle incoming traffic. If the inbound load is not handled, it may queue back onto the street and interfere with normal street operations.

A similar problem can take place at a mechanical garage. Additional attendants usually will not alleviate the problem. The limitation is in the number of lifts and their operating capacity. Proper planning of the placement of vehicles can help. A substantial reservoir area is the only relief for such a problem at a mechanical garage and must be included during the design stage.

Self-Park

The entry problem is less severe with a self-park operation because no change in vehicle driver is required. If the facility is a free operation there is no requirement to stop when entering, and little reservoir space is needed. In larger self-park garages where a fee is charged, the parker is required to stop and take a ticket, often from a ticket-dispensing machine. Because people tend to "steer clear" of a fixed object, it is not unusual to observe many entering drivers stop and get out of their cars to reach a ticket. This causes congestion and delay. A portable curb on the right side of the entrance can guide the motorist closer to the ticket machine.

During extremely heavy entry periods it is sometimes worthwhile to have an attendant pull the ticket when the machine is actuated by an incoming vehicle and hand the ticket to the driver. In this way the vehicle does not have to stop.

If the ticket machine is located too near the street, incoming traffic may back onto the street. Sometimes the machine can be relocated, or a portable unit can be placed further into the facility during periods of peak inbound load.

Entry Charge

A direct parking charge may be assessed on entry. Typical applications include flat-rate evening charges at CBD facilities (which may be unattended when the parker returns), at race tracks (where the parker may literally have no funds in his possession when he leaves), and at other large outdoor events such as state fairs and sports events.

The entry charge is usually collected by an attendant. However, parking gates are sometimes installed on a pay-in, free-out operation. An obvious disadvantage to the collection of even a flat rate on entry involves the off-street reservoir space required to handle collections during higher-than-average arrival rates.

"Full" Signs

Regardless of the type of facility, one very important operation is to notify prospective parkers when the facility is full before they arrive at the entrance. A large "full" sign, visible at the cross street before the facility entrance, should be used. This will minimize unnecessary delay to the parker, will allow him to make a turn to another parking location, and may save him considerable time in a lane of traffic if the street is operating at capacity.

It is possible to set up the sign operation on an automatic basis. Such a system for the 700-car Brooklyn Civic Center garage was described as follows (*2*):

> An automatic counter connected to the issuing unit adds and subtracts the number of cars entering and leaving. Set at a little less than capacity, the counter makes a mathematical decision as to when the garage is full. It then refuses to issue any more tickets. A sign at the entrance

This facility gives maximum service at minimum operating cost. Entry is handled by a well-designed mechanical ticket dispenser. Exit is through a coin-operated gate.

informs motorists that the next ticket will be issued as soon as space is available.

When a car moves over the exit treadle, the count diminishes by one. The sign now indicates the availability of space and a ticket is dispensed to a waiting vehicle. Automatic balancing of entries and exits plays an important role here, where the entrance is hidden from the cashier.

CIRCULATION

Attendant Handling

In an attendant-park operation the storage location of the vehicle is determined by the management. In general, an operation that requires handling only twice (on arrival and at departure) will result in the most efficient utilization of manpower.

It should not be assumed that attendants park vehicles at a uniform rate. One study showed that average handling time within a facility ranged from 2 min 52 sec to 4 min 32 sec, the latter attendant requiring 58 percent more time and thus handling only 63 percent as many cars as the faster attendant (*3*).

Mechanical Handling

Circulation in a mechanical garage is limited by the more-or-less fixed location and operation of the lifts. As with other attendant operations, peak-hour handling can be critical. Temporary storage at lower levels and subsequent relocation to a more remote area can expedite accommodations during peak periods. This rehandling is not as effective in a mechanical garage as

in an attendant-park operation because the time that can be saved is much less. Generally, mechanical garages can handle each vehicle in as little as 1 min. More than 1¾ min is rarely required.

Self-Parking

Self-park facilities exhibit special problems. The operator of the circulating vehicle is not a professional driver or parker. Aisles and parking spaces must be wider and more accessible. Stacking cannot be allowed; each parked vehicle must have immediate and direct access to an aisle. Provisions for the safe and convenient passage of pedestrians must be made.

It is desirable to have the parker locate a vacant stall as quickly as possible. A minimum length of travel past other parked vehicles is desirable. In an open parking lot, the parker will usually attempt to locate a space as close as possible to his destination. In a garage, however, there is less orientation toward an external reference.

In the small lot or garage, the search pattern is short and no particular guidance is needed. At an attendant-manned entrance to a larger facility, the employee is frequently able to give some general guidance to the parker by directing him toward certain areas, floors, or aisles.

If entry has mechanical ticket dispensing, or is free, there are several methods of signing the "full" sections. The precise method used depends on the facility design, operation, and kind of use. If the lot or garage serves long-term parkers, an attendant can place "aisle full" signs if the circulation system permits. These signs, of course, must be removed prior to the beginning of exit demand.

In garages having bypass lanes or ramps, variable-message internally illuminated signs may be used. These signs are usually operated manually from a local or a central control panel. They may indicate "full" conditions of parking aisles or complete floors, and may even direct parkers toward vacant areas.

More sophisticated internal guidance systems are now coming into use. They involve sensors and differential counters, which continuously compute entry and exit volumes for a particular floor as a function of capacity. As parking demand varies, signs are automatically turned on or off in a fashion similar to the Brooklyn Civic Center garage entry operation (*2*).

In 1967 a computer parking control and data storage system was developed for application to the extensive New Haven, Connecticut, municipal parking facilities. Although primarily used for audit control, the system potential was reported to include floor-to-floor occupancy tabulations, internal direction and exit signing, measurement of queue lengths, and even adjustment of traffic signals on nearby streets to better accommodate both garage and street traffic.

Operating experience is required to assess the merits of various sophisticated systems. Maintenance is a factor warranting careful analysis. There can be little question, however, that automated guidance will increasingly be used to improve circulation in the larger self-parking facilities.

EXITING PROCEDURES

Attendant Facilities

When a parker arrives to pick up his car, its exact location must be known. A location code can be noted on the ticket, or the ticket can be stored in a separate bin that corresponds to a specific parking stall or a small sector in the facility.

If the vehicles are relocated from one space to another, it is vital that office information about their locations be kept current with each move. In all cases, the cashier must be able to match a surren-

Internal direction signs of large size and clear meaning are essential to operation of a self-parking garage. The floor identification numbers on structure columns aid in parking stall identification and subsequent retrieval by the driver. (Source: Public Parking Authority of Pittsburgh.)

dered ticket to a vehicle location promptly and precisely.

Self-Park Facilities

Vehicle retrieval is not a problem in a self-park facility,but vehicle location sometimes is. In larger facilities, a parker occasionally forgets where he parked his car. Situations have even been reported where a parker and an employee have spent an hour or more looking for a car only to find that the owner had actually parked in another garage. When a car is reported lost, the employee should first check the parking receipt.

Vehicle location is aided by marked sections or zones. Numbers, letters, colors, names of animals, or any one of a number of coding systems may be used. Numbers and letters are most systematic because they are naturally sequential. However, many people have less trouble remembering a color or some object. Garages are well adapted to floor numbering and letter or color sectors, each letter or color being in the same relative position on each floor. The code should be prominently

displayed throughout the facility. It may be necessary to guide the parker to the sector in which he is parked through a series of signs or colored pavement markings if a color code is used.

The Brooklyn Civic Center garage was reported to utilize its ticket system to aid motorists in locating their cars (*2*). Each ticket has the alphabet printed on one side, and lettered decals have been placed on garage columns. Once he has found a parking stall, the motorist can circle the proper letter on his ticket.

Good exit route signing is necessary to direct the driver out of the garage as efficiently as possible.

Parking Meter Charge

Parking meters have been effectively employed in both lots and garages of the self-parking type. White Plains, New York, is believed to be the first city to install meters in a parking lot. It was sponsored by the local chamber of commerce, and opened after the end of World War II (*4*).

When used in off-street facilities, meters have the following advantages:

1. They require no inbound stopping to receive a ticket, nor outbound stopping to pay a cashier;
2. They require little supervision and generally have a low maintenance cost; and
3. Their use is understood and accepted by the public.

Disadvantages of meter use include the following:

1. The parker must estimate his length of stay in advance and must also provide payment that requires having or securing proper change;
2. A ticket validation plan with merchants is not usually practical (however, a token-dispensing validation meter became available in the late 1960s—see Chapter Nine, Types of Meters); and
3. Enforcement is required, and vandalism or theft may become a problem.

The meter may work well for long-term parking, such as employees in or on the CBD fringe or in a change-of-mode commuter facility. This operates, in effect, as a flat-rate charge.

Exit Charge Operations

With a flat-rate charge, coin-operated gates are often used. The problem of proper placement of coin receptacle and proper vehicle positioning is similar to that of the ticket dispenser. The coin slot height is critical, as is the need for a basket below the slot to catch "fumbles." The problem of nonavailability of correct change is always present. Change-making machines may be positioned at strategic places to intercept the parker prior to entering his car or may be located near the exit gate. If they are located near the exit, the process of change-making can cause delay to other patrons.

Parking gates are successfully used at commuter, airport, hospital, and industrial parking facilities. They are also used at apartment buildings where tenants are issued cards or keys, and at more commercially oriented lots where employees or visitors may be issued tokens. In both cases, a selective control may be exercised over the clientele.

The parking gate system usually works best on a free-in, pay-out kind of operation. This practically eliminates the need for inbound reservoir space. The entry gate may even be manually locked open during heavy flow, provided that entrance design or an attendant will prevent "free" exit through the opened gate.

Malfunction is often a problem with the parking-gate exit-charge operation. This can be caused by a jammed coin or failure of the vehicle detector. In either case, the patron may have no choice but to break the wooden gate arm in order to escape.

Exit charges may be handled by paying a ticket received from a dispenser upon entry. This Boise terminal also features a ticket validation plan for motorists patronizing the restaurant or lounge.

Operators of facilities having parking-gate control should maintain a ready supply of replacement arms. A breakaway arm can be used, with a splice section of weaker wood. This will protect the mechanical equipment.

If a graduated rate charge is used, a record is needed of the time of arrival and time of departure. In a self-park facility, this is generally recorded on the patron's ticket. A cashier must compute the elapsed time between arrival and departure, mentally or by machine.

Because of the nonsequentiality of time used in this country (1 o'clock following 12 o'clock) it is worthwhile using 24-hour time for recording on the tickets. Under this system, a period begins at midnight. The process can be further simplified by using hours and hundredths of hours rather than hours and minutes. For example, if a vehicle arrives at 10:45 a.m. and departs at 2:10 p.m., the time of arrival printed on the ticket would be 1075 and the time of departure 1417. The difference is 1417 minus 1075 = 342. This figure represents 3.42 hours and the applicable charge would be the 3- to 3½-hour parking fee, if a half-hour fee increment is used.

During periods of peak discharge when an exiting queue of some length develops, it may be well to have an employee request the ticket of those individuals in the exiting line, compute the charge, and note the total fee on the face of the ticket. This relieves the cashier of the responsibility of calculating the charge and also encourages the patron to get the exact change ready or, at least, have sufficient money in hand when he reaches the cashier's booth.

Management should establish a policy of not charging a patron for the time he is in the exiting line waiting to pay out. In other words, an amount of time approximately equal to the time he spends waiting to get out should be deducted from his total time in the facility. This could be from 5 min to as much as ½ hour in larger facilities under extreme conditions. Unless the patron knows of this practice, the public relations benefit the management is seeking will be lost. The cashier should tell each exiting motorist that the time he spent in line has been deducted from the charge. Many operations regularly offer a

6-min grace period on all tickets. This eliminates much discussion and many arguments about whether the parker was in the facility for 2 min over 1 hour or 1 min less than 1 hour.

AUDIT CONTROL

Automated Systems

Audit control techniques are in a rapid state of development. The following description of a highly sophisticated operation will illustrate possible functions of a computerized system:

> Upon entering the facility, the motorist receives a pre-punched ticket from a dispensing machine. This machine transmits to a computer the ticket number and time of entry. At the time of exit the parker surrenders his ticket and an electronic reader conveys the ticket number to the computer. From its stored information the computer retrieves the parker's time of entry, computes his elapsed time in the garage and computes the charge. Within a few milliseconds after the ticket is placed in the reader, the charge is displayed on a sign board. The parker then either pays the cashier or a machine capable of making change.

This procedure reduces exiting time because it does not require the cashier to compute charges. It also maintains a continuous record of cash transactions during each cashier's tour of duty. The machine can be programmed to provide any statistical data desired and will keep a running total of cumulative business for the entire year.

Computer equipment can be provided to keep track of several facilities using different rates. The machine can be made to handle charges, monthly pre-pays, employee and other passes, and punched validations. The equipment, if supplemented with floor or zonal vehicle counters, can be programmed to actuate and deenergize zonal "full" signs and shift the flow of traffic by establishing altered one-way systems in response to a given set of conditions within the garage.

This type of equipment will minimize the need for personnel in a garage while providing a high level of audit control. It has the obvious disadvantge of high initial cost plus delicate electronic equipment to be maintained.

Only larger facilities or operations could afford this type of equipment. Less sophisticated, less expensive techniques are available to effect a reasonable level of audit control. The most appropriate procedure can be determined by the management. The decision should be made after considering cost, benefits, and the losses that can be expected without it.

Parking Charge Tickets

In an attendant-park operation employing a graduated rate, it is vital that each parked vehicle be issued a ticket and that each ticket be imprinted with the exact time of arrival and departure. Tickets imprinted with the time of arrival an hour or so after the vehicle actually arrived or with a time of departure an hour or so before the actual departure can result in a loss of 1 or 2 hours' parking charge. Extended over a large number of transactions, this could represent a sizable loss.

Cars parked without tickets will never be recorded and represent a loss. This can be avoided by notifying the arriving motorist that he must receive a ticket showing his time of arrival. The part of the ticket given to the parker contains the time of arrival and a sequential number. A second part of the ticket is put on the windshield of the vehicle, and a third part is retained in the office with the vehicle location noted on it. Upon returning, the owner surrenders his part of the ticket, which is then stamped with the time of departure. After delivering the vehicle to the owner, the attendant takes the second part of the

ticket from the windshield and hands it to the cashier, who staples all three parts of the ticket together as a completed transaction.

At any point in time, the garage can be inspected to determine that each car contains the second part of a current ticket. It is important to keep all three parts of the ticket together following the completion of the transaction so that the second part cannot be reused to designate a legally parked vehicle when, in fact, no record has been made of the vehicle's presence in the facility.

Self-park facilities can be controlled by ticket dispensers that automatically imprint the time of arrival. The ticket is retained by the parker and surrendered to the cashier upon leaving. The ticket is then imprinted with the time of departure and the fee is computed.

A printing time clock is the key to accurate audit control in a smaller operation. If there is more than one entrance-exit, the clocks at each entrance and exit should be coordinated by a master clock system. This assures the parker that he leaves the facility on the same time base that he entered. The clock works are normally locked so that they cannot be set back and forth by a cashier intent on cheating the operation. But keys can be reproduced. The manager or operator should make sure he controls the keys or delegates the responsibility to one trustworthy person who has no involvement in the collection of fees. Periodic changing of the lock is an inexpensive process.

Checking of Tickets

It is generally not possible to audit every ticket, but periodic checks should be made. One method is to check all tickets for each operation for one day each week. The day of the week must be selected randomly because any pattern of checking can be detected by an employee. Each ticket should be checked for elapsed time and the rate applied. Total calculated receipts should be checked against reported receipts. The charge for each ticket should be shown on its face as a cash register transaction receipt. Each ticket should be checked for the correct calculation of charge.

Checking tickets is not sufficient to ensure proper audit control. Randomly timed inspections of the facility should be made. Checks should include time clocks and the sequentiality of tickets in use plus those stored for future use. Improved procedures can also result from periodically watching the operation of the facility. It may be worthwhile in a smaller operation to spend an entire day checking time of arrival and departure for each vehicle, using the license number as a check. Total receipts can be calculated and checked against reported receipts for that day and against the pattern of receipts for comparable days.

Overcharges

Overcharging of the patron is difficult to detect. Parkers depend on the cashier to compute the charges and generally do not protest unless they are grossly overcharged. Individually, overcharges are small amounts; collectively, they can amount to a considerable sum. This problem can be best overcome by having an internally illuminated sign that is connected to the cash register display the total charge, in full view of the motorist, at the time the cash register is actuated. If the cashier must account for all transactions entered into the cash register and he can charge no more than what he rings up, there is less likelihood of overcharging.

CUSTOMER FACILITIES AND SECURITY

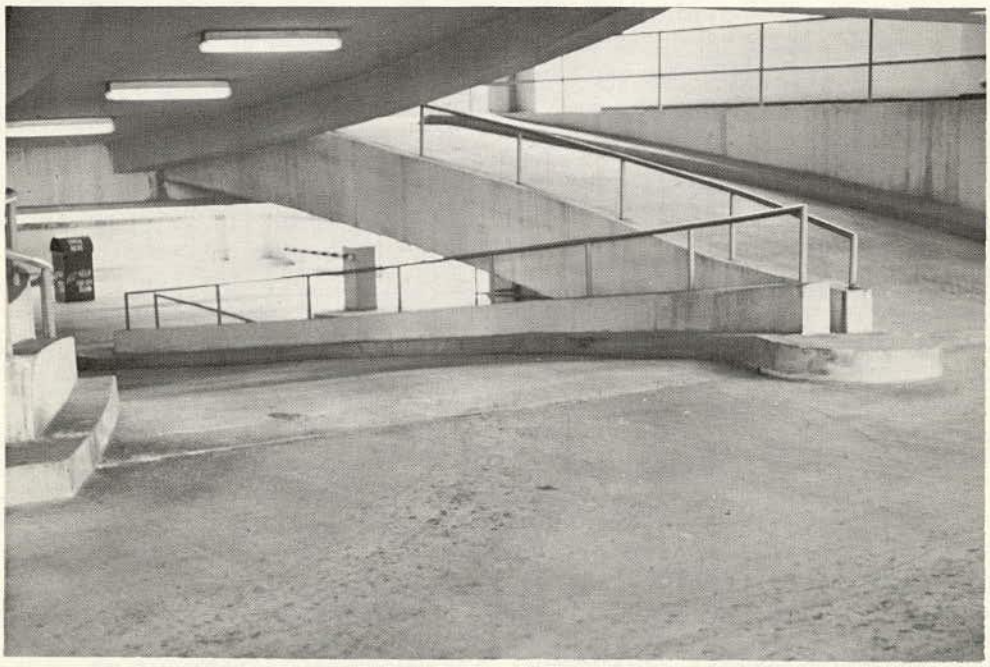
The provision of facilities such as rest rooms, waiting rooms, office space, check

rooms, elevators, and storage rooms should be considered during the design of a parking garage. Keeping these areas clean, attractive, and relatively safe is an operating problem. If not properly supervised or maintained, these out-of-the-way areas can be depressing or even dangerous to the facility patron. They may attract hoodlums, transients, and derelicts. They tend to become collection spots for empty bottles, litter, and defacement.

It is important to provide rest room facilities for the patron and also to discourage misuse of these facilities. Keeping a rest room locked is an inconvenience to both the customer and the employee, but this may be the only way to maintain adequate supervision of the facility. If a problem becomes sufficiently severe, it may be worthwhile to relocate the rest room to an area within or near the offices of the operation.

Because self-park facilities must be accessible to the public and many remote sections of larger facilities are visually isolated from employees, it is necessary to take special precautions to protect the parker from muggers and molesters. A high level of lighting is desirable during periods of use. Visual and sonic monitoring devices have been used on a limited basis. Television monitoring of remote areas can result in a safer operation and can serve as a tool for locating operating problems in large garages. This type of equipment is quite expensive. A less sophisticated, but very effective, device is a sound monitoring system that allows the person monitoring the equipment to hear extra-normal sounds or voices in the facility and to respond to a possible emergency.

Both types of equipment require the presence of some individual who, in addi-



Good lighting and avoidance of remote interior corners are essential to pedestrian security within a garage. Ample visibility at the ramp speeds safe traffic flow. (Source: South Carolina Highway Department.)

tion to any other task he might be doing, will take appropriate action in case of need. If equipment such as this is not available, the manager, or some employee, should be within visual range of the entire facility continually or as often as possible.

Easy pedestrian access from the parking space to the exterior of the facility should be given serious consideration during the design phase. Once provided, these access routes should be kept clean and well lighted.

FUMES

The area around the cashier's booth in a garage is subject to the highest carbon monoxide accumulation. Carbon monoxide toxicosis is influenced by the concentration in the air, the length of exposure of the individual to that concentration, and to a lesser extent the general physical condition of the individual. Because length of exposure is a major factor, the effects will probably first be felt by the cashier. Symptoms of the condition are headaches, dizziness, and nausea. Any complaint of these conditions is reason for relief of the cashier; persisting complaints of this nature are cause for checking the concentration of the gas in the area.

Excessive concentrations are most likely to occur during peak exiting hours, when the air is very still, and during periods of atmospheric inversion. State and local health departments can provide information on tolerable levels of the gas and will often assist in the detection of unhealthful concentrations.

PHYSICAL MAINTENANCE

The cost of maintenance is usually not a major element in the financial stability of a facility. Garage structures are faced with building maintenance, whereas lots are plagued with surface maintenance problems. Mechanical garages are a special case because of the extensive mechanical equipment used in the operation.

Maintenance costs are relatively low during the early years of operation because of the newness of the facility and the equipment. As equipment ages, higher maintenance costs can be expected, particularly in the case of mechanical garages.

Facilities have been known to require quite high maintenance costs during the first year or two of operation. This unusual condition comes from changes required due to inadequate design or construction and to the relatively high cost of maintenance contracts that may be obtained on some equipment.

Snow Removal

Depending on the geographic location of the facility, snow removal can be a major item of maintenance. Normally, a major snow removal effort will be conducted at night when there are few cars in the facility. This involves overtime work and can be quite expensive. Snow must be hauled away from the site or a section of the facility can be set aside for piling the snow. In the latter instance, the loss of income from the lost spaces may prove less costly than the high cost of snow hauling. After the snow has been removed the aisles should be sanded or salted if needed. It is wise to also clear, salt, or sand pedestrian walkways.

Heating systems involving wires or pipes in the ramps must, of course, be included during initial construction; however, infrared heaters, if found to be necessary at key locations, can be installed after operational problems appear.

Routine Items

Other maintenance items include regular replacement of lamps and regular inspection of mechanical and electrical equipment. A maintenance program can

be carried out using a maintenance crew, employees normally assigned to other duties, maintenance contracts on certain equipment, or maintenance contracted for when needed. A maintenance crew should be considered only if the work is sufficiently heavy to keep the full crew busy during normal working hours. This is generally not the case except where one operator is responsible for several facilities. Usually facility employees do not have the training or equipment to handle large maintenance jobs.

Equipment normally coverable by a maintenance contract includes cash registers, calculators, elevators, typewriters, adding machines, and copiers. The firm will have the expertise and equipment and will usually follow a program of routine preventive maintenance.

OPERATING COSTS

Operating costs vary greatly with the method of operation, size and type of facility, and to some extent the city in which the facilities are located. The latter variable probably is affected most by differences in personnel costs from one area to another.

Exclusive of debt service, personnel cost alone comprises over half of the total operating budget. As such, it is the most critical item. The need for personnel at a free self-park facility will depend on the location, size, and nature of the operation. Minimal needs include ensuring the safety of the parker, keeping the facility clean and well maintained, directing traffic, and removing stalled vehicles.

In pay facilities, the type of parking activity (i.e., short-term, long-term, or a combination of the two) has a direct bearing on operating expenses because manpower requirements must be geared to serve the differing characteristics.

To illustrate the degree to which operating costs can vary, a limited study was made of facilities located in typical midwestern and eastern cities. Four garages were selected in each city, and a cost comparison was developed on a per-car space basis. Both systems are municipally owned, but operated privately under lease or management contracts. Garage capacities ranged from 430 spaces in one midwestern city facility to 840 spaces in one eastern city garage. It was virtually impossible to make a direct comparison between all above-grade or all underground facilities. In fact, two of the four midwestern city garages are underground structures. It was felt, however, that including underground garages in the analysis would point out more dramatically the extent to which certain items of operating expense can vary.

The lowest and the highest costs per car space were computed for each item of operating expense. Averages also were determined for each city, and a composite average was calculated for both municipalities. Results are given in Table 7.1.

Payroll and related costs may be seen to entail the largest single item of expense. The eastern city personnel costs are almost double those in the midwestern city. In general, this can be attributed to higher wage rates and more personnel requirements to operate the facilities in the eastern city. Whether or not attendants and cashier personnel are unionized also can cause a significant differential in labor expense.

Higher utility costs observed in the midwestern city are due primarily to the larger expenditures required for lighting in the underground garages. Greater maintenance and repair costs also were found in the midwestern city. This shows that underground garages, in some instances, are more expensive to maintain. Other factors affecting maintenance and repair costs are the age of the facility and the extent to which the owner or operator conducts a continuing preventive maintenance pro-

Table 7.1—Annual operating cost (in dollars) per car space—1969

Expense Item	Midwestern City			Eastern City			Average Both Cities
	Low	High	Average	Low	High	Average	
Payroll (including taxes and benefits)	53	74	64	95	144	118	92
Utilities	9	30	20	8	19	12	16
Repairs and maintenance	16	32	26	8	18	15	21
Supplies	3	5	4	4	6	5	4
Insurance	1	2	2	—	6	3	2
Legal and audit	—	—	—	1	6	3	—
Security guard	11	21	16	—	—	—	—
Management fee	10	15	13	—	—	13[a]	13
Miscellaneous	—	—	—	3	12	5	4
Total	103	179	145	119	211	174	152

[a] Figure is for one garage only.

gram. If parking structures, whether above or below ground, are allowed to fall into such a state of disrepair that major renewals or replacements become necessary, this can result in very large expenditures in a particular 1- or 2-year period.

Insurance expense can vary considerably, depending on whether the coverage is maintained by the owner or provided by the operator. In the case of the eastern city garages, lease provisions for three facilities require the lessees to furnish and pay for the insurance. One garage involves a national department store chain as the lessee/operator. In this case, the lessee has included the facility in its corporate insurance portfolio, thereby being able to secure a minimal cost of only 23 cents per car space in the garage.

Legal and audit expenses were not charged directly as such for the midwestern city facilities. These costs are apparently paid by the municipality from its administrative budget for the system.

Of particular note is the security guard service employed in the midwestern city garages. In the interest of providing safe, secure facilities for garage patrons, the city has incurred expenses that exceed those paid for management of the facilities. The need for garage surveillance has been a growing problem. There is a definite trend toward assuring the parking public that adequate protection will be afforded against loiterers and unauthorized persons.

All of the midwestern city garages studied were operated under management-type contracts, whereas the eastern city facilities, with one exception, were leased for operation. Under a private enterprise lease agreement, management expenses are not necessarily reflected in the operating costs. In leased operations, for example, the difference between the total income retained by the operator and the reported direct operating expenses may be classified as profit or management fees. Also, in a municipal operation there are charges of administration and overhead incurred by the department or agency that are not included in the overall cost of operation of the facilities.

Miscellaneous expenses can vary substantially, depending on just what may be charged to this "catch-all" item. The method of accounting and bookkeeping procedures followed by the owner or operator can result in a wide variation in this cost category.

The figures from this survey verify that garage operating costs differ by geographical area and are a function of many vari-

able factors and local conditions. Improved garage layout and design, better operational efficiency and management, and increased application of modern technology to operational procedures and practices all can work toward reducing garage operating costs.

Attendant Versus Self-Park Costs

As previously noted, the trend toward self-parking operation has continually increased since the mid 1950s because of the greater convenience and lower cost to the patron. Most municipal and private parking developers are designing and building garages for self-service operation. The substantially smaller number of personnel required to operate a self-parking facility represents a significant savings in operating costs.

As an example of the higher operating costs inherent in attendant-park facilities, figures have been compared for two garages in another medium-sized eastern city, both within a block of two major department stores. The self-service facility with a capacity of about 600 spaces had been open for less than 3 years. The attendant-park garage with about 900 spaces had been operating for more than 20 years. Personnel costs for the attendant-park garage were found to be more than six times those for the self-park garage. Expenses for office and janitorial supplies and other employee costs ranged from about 3½ to 12 times higher than the same expenses incurred for the self-park operation. Loss and damage claims alone amounted to over $24,000 in the 1-year period. Quite obviously, the 20-year-old attendant park garage is outmoded for the modern automobile and reflects its low operating efficiency through such high costs of operation.

A comparison of costs has also been made for an attendant parking lot, a mechanical parking garage, and a modern self-park garage. These facilities are all operated by a parking authority in an eastern city. As shown in Table 7.2, the personnel costs for the lot and mechanical garage are similar, but wages for the self-park garage are far less. The operating cost for the self-park garage is very similar to the eastern city "high" values in Table 7.1. However, the *mechanical* garage operating costs on a per-stall basis are nearly twice as high.

COMBINATION OPERATIONS

Because of the nature of the facility and the service requirements of the customer, it may be advantageous to change the method of facility operation periodically. For instance, a lot or garage may be operated as cashiered (self- or attendant-

Table 7.2—Lot and garage operating cost comparisons (in dollars)

Expense Item	Average Annual Cost per Space[a]		
	Attendant Parking Lot (142 spaces)	Mechanical Garage (270 spaces)	Self-Park Garage (1,280 spaces)
Personnel	128	131	75
Insurance and claims	1	5	6
Operating cost	32	105	53
Total	161	241	134

[a] Average for 1968 and 1969.

park) during the day to satisfy the needs of shoppers and workers in the vicinity. Then, if there is a theater or sport activity demand for parking in the evening, the operation could be changed to a free-gate-in, coin-operated-gate-out arrangement. It may be necessary to keep a cashier on duty for a short time to satisfy the requirements of those parkers leaving shortly after the change. A stamped, addressed envelope could be left on the windshield of those vehicles remaining in the facility after the change requesting remittance of their original ticket and the charge that would be assessed for parking from time of entry to time of change in operation. The license number of the vehicle would be recorded and if a persistent violation of the intended operation occurs, steps could be taken to collect the fees due.

Another example of a combination operation would be a free lot that serves the needs of doctors near a hospital. After the doctors' demand has terminated, visitors to the hospital could be allowed use of the facility through a pay-gate-in, free-gate-out operation.

A third example would be an operation that allows discounted long-term self-parking in the more remote sections of the facility. Advantage of these cheaper rates would be taken by workers who come in early and leave late in the day. No in-and-out privileges would be allowed. During the off-peak period, an attendant-park operation would be used to satisfy the needs of short-term parkers. After the short-term demand has passed, the attendants would be dismissed and the workers would get their own cars and leave. The long-term parkers could pay on a monthly basis or a daily pay-in-advance or daily pay-on-leaving basis.

RATES

Operations that assess a charge for their parking can generally divide their customers into two categories: long-term parkers (workers) and short-term parkers (shoppers, clientele of professionals, customers, salesmen, and servicemen). If a facility is operated for the single purpose of maximizing income, management will make a decision as to how many spaces can be filled with maximum-charge customers, who are generally the short-term parkers. The remaining stalls will be filled

This combination operation of municipal parking uses meters along the alley in the foreground, which allows long-term parking. This area is physically separated from the main self-parking facility that serves high-turnover shopper parking. (Source: Paul C. Box and Associates.)

with parkers utilizing a reduced all-day or monthly rate. On the other hand, the primary objective of a facility may be to provide parking for one or several stores. The secondary goal will be to maximize income. Under these conditions more short-term spaces would be kept open and fewer long-term customers allowed into the facility.

A privately owned and operated facility can favor certain types of parkers. In a municipally owned or operated facility it may not be possible to reject any parker as long as space is available in the facility. Under these conditions rates can be adjusted to encourage or discourage certain parkers. For instance, it may be found that increasing all-day rates by 10 cents will cause 15 percent of the all-day parkers to seek parking elsewhere. The loss of this 15 percent may bring about the desired balance. Also, if a uniform hourly rate results in too many long-term parkers in the facility, an increasing hourly rate may be used to discourage longer lengths of stay.

Specific rates in any facility will depend on facility cost, operating costs, parking demand, competitor's fees, and service provided. Fees are generally set on an hourly, all-day, weekly, and monthly basis.

Monthly rates are set to satisfy the requirements of workers. Because many establishments are open only 5 days each week, a normal month will contain approximately 22 working days. Many organizations allow from 1 to 1¼ days of sick leave each month and from 1 to 1½ days of vacation each month. A worker can thus be expected to go to his job about 20 days a month.

Monthly rates are often set in the range of 15 to 20 times the maximum daily charge. One study of 18 garages in 1961 showed the average ratio of monthly charge to maximum daily charge to be 17.8 (*1*). If a maximum daily rate is used, it is often set at about the same charge that would be assessed for 5 to 6 hours of parking.

Programs of store validation of parking tickets are widely used, with many variations. The program may be administered by a merchants' organization or the chamber of commerce. Under this plan the organization sells stamps (or some other evidence of validation) to the merchants who wish to participate. The merchant then places stamps on the parking ticket of the customer. The customer's parking fee is reduced by the amount of stamps on the ticket, and the facility operator turns the stamped tickets back to the chamber for the face amount. Because the stamps are worth as much as the money to an operator, this plan is applicable to a whole group of parking operations. Other arrangements can be made between a store and an operator. The plan helps both the store and the parking operation. Handling tickets is an added expense to the operator, and he will have to decide if such a program is worthwhile for his operation.

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3. RICKER, E. R., *Traffic Design of Parking Garages.* Eno Foundation for Highway Traffic Control, 1957, p. 147.
4. O'DONOVAN, W. L., "Auto Parking at a Profit." *Traffic Quarterly,* Eno Foundation for Highway Traffic Control, Jan. 1968, p. 117.

CHAPTER EIGHT

PARKING AT TRANSIT STATIONS

Mass transportation is especially well adapted to commuter trips to and from the CBD. As the street system becomes more congested and CBD parking costs increase, the convenience of driving downtown diminishes and the need for an alternative means of commuting increases. Change-of-mode parking, convenient to quick, reliable transit service, provides the commuter with such an alternative.

Change-of-mode can actually be a transfer between any two methods of travel (such as pedestrian-to-automobile, pedestrian-to-bus, bus-to-train). As used in this text, however, it is intended to mean only the transfer from passenger car to some form of bus or rail public transportation during a single trip. Thus the housewife when picking up or dropping off her husband at a suburban rail station is functioning in one change-of-mode form. If instead the husband himself drives to the station and parks, this is a second form of the *same* modal change (car-to-rail). The latter form is of primary interest in this chapter.

ADVANTAGES TO THE COMMUNITY

Thousands of daily commuters throughout the nation drive for a portion of their trip and then ride public transportation to their destination. Certain advantages accrue to the community:

1. Automobiles are taken off the road in and near the central area, where the transportation problems are most acute.
2. The addition of the new passengers may allow increased frequency of transit service during at least the rush hour.
3. Downtown parking problems of the central city are eased, and more spaces can be available for the shoppers and other persons desiring midday parking.
4. The reduction in demand for CBD parking has secondary benefits in that more space is then available for primary land uses. This results in greater development efficiencies by allowing a more compact central area. Higher tax yields may also be achieved with retention of strong property values, which benefits the entire city.

Estimates have been made of the potential needs for outlying parking along freeways or rapid transit routes (*1*). These estimates are related to CBD parking supply and urbanized area population. They range from a low of 10 percent (in areas of 500,000 population) to a high of 35 percent (in areas of 5,000,000 population).

CONSIDERATIONS BY THE USER

By parking away from his destination and completing the trip by rail or bus, the user stands to avoid congested driving conditions and high downtown parking costs. He can read or relax while riding on public transit. He minimizes the opportunities for his car to be involved in a traffic accident. In the case of rapid transit (rail or bus running in exclusive rights-of-way), travel time may be equal to or even less than driving time.

On the negative side, the user will have the inconvenience of interrupting his drive to downtown, parking, walking to the boarding area, and waiting for the bus or train. Where the transfer is made to buses operating on highways and streets with other traffic, the trip will almost always be slower than if he drives the entire distance. Even where express buses are used direct from an outlying lot to downtown, the bus can at best only match the auto speed, if running in mixed traffic, and the time required to park and transfer is lost. Figure 8.1 shows this time loss in a Washington travel corridor, based on trip times reported by downtown commuters.

The decision to park-and-ride is largely determined by the weight the commuter places on the inconvenience and lost time in change-of-mode parking versus the higher parking costs and the strain of driving in more congested traffic.

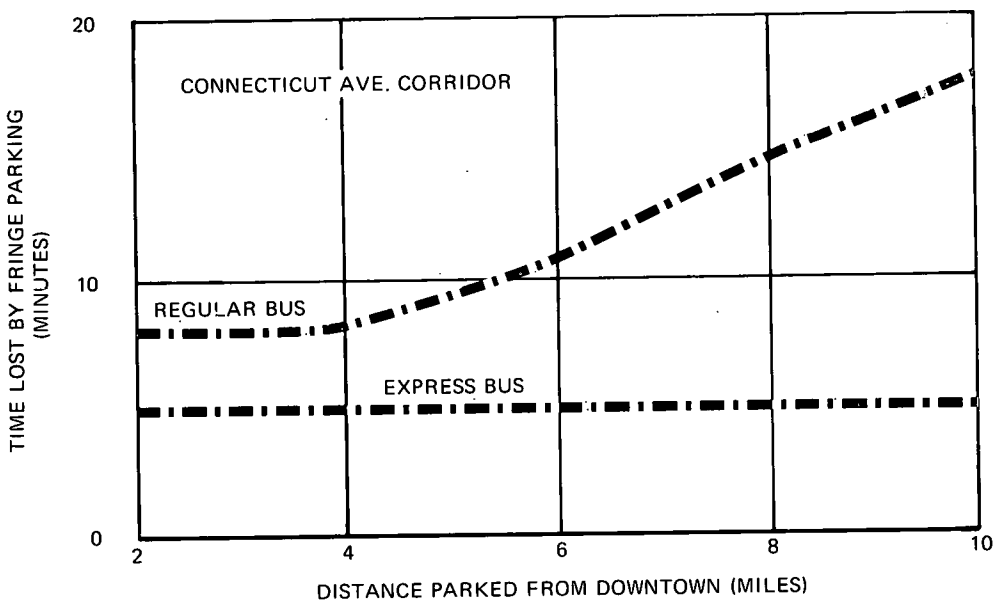

Figure 8.1. Time lost by fringe parking at various distances from downtown, assuming 2-minute walk and 3-minute wait at fringe parking bus stop (travel times as reported in 1959 federal employee parking study). (Source: Thomas B. Deen, "A Study of Transit Fringe Parking Usage," Highway Research Record 130, 1966, pp. 1-17.)

EXPERIENCE WITH MODAL-TRANSFER PARKING

The obvious advantages of change-of-mode parking have been recognized for years. As a result, many attempts have been made to increase the incidence of park-and-ride by the establishment of outlying or CBD fringe parking lots expressly for this purpose. Some of these lots have been fully used; others have failed.

Two major studies have been made of areas that have experimented with change-of-mode parking. The first study, by Deen, was published in 1966 and summarized findings from 27,000 spaces for rail rapid transit, 13,000 active spaces at bus transit, and 6,500 spaces that had been discontinued due to lack of patronage (*2*). In 1970, the Federal Highway Administration tabulated data on 48,000 spaces currently available in outlying or CBD fringe lots (*3*). Such studies have the purpose of investigating those factors that tend to induce more outer parking and, conversely, the factors that tend to discourage it. An understanding of such factors is essential in order to evaluate needs, locations, and economics of developing outlying parking facilities for modal change.

Case histories of several change-of-mode parking lots have been included in the Appendix. Findings peculiar to some of the specific operations may have application elsewhere.

Rail Transit

The bulk of rail rapid transit parking, as researched by the Federal Highway Administration, was found to be located 6 to 10 miles from the central city CBD and to have a peak-hour transit travel time to the CBD of under 30 min. A substantial number of other spaces were also located less than 30 min transit time from the CBD, as shown in Table 8.1.

Of the 139 parking lots surveyed, 98 percent used self-parking operation, 87 percent were paved, and 79 percent were lighted. Only 45 percent were reported to have shelters.

The lots were served on the average by train headways of 12 min during peak hours and 23 min during off-peak hours.

Ownership and operation of the lots were generally by the transit agency or the city. Parking at the Cleveland lots was free, whereas charges ranged from 10 cents to 60 cents at lots in certain other cities. Fees were generally collected by meters or at coin-operated gates.

Operating characteristics of several Chicago area lots serving rail rapid transit are given in Table 8.2. The peak accumulation was found to average 88 percent, and the turnover for a 16-hour day averaged 1.1.

Studies have been made of traffic and parking characteristics at two Cleveland lots (*4*). More extensive studies have been

Table 8.1—Rail rapid transit parking as related to travel time and distance

Transit Travel Time to CBD During Peak Hour (minutes)	Number of Spaces by Distance From CBD (miles)						Proportion
	0-1	2-3	4-5	6-10	Over 10	Total	
0-10	0	750	660	0	0	1,410	4%
11-30	0	2,070	8,920	18,040	4,590	33,620	87%
31-60	0	0	0	410	3,220	3,630	9%
Total	0 (0%)	2,820 (7%)	9,580 (25%)	18,450 (48%)	7,810 (20%)	38,660	100%

Table 8.2—Chicago area change-of-mode terminal parking operations

Terminal	Capacity	Peak Accumulation		Total Parking (6 a.m.-10 p.m.)	
		No.	Percent of Capacity	No.	Turnover
Linden	466	266	57	311	0.7
Swift	522	509	98	569	1.1
Howard	295	306	104	385	1.3
Des Plaines	512	510	100	795	1.6
Cicero	310	238	77	300	1.0
Ashland	235	218	93	268	1.1
Average			88		1.1

SOURCE: Terminal Parking Statistics, Chicago Transit Authority, October 1969.

made at the Skokie Swift terminal. Findings have been related to the daily number of passengers originating at the stations on the days of survey and are summarized in Tables 8.3 and 8.4.

The distances driven to transit terminals have been surveyed at two other Cleveland stations (*5*). As shown in Table 8.5, 66 percent of the parkers and 83 percent of the pickup and dropoff activity was from homes within 4 miles of each station.

Because the average distance driven by the Cleveland parkers was 3.8 miles (Table 8.5), the round-trip vehicle mile-

This Chicago terminal includes a rail rapid transit end-of-line loop, a transfer area for bus operation, and a pickup-dropoff area for private autos. Parking is provided for 540 cars. The terminal is served by rail on 5-minute headways during the peak hour and 7-minute headways during off-peak. (Source: Chicago Transit Authority.)

Table 8.3—Peak-hour characteristics of selected rail transit parking terminals

Characteristic	Peak-Hour Factor per Daily Passenger Originating at Station				
	Skokie Swift (Chicago)		West Park (Cleveland)		Triskett (Cleveland)
	a.m.	p.m.	a.m.	p.m.	a.m.
Vehicles parking	0.13	—	0.10	—	0.14
Vehicles unparking	—	0.10	—	0.12	—
Vehicles picking up or dropping off passenger (one-way movement)	0.09	0.08	0.05	0.03	0.04
Passengers boarding rail	0.37	0.08	0.34	0.04	0.37
Passengers alighting from rail	0.07	0.30	—	—	—

SOURCE: Unpublished operating studies of the Skokie Swift and Highway Research Circular 91, "Cleveland Transit and Parking Operations," Jan. 1969.

age is 7.6 miles. Alternatively, a person who is dropped off and later picked up causes two round trips to be made each day. Assuming the average mileage of 2.7, a total of 10.8 vehicle-miles of automobile travel occurs. From the transportation standpoint, and assuming available "second" cars, a greater parking supply at the stations could reduce total vehicle miles driven during the peak hours.

More study is needed to produce data of the type given in Tables 8.3, 8.4, and 8.5. With further knowledge it may be possible to develop factors to estimate the optimum "mix" of parking spaces versus pickup/dropoff stalls as related to passenger ridership at each station.

Table 8.4—Proportion of morning peak-hour passenger arrivals by mode

Mode	Percentage of Total Peak-Hour Arrivals		
	Skokie Swift (Chicago)	West Park (Cleveland)	Triskett (Cleveland)
Parking	41	35	47
Pickup/dropoff	25	17	12
Bus	12	47	31
Walk-in	22	1	10

SOURCE: Unpublished operating studies of the Skokie Swift and Highway Research Circular 91, "Cleveland Transit and Parking Operations," Jan. 1969.

Bus Transit

A large city with bus service may have hundreds of bus stops established within the network. A significant number of these

Table 8.5—Distances driven to park or serve passengers at rapid transit terminals

Airline Distance (miles)	Parkers (%)	Passengers Picked Up or Dropped Off (%)
0-1	12	21
1-2	24	36
2-3	15	13
3-4	15	13
4-5	10	4
5-6	6	3
Over 6	18	10
	100	100
Average distance (miles)	3.8	2.7

SOURCE: Henry Quinby, "Coordinated Highway-Transit Interchange Stations." Highway Research Record 114, 1966, pp. 99-121.

are located in areas where there is opportunity for a degree of all-day curb parking. Some drivers take advantage of these opportunities—often to the consternation of people residing near the bus stops. Outlying parking is therefore already inherently available to some degree in any city with bus transit. As a result efforts to induce the commuters to park in an outlying lot and ride a regular bus may fail, particularly if a fee is charged for the parking.

Even where no fee is charged, the outlying lot must offer something better than is available on the street if it is to be used. A well-located and well-designed lot *can* offer certain advantages over on-street park-and-ride, such as the following:

1. Better bus service—A large, well-utilized lot may generate extra express service with increased frequency and reduced travel times compared to regular buses.

2. Parker security—Parking on the street in some areas exposes the commuter's car to vandalism or theft. His personal safety is also enhanced by the presence of fellow commuters and security guards that are sometimes employed to patrol the facility.

3. Assurance of parking—Some streets near transit stops lack sufficient parking. Space hunting may discourage the commuter, whereas the assurance of space in a lot would encourage him to park-and-ride.

4. Shelter—An overhead canopy to shield riders from the rain represents a minimum convenience at major transit stops. In northern climates, windbreaks, heaters, or heated enclosures are desirable.

A survey of three outlying parking lots near Washington, D. C., showed that about 85 percent of the persons using the lots came in a car that was parked on the site. On the average, each parked car carried slightly over 1.1 persons. About 1.2 transit trips were generated per parked car, which reflects some pickup or dropoff passengers.

Data from the Federal Highway Administration survey of 37 parking lots for change-of-mode to buses are given in Table 8.6. On a percentage basis, spaces may be seen to be concentrated somewhat closer to the CBD than those serving rail rapid transit.

Of the lots in Table 8.6, 95 percent were self-parking, 92 percent were lighted, and 97 percent were paved. Shelters were provided at 51 percent of the lots. The facilities are serviced by bus headways averaging 8 min in the peak hours and 26 min during off-peak hours.

Much of the parking is free. The Deen study found only three cases of successful bus change-of-mode lots where a parking charge was levied (*2*). These locations—in Cleveland, New York, and Chicago—all had somewhat special conditions. In Cleveland, several lots are located within 1 mile of the downtown, where on-street

Table 8.6—Bus transit parking as related to travel time and distance

Transit Travel Time to CBD During Peak Hour (minutes)	Number of Spaces by Distance From CBD (miles)					Total	Proportion
	0-1	2-3	4-5	6-10	Over 10		
0-10	4,410	620	0	150	0	5,180	34%
11-30	0	1,870	1,760	1,130	150	4,910	32%
31-60	0	290	0	2,000	2,990	5,280	34%
Total	4,410 (29%)	2,780 (18%)	1,760 (12%)	3,280 (21%)	3,140 (20%)	15,370	100%

parking is unavailable. Furthermore, many of the parkers do not use transit but walk to their destinations.

At the Lincoln Tunnel lot just west of New York City, drivers are discouraged from driving by tunnel fees and lack of Manhattan parking space. They are encouraged to park-and-ride because buses terminate at the Port Authority Bus Terminal, where direct connections are available with the New York subway system for distribution throughout Manhattan. Chicago's Soldier Field charged for parking but reduced the bus fare between the lot and the CBD. This produced a total daily round-trip cost, including parking, of only 5 cents per day above costs of parking on the street and riding a regular bus. This lot is only 2 miles or a 12-min bus ride from downtown.

Table 8.7—Bus park-and-ride

City	Location of Lot	No. of Spaces	Cars Parking Daily	All Day Parking Fee ($)	Distance to Downtown (miles)	Transit Time to Downtown (min)
Harrisburg, Pa.		225	Few			
Ft. Wayne, Ind.	Transit stop	25	6	0		11
Richmond, Va.	30 filling stations					
Cincinnati, Ohio	Public Landing	1,400	1,400	0.25	0.6	4
San Diego, Calif.	Balboa Park	900	10	0	2.0	8
Louisville, Ky.	Bowman Field	500	35	0	6.0	26-30
St. Louis, Mo.	Texas Street O'Fallon Park Willow Wood St.					
Los Angeles, Calif.	Hollywood Bowl		130	0.15	7.0	25
Baltimore, Md.	Pier C, Pratt St.	200	Few	0.30	1.5	
Washington, D. C.	Eastover Shopping Center	150	10-15	0	5.5	25
	Pen Mar Shopping Center	150	5	0	8.5	35
	Gregory Estates			0	7.0	
Boston, Mass.	Neponset Drive-In Theater	1,500	25-30	See transit fare	5.5	
Boston, Mass.	Revere Drive-In Theater	1,500	10	See transit fare	5.0	

SOURCE: Thomas B. Deen, "A Study of Transit Fringe Parking Usage," Highway Research Record 130, 1966, pp. 1-17.
[a] Round trip, including parking.

A number of bus change-of-mode lots have failed due to lack of patronage. In some cases, details of the operation are no longer available, and it is difficult to determine the cause. A listing in Table 8.7 provides evidence, however, that a successful change-of-mode operation requires some ingredients other than a paved lot, bus service, and a sign announcing the availability of parking. San Diego's 900-space Balboa Park lot attracted only 10 cars, and Louisville's Bowman Field lot with 500 spaces attracted 35. In Boston, the Neponset and the Revere Drive-In Theaters, each with 1,500 spaces, were opened to commuters for change-of-mode parking. The round trip bus fare was set at $1.00 and bus headways were established at 5 min during peak hours. The average number of cars parked in Nepon-

lots that have failed

Transit Fare to Downtown ($)	Buses per Hour		Date Discontinued	Factors Believed Contributing to Low Patronage	Remarks
	Peak	Off Peak			
			About 1955	Low downtown parking costs; easy drive	No lots now operating
				Low downtown parking costs; easy drive	
				Low downtown parking costs; easy drive	Gradually abandoned
0.10	10	0	1955	Drivers within walking distance of destination	Parking still provided; bus service discontinued
0.17	4	0	1955	Low downtown parking costs; no off-peak service	
0.19	6		1955	Low downtown parking costs; no off-peak service	
			1955		No other information available
			1955		No other information available
			1955		No other information available
0.23	6	3	1957	Parking fee charged	
0.10	7	0	1949	Parking fee charged	
0.30	3	0.5	1964	On-street fringe parking near with lower transit fare	
0.50	2	1	1962	On-street fringe parking near with lower transit fare	Lasted about one month
0.30				On-street fringe parking near with lower transit fare	On-street parking only; apartment house owners in area objected to cars parking on street, so discontinued
1.00[a]	12	0	1963	Rapid transit fringe parking nearby	Demonstration project; rail fringe parking nearby
1.00[a]	5		1963	Rapid transit fringe parking nearby	Demonstration project; rail fringe parking nearby

The North Bergen parking lot on New Jersey approaches to the Lincoln Tunnel has 1,550 spaces. Nonstop, air-conditioned bus service is provided directly to the Port Authority Bus Terminal in New York City at 5-minute headways during the rush hour and 15-minute headways at other times. The purpose is to relieve peak-hour congestion by having auto users transfer to buses. (Source: Port of New York Authority.)

set was 25; in Revere the number was only 10. The drive-in theaters are located on major routes. Inbound traffic moves quite freely beyond the theaters; between the theaters and downtown Boston, however, traffic is extremely congested during peak hours and heavy during other daylight hours. The minor response at these lots can be attributed to the availability of outlying parking at nearby rapid transit stations that offer faster service. The drive-in lots were subsequently discontinued.

Failure of change-of-mode parking in the small and medium-sized cities of Harrisburg, Fort Wayne, Richmond, Louisville, and even San Diego can probably be explained by the relatively low average downtown parking costs. Avoidance of downtown parking costs is one of the prime motivations of outlying area or

Table 8.8—Proportions of public transportation use, Chicago downtown area

	Percent Use by Each Mode					
	Arrivals			Departures		
Mode of Travel	7-10 a.m.	10 a.m.-4 p.m.	4-7 p.m.	7-10 a.m.	10 a.m.-4 p.m.	4-7 p.m.
Suburban rail	25	3	3	2	5	23
Rapid transit	31	22	32	31	22	33
Bus	16	16	15	19	15	16
All others	28	59	50	48	58	28
Total	100	100	100	100	100	100
Number of persons	399,000	261,000	159,000	136,000	260,000	378,000

SOURCE: Cordon Count, 1968, Bureau of Street Traffic, City of Chicago.

CBD parkers, and when this element is not present park-and-ride is not likely to be popular.

The many variables affecting bus change-of-mode facilities are difficult to isolate, because in each case several factors may operate simultaneously to determine the outcome. In general, however, successful bus lots involve such factors as (a) no charge for parking; (b) location on public or other land already used for parking; (c) self-parking, which minimizes the operating cost; and (d) adjacent bus lines that give frequent service.

Suburban Rail

Perhaps the oldest and most widely known type of modal change concerns the suburban rail stations. Small towns have grown up around stations located along radial lines leading to the larger cities such as New York and Chicago. Many of the commuter railroad operations have failed. By 1970, the need was becoming widely recognized to fit the remaining lines into a coordinated transportation system, irrespective of public or continued private ownership and operation of each travel mode.

The railroads can represent a very important carrier of people to the CBD. For example, about 25 percent of all persons entering the Chicago downtown area during the morning peak hours arrive by suburban rail. The operation is commuter-oriented, as shown in Table 8.8 by the concentration during rush hours.

The primary transportation used by commuters in reaching the outer rail stations is the private auto. The mixture of park-and-ride versus dropoff-and-ride varies with location of stations but tends to be affected most by parking supply.

Municipal parking field at the Rosedale station of the Long Island Rail Road permits 96,000 commuters annually to park and continue into the Manhattan central business district by rail. The 366-space facility near the city line is convenient by highway to south shore Long Island points. (Source: New York City Department of Traffic.)

SITE SELECTION

General Locations

Two general areas for change-of-mode parking may be identified. One is the outlying area typified by the suburban rail station, the outer terminals of rapid transit lines, or major stations or bus stops along the lines. The second location is in the *CBD fringe* area where several modal changes might take place. For example, thousands of suburban rail passengers destined to the Chicago Loop arrive each day at rail terminals located in the fringe several blocks away from the actual places of work. Some transfer to buses or taxis, while others walk into the central area. A subway connection is planned.

It is also possible to postulate other means of pedestrian "penetrator" travel, such as moving sidewalks or small conveyances on structures above the streets or underground.

Transportation System Factors

A change-of-mode parking program can reduce the cost of total urban transportation in two ways: Parking can be located so that it reduces the need for additional transportation facilities, and the costs of providing parking can be reduced.

Standards for the selection of sites should promote the larger community transportation objectives of (a) improving mobility and convenience for travelers, (b) promoting desirable land use development, (c) minimizing direct public expenditures for transportation, and (d) minimizing adverse impact on local communities and neighborhoods.

New facilities should generally be located in areas that are not already served by change-of-mode parking. However, in certain cases it may be desirable to reinforce a transit corridor by systematically locating lots along the route. This is especially true in connection with rapid transit.

Lots should be located just outside of major radial traffic bottlenecks to remove as many cars as possible from the traffic stream before entering the point of congestion. Change-of-mode lots should be visible from radially oriented major routes or freeways whenever possible. Commuters must know about a lot in order to use it. Furthermore, drivers observing other persons using the lot are more likely to try it themselves. If the lot is not visible, then additional promotion efforts should be made by use of roadside signs and television, radio, and newspaper publicity.

The closer to downtown a facility is constructed, the better will be its chance of attracting users. Such a facility may minimize travel time by allowing most of the distance to be driven by car; it can draw from the largest possible number of potential customers; and it may take advantage of the most frequent transit, both peak and off-peak. However, from a public investment standpoint, the facility should be located as far from downtown as possible in order to remove the maximum number of vehicle-miles driven during the rush hour traffic period and to use land that is less costly and for which there is less competition. Rail rapid transit and express bus service, at reasonable fares and frequent intervals, allow the greatest distances.

Impact on Adjacent Areas

Change-of-mode lots can be located in commercial, industrial, or high-density residential districts without adverse impact because these areas typically have significant land areas already paved for off-street parking. A facility in a single-family residential area, however, would probably be unacceptable unless there was sufficient land on the site to develop a

buffer from the surrounding homes or unless topography provided a natural separation.

Some otherwise desirable lot locations are in areas where a local parking shortage now exists. Care must be taken to ensure that the parking space is not utilized for local needs. If the local demand is primarily retail in nature, then the lot can be filled with change-of-mode parkers early in the day. However, if there is a shortage of local employee parking, these workers will compete with the change-of-mode commuters.

Lots should have direct or nearly direct access to major streets and should not require traffic to filter through local residential streets. The major street traffic flow should not be unduly penalized. The potential driveway problems can usually be handled by proper design and control. However, there are some otherwise desirable locations where sufficiently serious traffic problems could be generated to preclude the use of such sites. Examples can be found in or very near to freeway interchanges, or on some sites immediately adjacent to intersections of major routes.

Bus Service

Research on factors influencing the use of public transit has indicated that time spent waiting for buses is about three times as irritating to riders as time spent riding on the bus. That is, the effect on transit use of 3 min of riding time is about the same as 1 min of waiting time. Frequency of service is one of the critical factors that affects the use of a change-of-mode parking lot for buses.

A lot would have to provide for about 400 cars to justify a 10-min headway during the peak hour, if all the service was provided exclusively for the lot (assuming that 60 percent of the parkers arrived during the peak hour carrying 1.2 persons per car and that 50-seat buses were filled with a seated load). Although this figure can vary depending on whether fares are high enough to support the bus service without full bus loads and other less critical factors, it nevertheless is a reasonable approximation illustrating the importance of locating outlying lots along corridors currently served by buses.

Although 10-min frequency during the peak hour can be regarded as a minimum standard for service, there are other factors influencing use—low fares, fast, direct service, and a convenient lot—that might allow frequency to be reduced while still attracting riders.

It is obviously desirable to provide parking lots along routes that provide off-peak service as well as peak service. Although current data indicate that the overwhelming majority of bus use from change-of-mode lots occurs during peak periods, off-peak service allows the commuter to get back to his car if he must leave his office early or late. Most of the successful bus fringe lots have provided off-peak service whereas most of the unsuccessful lots did not. It would appear that a headway of at least 1 hour is needed. Because there will not be enough park-and-ride passengers to support the cost of such service, the concept of lot location along routes currently providing off-peak service is reinforced.

The location of any fare zone boundary should also be considered. Experience has demonstrated that drivers will not use a lot if it is located where they can drive a few more blocks, park at the curb, and save money on their bus ride. Care should be taken to locate lots so that a significant additional distance would have to be driven to reach a lower fare zone. In some instances this may require moving a fare zone boundary.

Some bus routes entering the downtown penetrate deeply into the heavy employment zones, providing direct service to large numbers of employees. Other lines come into the edge of the CBD, but not

within an acceptable walking distance of large numbers of employees. Lots located on bus routes of the latter type would be able to attract commuters destined to only a small proportion of downtown employment locations.

Land Development

Land for change-of-mode parking should be selected on the basis of (a) land currently in parking use; (b) undeveloped or unused land now in public ownership; (c) undeveloped private land; and (d) developed private land.

Some successful facilities are located on shopping center or stadium parking lots that are already constructed. They also may service parking demands occurring at times other than weekday business hours. Costs of developing park-and-ride facilities at such locations are minimal.

Undeveloped land in public ownership should also be considered early in the study of potential sites. Sometimes land is being held for future development, but it could be used on an interim basis. Excess land acquired in connection with street widenings or freeway construction should also be considered.

A low-demand corner of a regional shopping center parking lot is used for change-of-mode to buses. The buses then use the adjacent freeway to reach downtown Milwaukee. (Source: Milwaukee and Suburban Transport Corporation.)

Vacant or marginally developed property may be purchased or leased. A short-term, extendible lease may be considered on an interim basis. During this period, the public agency could experiment with the effectiveness of change-of-mode and accumulate the experience desired before entering into land purchase or a long-term lease.

A potential site should be reasonably flat and well-drained so that grading, paving, and drainage can be provided at minimum expense. Ideally, the site should have adjacent land available to allow for future expansion.

Parking at Suburban Rail Stations

In general, local suburban business areas have developed around the older rail stations. Competition for the available parking spaces may develop among shoppers, local employees, and commuters. Because these areas often have a high local land value, there may be difficulty in expanding the facilities. Economic factors tend to preclude the more complex development of parking structures under or over the tracks.

Simple expansion of parking is often accomplished by paving sections of railroad right-of-way. However, there are two principal disadvantages to this method. Both are products of the generally limited width of railroad land ownership:

1. The area between rail bed and edge of railroad right-of-way is often only sufficient for a single row of cars to be parked facing toward the rail. Such a linear expansion of parking quickly produces a problem of excessive walking distance. Furthermore, the extension of such parking is often interfered with by nearby streets crossing the tracks or by differences in grade within the railroad right-of-way.

2. The railroad in the area of stations is usually bounded on one or both sides by streets or service drives. The arrangement of parking at an angle along the tracks also tends to require unparking by *backing* into the street, which is a hazardous and undesirable arrangement.

Successful examples exist where the railroad and the town have cooperated in the development of commuter parking. This may take the form of mutual agreements on leasing or exchange of properties and local operation (sometimes with parking meters to pay for improvement, lighting, and policing costs).

The specific elements and local application depend on precise individual conditions. The degree to which typical commuters add to the vitality of each business area may be expected to vary widely. In some cases, the towns might benefit by relocation of a station *outside* their business area. In order to explore this, however, several factors warrant study:

1. The percentage of passenger pickup or dropoff operations that also directly results in use of nearby retail, medical, or service facilities—station relocation might well result in transferring such secondary trip trading elsewhere.

2. The extent of additional commuter spaces needed—in many cases, added spaces would be expected to reduce the amount of pickup-dropoff activity. This relates not only to factor 1 but also to existing traffic problems that the pickup-dropoff may be fostering.

3. The degree to which local employees are competing for commuter-oriented spaces—a possibility may exist to relocate much, if not all, employee parking to the other sides of the business sections. Facilities in such locations might involve little or no difference in average employee walking distance but would be out of practical reach for commuter parkers.

4. The degree to which local retail or service customers are using prime commuter parking areas—sometimes new retail lots are needed on streets away from the station that can serve shoppers equally well.

When factors such as these are considered, it should be clear that city-railroad cooperation and mutual assistance are essential.

Compatibility With Future Plans

Comprehensive plans being developed by the various local planning agencies are now recognizing the need for change-of-mode parking facilities adjacent to proposed rapid transit stations. However, less planning attention has been given to the development of change-of-mode lots for local bus transit.

When planning change-of-mode parking for a revised urban center or new satellite town, consideration should be given to the following points:

1. The change-of-mode lot is a low-activity area during all but the peak hours of the day. If urban subcenters are planned for high-intensity use, then change-of-mode parking should probably be on the periphery and not in the core of such areas.

2. Care should be taken that the local employee-parking demand for such communities will not usurp space designed for change-of-mode parking. However, allowing use by local *shoppers* is a practical and functional arrangement. The peak shopper parking demands in such areas typically occur during evening hours and on Saturdays. If the shoppers can readily "overflow" into the change-of-mode lot during these times, a greater community use can be made of the parking facility investment. For this to occur, careful coordination of location and design is required (*1*).

3. Change-of-mode parking for buses operating in *mixed traffic* may be feasible only if the community is not served by rapid transit parking. Satellite towns should probably be located on rail transit lines, but the possibility should be kept in mind of future reservations of exclusive lanes for bus rapid transit on freeways.

In the development of travel corridors, the freeway, a form of rapid transit, and (in the large centers) suburban rail should all be considered. In developing Chicago area radial freeways during the 1950s and 1960s, planners provided for added median widths that later accommodated rail rapid transit. The need for change-of-mode parking was also recognized. Plans were proposed that included parking structures spanning the freeways at station locations and having direct ramp access (*6*).

Bus rapid transit can also utilize exclusive lanes in freeway median areas (*7, 8*). Because of their greater flexibility, bus operations of this type can have application to a wide range of city sizes. Furthermore, bus rapid transit offers the opportunity of developing parking on land a block or two from the freeway. Short-radius ramps usable by buses, but totally impractical for rail, can allow convenient and less expensive connecting access (*9*).

DESIGN ELEMENTS OF TERMINALS

A variety of possible designs exist for different kinds of modal changes. Most of the principles peculiar to change-of-mode facilities can be illustrated by review of a lot designed to service a rail rapid transit station. The design conditions (except at outer terminals of the line) would be similar for stations serving express buses operating on exclusive lanes.

The basic dimensions needed for automobile parking were covered in Chapter Six. Reference is made to that chapter for stall widths, aisle widths and angles, markings, driveway designs, surfacing, drainage, lighting, and general methods of control. Certain details of self-park, fixed-rate parking fee collection have been covered in Chapter Seven.

There are three main elements of modal-change parking facility design that tend to be unique. These involve the inter-

relationships as well as design of areas for train boarding, bus or taxi loading, and private automobile pickup-dropoff. These elements are discussed in the following sections.

Orientation to Boarding Zone

The boarding zone consists of (a) the train platforms, including connections to both directions of travel, (b) the transit fare control system, and (c) the walks connecting to the bus, taxi, and passenger car loading and unloading areas. These areas should be located as close as possible to the boarding zone. The following schedule of location priorities is suggested:

1. Bus loading-unloading;
2. Taxi loading-unloading (may intermix with buses or with cars);
3. Passenger car unloading (dropoff);
4. Passenger car loading (pickup);
5. Short-term parking; and
6. Long-term parking.

Extreme care is needed to minimize pedestrian-vehicular conflicts within the more *active* areas such as the first three listed. A separation is also desirable between buses and passenger cars.

Figure 8.2 shows how conflicts can be avoided by proper arrangement. Depending on the size and shape of the total site, the functions may be grouped in the manner shown, separated, or combined. For example, the original Skokie Swift design combined the car, bus, and taxi entries with a one-way inbound driveway, including the major access lane to its parking lot. Internal layover space was provided for one bus and four taxis, plus 26 waiting stalls for pickup by private cars. The overwhelming success of the Swift system also immediately demonstrated the need for a larger terminal area and separation of certain conflicts.

Bus Loading and Unloading

The facilities needed for the bus transfer operation include entry and exit driveway, sidewalk-level loading and unloading, and layover or holding area. The linear feet of loading space, the need for a bus bypass lane, and the capacity of the holding area are related to the frequency of bus service. If taxi, airport limousine, or interstate bus connections are also included in the bus area, additional space may be required.

Bus layover to maintain scheduled headways may be provided in two ways. The buses may wait at the loading curb itself, or they may be temporarily stored in an offset lane as shown in Figure 8.2. Curbside layover is limited to about two buses for the design shown, and a bypass lane would be essential. Late-arriving passengers should be able to board buses in the layover area without any vehicular conflict.

The principal loading area should be sheltered and a covered walkway for the remaining distance to the train boarding area should be provided. The minimum shelter should be overhead as a protection against rain, with a 14-ft vertical clearance over the bus roadway area. In northern climates, three-sided or full enclosures with transparent walls would be desirable.

Automobile Loading and Unloading

The automobile passenger operation contains three critical elements: (a) dropoff, (b) temporary standing while waiting to pick up an arriving passenger, and (c) the actual pickup. The dropoff is principally a morning activity, whereas the pickup typically occurs in the evening. An exception would be domestic-help arrival in the morning and departure in the evening.

Ideally, a car arriving for pickup purposes should be able to enter and exit from a holding area without having to pass by any dropoff activity. The vehicle should (during inclement weather) also be able to recirculate close to the train platform to make the pickup.

On-street or in-driveway pickup or dropoff is undesirable because it promotes

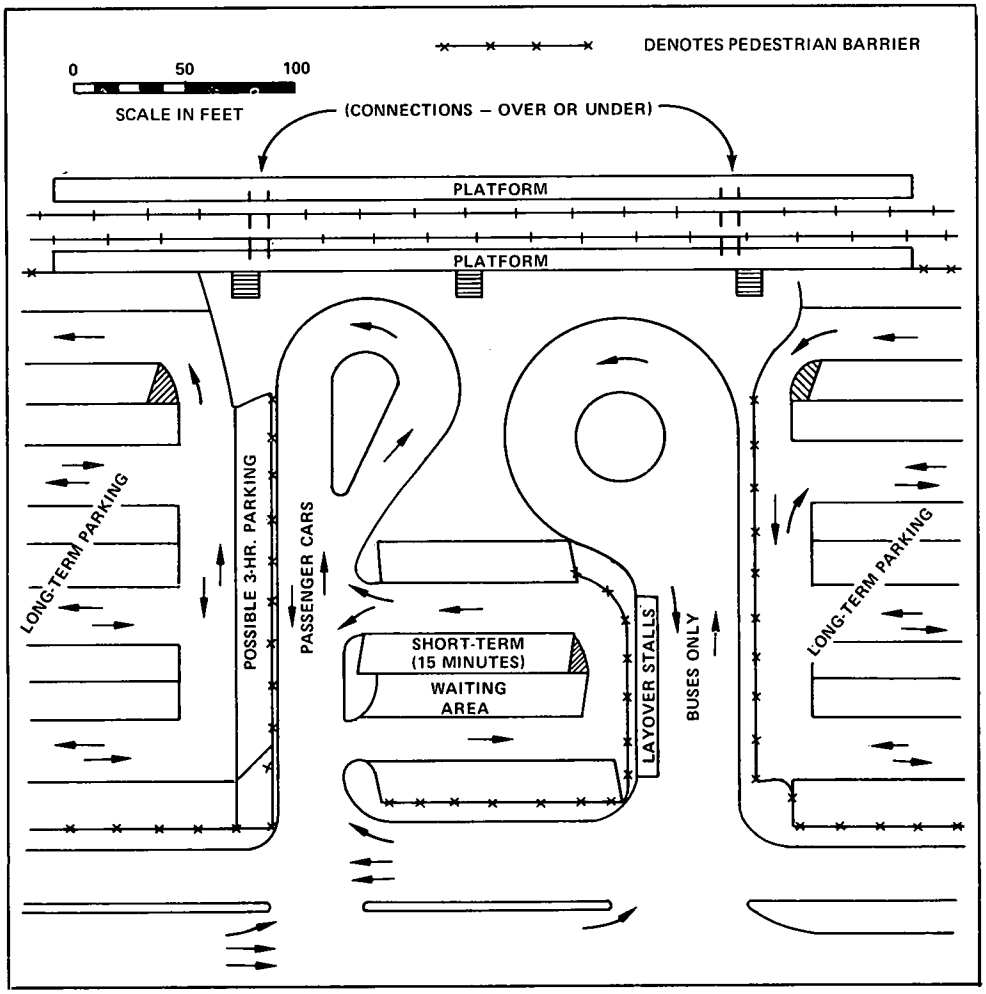

Figure 8.2. Example of a rapid transit change-of-mode terminal.

congestion and hazard. The terminal area provided to handle this activity should be designed with a sufficiently high level of service to encourage use in a positive fashion. This can be done by (a) locating the train boarding area at a substantial distance from the nearest street, (b) placing the pickup-dropoff lane close to the train area, (c) providing adequate capacity by ample driveway widths, bypass lanes, and temporary standing area, and (d) erecting barriers—fences and guardrails—to prevent pedestrian access from nondesignated loading areas.

The Skokie Swift studies found a pickup waiting area need for about 10 percent of lot capacity, or one space per 20 train passengers arriving during the peak hour. A modest over-design of any waiting area would appear to be far preferable to under-design. Part or all of the spaces can readily be metered for intermediate term parking, and hence produce revenue during the day. They can be cleared for

pickup use by imposition of a very short time limit (5 to 15 min) regulation, commencing just prior to the evening commuter surge.

Parking Operation

To minimize walking distance the parking lots should ideally radiate outward from the train boarding area. Aisles may readily be used by drivers walking to or from their cars, and special walks within the lots are usually unnecessary.

For lots of more than 200 spaces, at least one access point should be separate from the pickup-dropoff area. For the very large lots (more than 500 spaces) it will probably be found desirable to eliminate any access via the pickup-dropoff area. In the latter case train riders arriving as passengers in cars where the driver will park and also ride the train can be dropped off near the boarding area but from *within* the lot. Figure 8.2 shows such an inclement weather arrangement, which also allows recirculation to make an internal pickup.

If the parking facility is to be operated with a nominal fee, it will be similar to a commercial parking lot *except* that 24-hour access and egress should be provided. Fee collection at all hours can be handled in an excellent manner by *free*-in, pay-out coin gates. The gates can be

This well-arranged parking lot for rapid transit change-of-mode includes space for 235 cars and provision for loading and unloading of buses and private autos. A 25-minute ride to the CBD is available every 4 minutes during the peak hour. This compares with a 35-minute automobile trip. (Source: Chicago Transit Authority.)

locked open during the peak morning entry, thus eliminating any inbound delay or need for reservoir space. A detector should be provided to open the gate for arrivals during other hours.

A parking fee can also be collected as part of the transit fare collection or upon leaving the train fare control area. A token would be issued to operate the outbound gate of a free-entry, pay-exit system. This method has the obvious advantage of eliminating change-making problems. It also would assist in controlling a lot subject to use by nontransit riders such as local employees or apartment residents.

The need for some reduced-time-limit stalls separate from the bulk of all-day commuter use may exist. Reservations can be made for midday arrivals by posting parking restrictions, such as 3 hours, on selected spaces. These would normally be spaces located closest to the boarding area, to *encourage* off-peak use of the transit system.

Under certain conditions there may also be a demand for very long term parking (several days). This would occur where the lot could be used by persons desiring to park and then ride to an airport via the transit, connecting bus, limousine, or even a taxi. Such users should not necessarily be encouraged in preference to regular commuters. Any problem of this nature could be handled by setting a 24-hour time limit for the majority of spaces and leaving a few unregulated ones at maximum walking distance from the boarding area. Such spaces would be exposed to overnight parking, and security would be enhanced by a corner location near a public street.

Security also dictates an adequate lighting system for the entire parking facility plus periodic police patrol. Such a patrol, plus the possible regulation of time limits, illustrates the urgent need for coordination and cooperation between the local government agency and the change-of-mode terminal operator.

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CHAPTER NINE

CURB PARKING

The primary functions of streets are the movement of traffic and the provision of access to adjacent property. Other uses must be considered of secondary importance. Without traffic movement there could be no business activity. It should be noted that the U.S. Chamber of Commerce issued a policy statement in 1955 calling for the giving of "first priority in street and highway use to movement of people and goods with such restrictions on curb usage as this principle may dictate" (*1*). This was followed in 1959 by item 10 of a program for parking progress developed by the National Parking Association. In summary, the item supported the eventual elimination of on-street parking along the main thoroughfares of downtown areas so streets could be used for their originally intended purpose—to carry traffic (*1*).

More recently, the San Francisco Chamber of Commerce recommended that the city eliminate parking and stopping between 7:00 a.m. and 6:00 p.m. weekdays on one side of most streets in the financial district. They further recommended that the remaining curb space be devoted to extensive new truck loading zones—principally for use during the morning hours. The regulations were approved on a 6-month trial basis and implemented in the spring of 1970 with very satisfactory results.

The curb-parking problem involves primarily parking-related accidents and the conflict between traffic movement and the preemption of roadway by parked vehicles. The elimination of curb parking would significantly improve the accident record on most streets. Because some curb parking is necessary, however, it should be regulated in such a way as to minimize congestion and the accompanying accidents. In many instances, the economic losses stemming from accidents and congestion due to curb parking would probably pay for equivalent space in off-street parking facilities.

This chapter provides an overview of the congestion and accident problems generated by curb parking. A discussion of the various restrictions that may be applied to curb parking to achieve better use of the limited street space is included. Because most of the parking meters in service are located at the curb, their application and maintenance elements are also covered.

CONGESTION EFFECT

There is no question but that parking along a street significantly reduces the traffic-carrying ability of that street. It matters little whether one or several vehicles are actually parked; a single car can effectively close a lane and have a restrictive effect on passing traffic.

Traffic capacity is lost not only in the portion of street used for parking but also in the lane adjacent to the parking lane. Sometimes the entire width of a roadway is affected, especially a narrow one. The stopping, starting, and backing of vehicles during the parking maneuver physically restricts other traffic movements. The presence of vehicle passengers in the street, the opening of vehicle doors, or pedestrians walking out from between parked cars all tend to interfere with efficient vehicular movements.

There are many ways to lessen the adverse effects that parking has on the capacity of the street system. Foremost of these is the total prohibition of parking, stopping, standing, and loading along major streets. To establish a basis for such prohibition, a functional classification of the entire street system is required. A determination can then be made as to whether the purpose of the various streets or segments of streets is primarily to serve through traffic or local access. Consideration should be given to rapid traffic movement over greater distances versus slower movement of local traffic. The function of a roadway system, especially the major streets, is to provide a travel way from one point to another and to provide access to abutting properties. A successful system is one that performs these functions efficiently and safely.

Congestion and accidents are measures of the failure of the system to operate well, and they occur as the result of a breakdown of the orderly and smooth flow of traffic. Many times this breakdown is caused by the side friction of curb parking. Even though a street with parking

A single parked car (in the foreground) has forced this condition of dangerous lane changing and congestion. On two different occasions, the residents along this route voted (by postcard questionnaire) two-to-one for parking prohibitions. Yet two different political administrations refused to authorize the regulations. (Source: Paul C. Box and Associates.)

may be wide enough to carry the present traffic volume, greater capacity can be realized and a significant reduction in congestion accomplished through the use of parking prohibitions.

Problems of capacity during certain hours are often remedied through a part-time prohibition of parking along the affected street. Peak-hour parking restrictions are in widespread use throughout the country. The theory is simply one of providing extra traffic lanes during the hours when traffic demands are heaviest. This type of control is prevalent in most large cities during the weekday peak commuter hours, periods of evening shopping, and times of special events such as ball games. In this way, the street may serve a dual function—as a major route during the peak traffic load periods and as a facility providing more local access during the lighter traffic periods.

In general, the need for restricting parking at the curb also dictates the necessity of prohibiting the standing of vehicles. This applies as well to loading because a single vehicle stopped for any purpose during the peak periods blocks a lane of traffic. In commercial areas where loading is required during the off-peak periods, it may be well simply to prohibit all parking throughout the day. This does not preclude stopping and standing for loading and unloading but reduces the probability of trucks or other vehicles double parking for these purposes.

There are several well-defined areas where parking or standing should be prohibited at all times. These include locations adjacent to or within intersections, near driveways and alleys, adjacent to fire plugs, opposite fire houses, and within bus stops. They are discussed in detail later in this chapter.

Of particular note with reference to congestion are those areas adjacent to intersections. Where parking is permitted too close to intersections the result is blocked sight distances and poor visibility of vehicles and pedestrians. Also, vehicles parked close to intersections often block lanes that could be used by drivers to get around left-turning vehicles. At signalized intersections, parking spaces for vehicles should be even farther away from the intersection on both the approach to and the exit from the intersection. This will allow for greater intersection capacity because turning vehicles may be more easily bypassed and waiting traffic can queue two or more abreast. Thus a greater number of vehicles will be able to proceed through the intersection in less time.

Through a careful study of the municipal street system and proper provision for parking, traffic can often be expeditiously handled and congestion minimized. The capacity of streets must be kept in excess of the traffic volume if safe and efficient operation is to exist. The regulation of parking is a prime means of accomplishing this.

ACCIDENT HAZARDS

There is a definite relationship between accidents and vehicles parked along the curb. In 1965 and 1966, 16 percent of all accidents in U.S. urban areas were directly noted on the accident reports to involve vehicles parked along the roadway. From a comprehensive review of accident data, it is safe to assume that curb parking is directly or indirectly responsible for at least one out of every five accidents that occur in our cities each year. A review of the statistics will show that there are five primary causes of these accidents:

1. Vehicles parked in the roadway. These vehicles in effect present obstacles and serve to narrow the usable width of the roadway and restrict the flow of traffic. Such parking also restricts right-turning movements into and out of side streets, driveways, and alleys. Furthermore, parked vehicles may be struck, or their

presence may cause sideswipe or rear-end accidents.

2. Vehicles leaving the parked position. These create a disruption in the flow of traffic and, by increasing congestion, lead to rear-end and sideswipe collisions.

3. Vehicles entering the parked position. This operation frequently requires cars approaching in the lane adjacent to the parking lane to slow or stop. Parking maneuvers are especially hazardous because they usually involve a backing and turning movement. Rear-end and sideswipe collisions can readily result from this maneuver.

4. Drivers or rear-seat passengers getting out of parked vehicles on the street side. The opened car door presents an added obstacle in the roadway. Not only are the door and alighting passengers in danger of being struck, but passing traffic may have to swerve or stop suddenly. This produces both rear-end and sideswipe collisions.

5. Reduced sight distance. Pedestrians, many of them children, attempting to cross the roadway from between parked vehicles may not be seen by the motorist in time to avoid collision. A danger from impaired view also exists when vehicles are parked close to intersections and driveways. Depending on street grades and speeds, curb parking can create a hazardous sight obstruction if allowed on a major route within up to several hundred feet of an egress point.

The degree of accident hazard is related to frequency (density) of parking, the turnover, and traffic volume. A Skokie, Illinois, study found curb parking accidents varied directly with type of route. The major traffic streets experienced an overall rate averaging 5.8 curb parking accidents per mile per year, whereas the local street rate was 1.8 per mile per year. On a few miles of selected major streets where dense curb parking occurred, the rate averaged 12 curb parking accidents per mile per year.

Another Skokie study examined accident frequencies as related to land use along local streets. In every case curb parking was the leading cause of the local street accidents. The effects of parking density and turnover are reflected in the data given in Table 9.1. Findings from data such as these indicate that cities should regulate and strive to minimize curb parking on *all* streets.

ANGLE VERSUS PARALLEL PARKING

At the hitching post of yesteryear, the horse or cart generally stood at an angle to the street. With the development of automobiles, the trend was to park in a similar fashion. This unfortunate tendency remains in many small towns and may even occasionally be found in larger and otherwise progressive cities.

Table 9.1—Local street parking accidents

	Accidents per Mile per Year			
Type of Area	Curb Parking	Driveways	Pedestrians and Bicycles	All Others
Single family homes	1.04	0.15	0.13	0.12
Apartments	3.10	0.45	0.25	0.52
Business	3.50	1.65	0.20	0.72
Industrial	1.15	0.95	0.04	0.20

SOURCE: Paul C. Box and Associates.

Arranging parking at an angle to the curb accomplishes more parking per unit of curb length than parallel parking. This apparent advantage becomes greater as the angle becomes greater, until at 90 deg almost 2.5 times as many spaces are available compared with parallel parking. Unfortunately, as the angle increases, so does the need for greater amounts of roadway for maneuvering and so does the hazard of starting, stopping, and turning in streams of moving traffic. As a result, the "apparent" advantage of angle parking disappears when considering the combined disadvantage of interference and hazard along the street.

Originally, when operating speeds and traffic volumes were low, angle parking worked satisfactorily. But with today's fast-moving concentrations of traffic, angle parking is an unsafe anachronism that should be eliminated as rapidly as possible.

Many studies have been made that have shown the serious hazard connected with angle parking. The accident rate is typically several times that of parallel parking. As previously shown, accident rates involving parallel parking are in themselves cause for concern.

Significant results were obtained from a before-and-after study in Kansas City, Missouri (*2*). On several streets where parking was changed, there were five accidents per block per year with angle parking and one accident per block per year with parallel parking. Another study in Oakland, California, compared one street using angle parking with another having parallel parking (*2*). The street with parallel parking carried more traffic, including buses. However, there were only 23 accidents involving parked cars on this street, whereas there were 46 similar accidents on the street having angle parking. Intersection accidents showed an even greater difference: 82 on the street with parallel parking and 183 on the street with angle parking.

The principal hazard in angle parking is the lack of adequate visibility for the driver during the back-out maneuver. A second hazard results from the driver who stops suddenly when he sees a vehicle ahead in the process of backing out. Because empty parking stalls are difficult to perceive with angle parking, a third hazard results from motorists who are seeking a place to park. They must either proceed slowly (thus tying up traffic) in order to see the empty stall or slow abruptly when they come upon an empty space.

Some otherwise well-intentioned officials have thought that angle parking could be allowed on wide streets without the increased congestion and accidents that occur with its use on narrower streets. However, 45-deg angle parking along both sides of a 100-ft-wide street will affect the *entire width.* The angle-parked vehicles occupy nearly 18 ft of space, and their back-out operation directly affects an additional 12 to 15 ft. This in turn can cause lane-change accidents in the second lane away from the angle parking. These problems may be readily noted by observing typical angle parking activities.

Because angle parking is such an obsolete concept, there has been a steady trend toward its elimination throughout the United States. In the Inventory of Traffic Safety Activities of the National Safety Council, it has been standard practice to record the amount of existing angle parking that a given city had *removed* since its last report. Such data were used to help establish "credits" toward general traffic safety efforts.

There are, of course, conditions where one or more blocks can be closed to through traffic and converted into parking malls. The necessary factors are that (a) the street is not required for the traffic network, (b) through traffic can be effectively prohibited, and (c) the parking is so urgently needed at the location that it is more important than block circulation.

Progressive traffic improvements are evident in this city: left-turn bays, adequate street lighting, good pavement markings, fine traffic signal arrangement, but *the angle parking along one curb is likely to cause needless accidents and congestion. This parking preferably belongs off the street, but at least it should be of the safer parallel type.*

CURB-PARKING PROBLEM AREAS

The general practice of parking will depend on the adjacent land use. The determination of time limits and, in fact, the decision of whether or not curb parking is to be allowed must be consistent with the demands of the motorists in the area. Functional classification of the street system and application of zoning provisions can help in formulating parking restrictions.

Within a city, various areas have different land uses and therefore different curb-parking practices. Such areas include retail (both within the CBD and outlying fringe), industrial, and residential, plus other uses including transportation terminals, institutions, parks, and shopping centers.

Regardless of the kind of curb parking being considered, there are certain common elements. These include type of parker, duration of parking, purpose of trip, and time of day of the parking demand. These factors are discussed in the following paragraphs in relation to the principal areas of curb parking.

Retail

Retail areas (non-shopping-center type) occur both within the CBD and in the outlying areas. In the CBD, very few curb parking places can be provided for the retail shopper. Because of this and the demand for long-term parking by employees, these few curb parking spaces must provide for a high turnover to be effective. Hence, short time limits must be imposed together with high parking meter rates and strict enforcement. Off-street parking facilities must be provided nearby for employees and long-term shoppers.

In the larger cities with mass transit systems, much of the available curb space will be required for transit and taxi loading zones and passenger loading zones at building entrances. After the evening peak hour, it is frequently possible to increase substantially the number of available curb parking spaces by allowing use of freight and passenger loading zones at buildings that have closed for the night. Curb parking in the evening can also be permitted along lesser streets when relieved of their burden of heavy traffic and daytime employee demand.

Retail curb parking in the outlying areas may occur along streets near neighborhood and community shopping facilities. These areas are generally older than most shopping centers and consequently often have little provision for off-street parking. Their usual location along and near the intersections of the city's major routes is particularly unfortunate. There is usually insufficient parking space. Accordingly, a high curb turnover rate is required along with the necessary controls to ensure such

A severe parking shortage in this older neighborhood area is evidenced by heavy use of the curbs for vehicle storage and even double parking, thus significantly increasing hazards and promoting congestion.

use. Further, all parking frequently must be prohibited during periods of peak movement. When allowed, it generally creates more hazardous traffic movements because of the continual conflict between through and local traffic.

Industrial

Curb parking in industrial areas usually involves employees, who often cause parking problems in adjoining areas. Obviously, industrial firms cannot rely on curb spaces to provide for all of their parking needs. Off-street facilities are essential. However, if convenient curb spaces exist, regardless of the off-street provisions, parkers will use the street areas. The more convenient spaces can be partially made available for visitors to the area by installation of time-limit controls. This will produce a higher turnover and hence ensure an efficient use. The time-limit restriction should be enforced equally against all users. It should not become a reservation of curb space for residents or for industrial executives.

There may also be a need to restrict parking along narrow streets to facilitate access by emergency vehicles.

Residential

An auto owner typically wants unlimited parking at the curb near his residence, generally without parking fee. The provision of one to two off-street spaces per dwelling unit (as recommended in Chapter Three) will greatly assist in freeing the streets of parking encroachment. It will help make the local street curbs available for guest parking. The single-family home and the small apartment must almost always rely on the local street system to act as a reservoir for unusual demands. It is practical and proper for a large apartment development to furnish adequate space for all users, but the average homeowner cannot be expected to store more than one or two guest cars, in addition to his own. Occasional overflow, such as that caused by parties, simply must be met by use of a local street.

In the older parts of cities, narrow streets frequently traverse districts of narrow lots with little or no off-street parking. Severe problems can thus occur in even single-family neighborhoods. The constriction of access often causes one-way street postings to be installed. If the areas contain even small apartments, the residents may suffer severe shortages of parking.

Milwaukee, Wisconsin, is one city that has levied a fee for overnight parking on the street. In opposition to a bill in 1969 to eliminate the $4.00 monthly charge, city officials reported that currently 15,000 cars were parked overnight, but that up to 75,000 would be if there were no charge.

Residences within the CBD may have parking problems and restrictions similar to all other CBD developments. Of late, many cities have experienced the construction of large numbers of CBD apartment units for which virtually all parking needs are met off-street, with little reliance on curb parking.

Other residential areas may be adjacent to commercial development. Services for the householder encourage such development "at-hand," but the commercial parking demands may spill over onto nearby residential streets. This not only interferes with the needs of the residences but occasionally prompts the application of time-limit controls so that the desired turnover can be provided. This in turn causes the longer term parker to seek space deeper into the residential area.

Recreational

For the most part, curb parking is limited on access roadways traversing park areas. The demand for parking spaces in recreational areas occurs in peaks, most often during the summer months and on weekends and holidays.

In addition to picnics and ball-playing, larger public events may be found such as concerts, sporting events, and outdoor shows. For all such cases, public parking lots are necessary.

At small neighborhood parks the infrequent demands for parking facilities may result in little or no effort being made to provide for off-street facilities. Available curb spaces are relied on to handle the demand. This can be hazardous and a source of annoyance to abutting residences. Progressive communities are providing parking lots for even small one-block parks.

Shopping Centers

At shopping centers, in addition to parking spaces for shoppers, special areas should be provided for passenger and commodity pickup. The shopping center's regular parking lot areas should not be used for this purpose because of the obvious inconvenience. Therefore, a sufficient number of strategically located curb pickup locations should be provided within the center. Generally, parking is not allowed in such areas and stopping is permitted only for the purpose of loading.

Change-of-Mode Terminals

Local problems are sometimes caused by people who park near a mass transit terminal or bus stop and continue their trips via public transit. When adequate off-street parking is not available, drivers encroach on parking spaces required for use by adjacent residential or retail areas. This creates friction and demands for

A parking lot serves this neighborhood park. The adjacent major route has street parking prohibited. Curb parking on routes bordering recreation areas such as ball parks is especially dangerous. (Source: Paul C. Box and Associates.)

"special privilege" resident permits. Issuance of such permits for public streets is clearly improper. The best action that municipal officials can legally take is to post and enforce special time limits that are of minimum inconvenience to residents.

Parking problems along the roadways within airports and at bus and rail terminals stem principally from the lack of adequate supply to satisfy the extensive demand for close-in, short-term parking. Obviously, considerable roadway space must be provided for standing vehicles to handle the significant loading of passengers, from both private automobiles and public conveyance. Within the loading area, designation of spaces for public use must be made and a regulation installed to prohibit parking. Very short (such as 5-min duration) parking stalls are sometimes provided for public standing.

Institutions

Schools, churches, hospitals, and public buildings such as city halls and post offices are among the types of land uses that create specialized curb-parking problems. For example, the increased use of cars by both high-school and college students, as well as the significantly larger enrollments in recent years, accounts for much of the school parking problem.

Very few institutions within cities can provide sufficient parking space to meet usual demands. Consequently, the parking commonly spills over into the adjacent street system. This in turn conflicts with residential and commercial uses. The problems of overflow into adjacent areas can frequently be handled adequately by time-limit restrictions and parking fees through metering. This will encourage use of less

Problems of baggage unloading are prevalent at airline terminal entrances. Double and even triple parking results from attempting to load and unload buses, taxis, and cars at the same curb. (Source: City of New York.)

This modern high school has been provided with off-street parking lots and areas for passenger car and school bus unloading. The access route has been signed "No Stopping or Standing" to prevent dangerous curbside activity. (Source: Paul C. Box and Associates.)

restricted and less expensive, though more distant, areas. It may, however, cause problems with abutting residents.

It is necessary to provide for visitor parking. At most institutions this can be accomplished within off-street areas. Time-limit restrictions can assist in producing the required turnover.

Curb loading areas and even specially designed curbs are necessary at most institutions for the handicapped.

PARKING PROHIBITIONS

Types of Regulations

Control of curb parking is accomplished through the adoption of various parking regulations, followed by conspicuous signing and marking along the roadway, and implemented by enforcement. Several different regulations are currently in use:

1. No Parking—A no parking regulation is used along those portions of roadway where occasional stopped vehicles will not cause a hindrance to the safe and efficient flow of vehicles. This regulation may be used throughout the full 24-hour period on the major roads, or only during the peak commuter hours, times of special events, or like periods. The no parking regulation permits the stopping of vehicles for the purpose of loading or unloading persons or goods. Such vehicles are not considered to be parked during the loading operation.

2. No Standing—A no standing regulation allows a driver to stop for passenger pickup or dropoff, but ordinarily does *not* allow prolonged unloading of merchandise from trucks. It is used where the curb space must be kept clear practically all the time during the effective limit of the regulation. In most cities, the no parking

regulation, when properly enforced, is almost equally effective.

3. No Stopping or Standing—The no stopping or standing regulation is used along those portions of roadway where the presence of vehicles stopped at the curb during any or all hours would constitute a critical impediment to the safe and expeditious flow of traffic. Such locations include those near fire houses, in tunnels and on bridges, at railroad tracks, or along the approaches to a signalized intersection where capacity problems are extremely critical. This regulation restricts the stopping of any vehicle (passenger car, truck, or bus) at the curb for any purpose during the times of the restriction, except in obedience to an officer or traffic control device. A high enforcement level of this regulation is very difficult to achieve and often requires the addition of a tow-away regulation to permit vehicles to be moved when considered to be an obstruction by a police officer.

4. No Parking (Loading) Zone—Various short-term no parking regulations are necessary in urban areas to ensure that adequate space is provided for taxis, loading and unloading, bus stops, passenger zones, and like situations. These are discussed under Special Purpose Zones later in this chapter.

Statutory Requirements

Certain common restrictions do not require posting of no parking signs. Typical "standard" prohibitions are set forth in the Uniform Vehicle Code (*3*). Many cities are able to take advantage of the regulations by direct adoption of pertinent sections or by reference provisions of state law. The more important standard regulations from Section 11-1003 of the

The problem of enforcing a no-stopping regulation is especially severe during a peak retail season. (Source: Delaware Valley Regional Planning Commission.)

1968 Edition prohibit parking in the following locations (wording not verbatim):

1. On a sidewalk;
2. In front of a public or private driveway;
3. Within an intersection;
4. Within 15 ft of a fire hydrant;
5. On a crosswalk;
6. Within 20 ft of a crosswalk at an intersection;
7. Within 30 ft on the approach to any flashing beacon, stop sign, or traffic-control signal located at the side of a roadway;
8. Between a safety zone and the adjacent curb or within 30 ft of points on the curb immediately opposite the ends of a safety zone, unless the traffic authority indicates a different length by signs or markings;
9. Within 50 ft of the nearest rail of a railroad crossing;
10. Within 20 ft of the driveway entrance to any fire station and on the side of a street opposite the entrance to any fire station within 75 ft of said entrance (when properly posted);
11. Alongside or opposite any street excavation or obstruction when stopping, standing, or parking would obstruct traffic;
12. On the roadway side of any vehicle stopped or parked at the edge or curb of a street; and
13. On any bridge or other elevated structure on a highway or within a highway tunnel.

Because these regulations are not necessarily known by all drivers, it is common practice for municipalities to install signs (especially in problem areas) for items 6 through 10.

Special-Purpose Zones

Loading (Freight) Zones—Historically, inadequate attention has been given by cities to truck loading problems. A post-World War II study in New Haven found 88 percent of truck loading or unloading to be conducted at the curb (*4*). Although the chronic alley shortage in that city might suggest unusual findings, a 1959 study in Nashville, Tennessee, found 87 percent of CBD truck loading to be at the curb, but only 36 percent of loading to take place at established curb zones (*5*).

Curb loading zones are needed to provide space for the loading and unloading of commercial vehicles when alley and off-street loading areas, frequency of loading and unloading operations, and general curb-parking conditions might otherwise result in truck double-parking.

Cities frequently post on the loading zone signs the hours and days of the week when effective. This frees the zone for off-hour use by other vehicles. Freight zones typically allow any user (truck, car, etc.) to load or unload. These zones should not be restricted to the place of business they may abut because the concept is one of a *public* loading zone. Because cities often levy fees for establishment and maintenance of the zone, friction will sometimes develop between the payer and his neighbors.

Zones should have sufficient length to allow parallel truck access. This will depend on the length of the trucks that will use the space and the location within the block face. Usual zone lengths are 30 to 60 ft. Extensions of existing no-parking areas (such as driveways, fire hydrants, or intersections) are preferred because these areas can be used for easier maneuvering. It is usually not necessary to have the zone at the exact point of loading access.

Proper enforcement is necessary to prevent curb loading zones from becoming "private" parking for store owners, managers, or employees. Violations can often better be handled by parking tickets

rather than zone removal. Taking the zone out may simply create a double-parking problem with trucks.

The frequency of truck use to warrant a zone is a matter of local policy. An average of one loading per day is sometimes used as rule of thumb, and the use by several businesses should always be planned.

Taxi Zones—Taxi operations play a necessary part in the overall transportation and traffic patterns in our larger cities. Most cities allow taxis to utilize exclusive curb areas at strategic points, although they require them to comply otherwise with general stopping and standing regulations.

Zones are usually limited as to the number of cabs. A two- or three-cab zone is typical in a suburban area or at a small CBD hotel. Use is sometimes restricted to one taxi company, but this may not be desirable for several obvious reasons.

The general change from "call box" to radio-control of cabs has greatly reduced the need for stands at busy intersections. Although taxi owners may strongly prefer such locations, it is good practice to locate the stands well back (150 to 200 ft) from signalized intersections.

When removal of curb parking meters is necessary for installation or enlargement of a taxi zone, some municipalities charge the companies for the lost meter revenue (gross revenue less maintenance and collection charges). An annual billing of $50 to $100 per stall may thus be developed.

Length needed for each stall is about 20 ft, plus 5 ft of added maneuver access at each end of the row, if not otherwise clearly accessible.

Bus Loading Zones—At bus stops, sufficient curb space must be provided for the boarding and alighting of passengers. It is essential that buses be permitted to enter and leave the traffic stream for this purpose. The required length of parking prohibition ranges from 50 to 145 ft, depending on bus size, number of buses at one time, and location of stop (near-side of intersection, far-side, or midblock). Whether bus stops are near-side, far-side, or not permitted at all depends on the intersection geometrics, the traffic volumes, turning movements, bus-route turns, and other pertinent factors, Midblock locations have certain advantages. An engineering study is required for proper placement of stops.

It is common practice also to allow use of bus zones by passenger cars to load and unload passengers, but *not* to stand in the zone. Truck standing, even when engaged in loading or unloading merchandise, is ordinarily *not* allowed.

Passenger Zones—Zones for picking up and dropping off passengers by private vehicles and taxis may be required at many places within a city. Theaters, hotels, stadiums, and schools represent the more typical locations where curb provisions are often made. Such zones are like bus zones in that they do not allow general parking or even standing. The success of these zones is dependent on rapid use of as small a space as possible by many vehicles.

A single stall will suffice for most passenger zones if it is properly designed. A vehicle should be able to pull into and out of the zone without any backing up. This requires 50 ft for most drivers, if parking is allowed at both ends of the zone. At certain high-demand locations such as hotels and change-of-mode terminals, two or more stalls may be required. A length of 25 ft should be provided for each added stall.

When not required for passenger use the zones can be released for general parking, but the opportunity for this is rare.

Agency Zones—Many cities have posted regulations such as parking for police, sheriff, or ambassador only. The

legality of such signs is questionable, and the public reaction may be adverse. A preferable place for the spaces is in parking lots, where the reserved parking is less obvious than at the curb.

Part-Time Prohibitions

Part-time parking and stopping prohibitions are perhaps the most prevalent form of restriction presently in use. Examples include prohibitions of parking or stopping or both along traffic routes heading into town during the morning rush hours and away from town during afternoon rush hours and prohibition of parking near stadiums and convention halls, in the area of parades and special events, near schools and playgrounds, and for uses such as loading, snow removal, and trash collection.

Part-time prohibitions, when properly used, have the distinct advantage of being able to ensure maximum capacity of the street facility during times of heaviest traffic movements while permitting parking during the hours of lighter traffic. As the traffic demands increase or as the periods of heavy traffic lengthen, the part-time restriction must necessarily be increased and perhaps become a full-time restriction.

Rush Hour—The commuter rush-hour parking restrictions are usually quite predictable and generally apply every day except Saturdays, Sundays, and holidays. The specific hours will vary according to the traffic volume and geometric design characteristics as well as the type of areas and land uses served by each route.

Rush-hour restrictions are sometimes posted to the nearest half-hour, but a preferable range is in full-hour increments, which allow maximum legibility. Morning limits are typically 7:00 to 9:00 a.m., and evening limits 4:00 to 6:00 p.m.

Business Day—The CBD areas of most cities require curb parking restrictions during both rush hours *and* the midday period. This is normally accomplished by allowing no parking from 7:00 a.m. to 6:00 p.m.

School Day—Adjacent to a school, the restriction should cover movement to and from the school, plus intermediate hours. A typical posting is "No Parking 8:00 a.m. to 4:00 p.m., School Days." If the location is on a major traffic route, the business day restriction is a preferable posting to clear for *both* rush hour and school traffic needs.

Street Cleaning—Other routine and predictable part-time parking restrictions include periods of trash collection and street cleaning operations. These will vary by neighborhood but may occur one or two times per week on a scheduled basis. In the case of street cleaning, special periods are sometimes necessary, particularly during the fall leaf collection season. Some other special and generally unpredictable parking restrictions include those associated with snow removal and related problems, construction areas, and unusual traffic operation problems such as detours, natural disasters, and other emergency use.

Special Events—Situations that might be categorized between the normal, thoroughly predictable part-time restrictions and those sporadic and unforseen are the anticipated, though infrequent, restrictions related to ball games, theater events, parades, and similar occurrences. For example, ball-game traffic may occur day or night, on a weekday or weekend, on a holiday, and during commuter hours or otherwise. Further, the traffic volumes will vary significantly from game to game. Such events are generally best handled on an individual basis by using temporary signs.

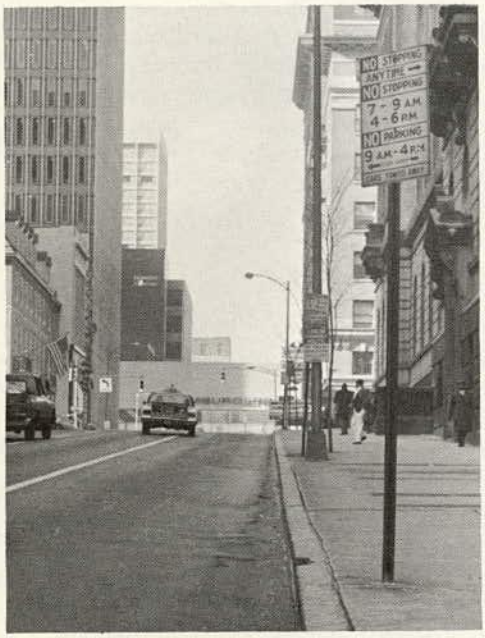
Full-Time Prohibitions

Full-time curb-parking prohibitions are desirable on all major traffic routes and

on narrow local streets. The regulations on major traffic routes may involve a prohibition of stopping and standing at all times or a prohibition of parking at all times with no stopping or standing during peak periods only. Where consistently high traffic volumes are a factor, the no stopping or standing regulation is used. Where traffic volumes slacken or are minor and there is a need for keeping the curb space free for loading and unloading or other purposes, the no parking regulation is used.

The no stopping regulation should be used sparingly because of the enforcement problems.

There are other full-time parking prohibitions involving smaller segments of roadways that are needed to provide intersection capacity, emergency vehicle accommodation, 24-hour loading areas, and bus stops. These prohibitions may consist of either the no stopping or standing designation or the no parking message, depending on the particular situation and its related traffic and safety requirements.



The confusing maze on this parking restriction sign is produced by attempts to allow standing and loading during the off-peak hours (9:00 a.m. to 4:00 p.m.) in part of the block but to restrict stopping in the entire block during rush hours and in the foreground area at all times. The need for such complex regulations is questioned by many engineers.

A local street having a width of less than 16 ft requires prohibition of parking at all times on *both* sides, even with one-way or occasional two-way traffic. A width range of 17 to 24 ft generally requires full-time prohibition on one side. When the two-way movement is more frequent, widths of less than 26 ft should have parking prohibited on *both* sides, whereas widths of 27 to 31 ft may need one-side prohibitions.

Warrants for Parking Prohibitions

Parking prohibitions can theoretically be warranted under three conditions—statutory, capacity effect, and hazard. A national consensus is available in the statutory warrants of the Model Traffic Ordinance (*3*). The 1968 edition of the Ordinance authorizes full-time prohibitions on both sides of roadways not exceeding 20 ft in width and on one side of those not over 30 ft wide.

Authoritative capacity studies have found that typical streets with parking have only two-thirds the capacity of those with curb parking prohibited (*6*). The *effect* of curb parking appears at volume levels that are only a fraction of typical capacities. This effect varies with the number of lanes and whether the location is midblock or at an intersection. On a four-lane street having parking on both sides (thus allowing one moving lane in each direction), a single vehicle waiting to turn left completely blocks the through traffic on its own side. However, if the street has at least two moving lanes for each direction, in addition to parking, a

Table 9.2—Parking prohibition criteria

Type of Prohibition	Maximum Vehicles per Hour per Lane When Parking Allowed (One Direction of Flow)	
	1 lane	2 or more lanes
Midblock prohibition for entire street	400	600
Intersection prohibition up to 150 ft on approach and departure	300	500

SOURCE: Paul C. Box, "Criteria for Regulation of On-Street Parking and Curb Loading Zones," Tenth Pan American Highway Congress, Montevideo, Uruguay, 1967, Table II.

higher per-lane volume can flow effectively.

The criteria recommended as a warranting condition for parking prohibition are given in Table 9.2.

Towing Zones

Many cities have established "tow-away" zones along their principal routes because a single parked car may create extended congestion and lane-change hazards for a block or more upstream. The ordinances allow the police to tow away vehicles that are parked illegally. The regulation may be used with any type of prohibition, but it most usually is associated with the rush-hour type.

Ordinances empowering tow-away typically require public notice through the use of signs. A small plate reading "tow zone" is often affixed below the standard no parking sign.

TIME-LIMIT RESTRICTIONS

Purpose

The primary reason for imposing time-limit restrictions on curb parking spaces is to provide an efficient use of such spaces through a turnover of users. Such a turnover, although compensating for a lack of larger parking facilities, can only be effective where business and social transactions in the area are short in time and when proper *enforcement* exists. A maximum use is thus made of each individual space. Time-limit restrictions placed along curb parking areas are also useful in discouraging employee, commuter, and other long-time parkers from usurping space in retail and business areas. Further, very short time limitations effectively provide the required rapid turnover at busy (short business time) places such as banks, post offices, and passenger or merchandise loading areas.

Methods

Time-limit restrictions in effect are conveyed to the parker through the use of signing. Such signs as "One Hour Parking 7 a.m. to 6 p.m." and "15 Minute Parking" are examples of those used. Use of signing alone requires that sufficient enforcement be available so that the parking durations of vehicles can be checked. Further, such timing must be by notation of vehicle registration license, marking of a tire, or other means of identification.

Often preferred in addition to signing is the use of parking meters. Meters give a definite measurement of time and an instant reading of remaining time or violation. They also can promote short-term parking through charging a relatively high fee and may be self-liquidating (see Parking Meters section of this chapter).

Types of Time Limitations

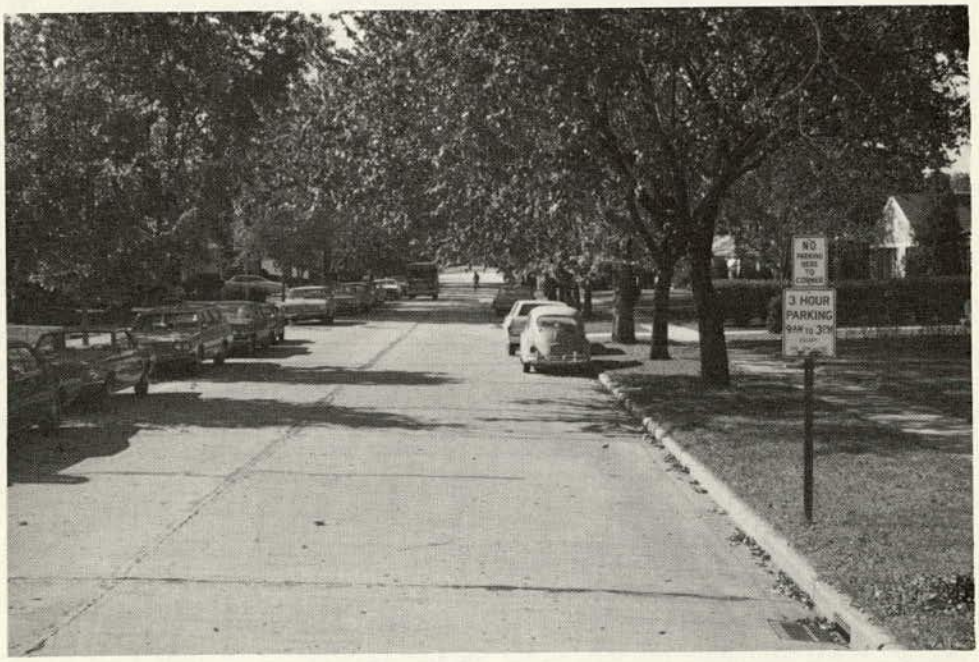
Very short limits (5 to 15 min duration) are used at places of high turnover such as banks, post offices, "quick-trip" shopping, and public buildings. The number of such spaces is usually small, and they are generally placed closest to the place of business served.

Average limits (30 to 120 min) are used at locations requiring a good turnover rate. Such locations frequently involve retail areas along major streets having little or no off-street parking, thereby requiring that as many persons as possible be given the opportunity to park. The type of business generally dictates the actual time limitation displayed. As examples, smaller stores with quick service such as repair shops, bakeries, and "five and ten" stores would more likely warrant a 30-min limitation; larger grocery stores and department stores generally require time limits of greater length. Other uses might include pickup areas at rapid transit stops and parking near medical offices. Here again, the shorter time limit is placed closest to the place of business.

Extended limits (3 to 10 hours) have various applications; 3-hour limits are useful in CBD fringe residential areas to discourage employee parking and are also used near outlying commuter stations. The longer limits can preclude the use of spaces for vehicle storage or by travelers out of town utilizing public conveyance.

SIGN INSTALLATIONS

In order to regulate parking it is necessary to inform the motorist of pertinent parking restrictions. This can be accom-



The time limit signs on this single-family local residential street were installed to discourage all-day parkers from a nearby transit station. The opposite side does not have the signs and is parked so heavily that a delivery truck has been forced to double park. (Source: Paul C. Box and Associates.)

plished by a thorough program of signing because this is the medium by which the motorist can readily be advised of applicable regulations.

Colors

The Manual on Uniform Traffic Control Devices for Streets and Highways gives certain generalized standards for signing. It is approved by most state legislatures and the Federal Highway Administration. In the 1961 edition the Manual states, "The legend on parking signs shall state whatever regulations apply, but the signs shall conform to the standards of shape, color, location, and use" (*8*).

The Manual further states that "where parking is prohibited at all times or at specified times, parking signs shall have red letters and border on a white background; and where only limited-time parking is permitted, or where parking is permitted only in a particular manner, the signs shall have green letters and borders." Where parking is prohibited for certain periods of the day and restricted for a certain time limit at other periods, two signs should be used together or a single sign with both messages may be employed, using the proper color combinations.

If the parking regulation applies at night (such as no parking anytime) and street lighting is poor, it may be desirable to use a reflectorized message.

A special type of sign is being used increasingly to guide drivers to off-street parking facilities. This parking area sign uses the word "parking" together with a directional arrow. The legend is green on a white background.

Locations and Sizes

The sign should state as concisely and clearly as possible the restrictions or prohibitions under which the motorist is placed. The area in which the regulation is applicable can be clarified through the use of arrow indicators in addition to the sign legend. At the end of a regulatory zone a single-headed arrow pointing in the direction to which the regulation applies should be used. Where the zone is longer than 200 ft, signs with double-headed arrows should be placed at intermediate points within the zone. When arrows are used, the signs must be placed at an angle of 30 to 60 deg with the curb.

For parking signs in urban areas, the size most frequently found is 12 in. by 18 in., although the 18- by 24-in. size is growing in use. The advantage of larger signs lies in their increased readability at a distance. Generally speaking, the sign immediately in *front* of a driver specifies the regulation if within the same block. Depending on the sign legend, a 600-ft block may require up to four signs of 12- by 18-in. size to convey adequately the same message as three 18- by 24-in. sizes.

The parking area directional sign is usually installed on major routes at the nearest point of access to the parking facility. Where driveways connect only to a side street, the sign can be used to direct traffic onto the access street, with another sign placed at the driveway.

The Manual recommends that parking signs "be mounted not less than 7 ft nor more than 10 ft above the top of the curb, and with no part of the sign less than 2 ft back from the face of the curb." Thus, the sign is not likely to be blocked by parked vehicles, and it will not be a hazard to pedestrians. Further, the sign standard will be less likely to be damaged by errant vehicles.

Parking signs should be placed on existing structures such as utility poles, street lamps, or traffic signal standards whenever possible because a major consideration in signing should be to minimize the number of obstacles and clutter along the roadway. However, correct loca-

tion should not be sacrificed through this practice, and utility poles should be used only with the permission of the controlling company. Where existing structures cannot be utilized, the parking sign should be mounted on a post of sufficient strength that it will resist the force of wind and vandalism.

Maintenance

The signs and supports should be well maintained and replaced if damaged or lost. Good maintenance includes regular, scheduled patrolling, adequate stockpiling of signs, and rapid replacement of defaced or damaged signs. In addition, a periodic replacement program is needed because of weathering. If not properly maintained, a sign will eventually cease to be visible to the public. The effect of many traffic engineering measures will be negated if the signing does not convey the regulations to motorists.

STALL MARKINGS

A study by the American Automobile Association reportedly found a 43 percent reduction in the average time required to park in properly marked stalls as compared with unmarked stalls (*9*). When parking meters are used it is customary to apply stall markings. The markings are also of value, however, when time limits are simply posted.

Layout of Parallel Stalls

There are three basic types of curb stalls to be considered—the end stall, the interior stall, and the "paired parking" stall.

The end stall is used where a vehicle can be driven directly into or out of the space. It occurs at one end of a row of parking adjacent to an intersection, alley, driveway, or restricted area such as a bus zone. An end stall requires a length sufficient to accommodate a typical passenger car. Because it can readily be done within 20 ft, this is the length most often used today.

Interior stalls require lengths of 22 ft. Assuming the centering of a vehicle within each stall, and an average vehicle length not to exceed 18 ft, a 4-ft area is left across adjacent stalls for maneuvering space.

"Paired parking" is a system of laying out curb stalls so that two cars are parked bumper to bumper in 18-ft stalls separated from adjacent two-car units by 8-ft open spaces used for maneuvering. In long unbroken lengths of curb not involving loading zones or similar gaps in the metered parking, this system can be slightly more efficient than usual stall arrangements. It requires clear marking of the open spaces as prohibited parking areas. This is usually done by crosshatching.

Parking stalls should be marked at beginning and end by white lines extending out from the curb. These lines are usually terminated at a distance of 7 ft from the curb. The end of a stall row is marked with an L, whereas interior stalls have a T-shaped mark. Some agencies feel it is helpful for parkers if the stall limit line extends an additional foot into the street. The T thus becomes a "cross." This can, however, give the appearance of a mistake in painting.

A common mistake in layout is to crowd driveways and intersections too closely. In general, no stall should begin closer than 20 ft from the nearest sidewalk edge of *any* cross street. If the cross street is a major route, or the intersection control is a signal or 4-way stop, the distance should be not less than 50 ft (100 to 150 ft is usually needed in such cases). These dimensions apply to both approaching and departing sides of the intersection.

Driveways should be cleared by a distance at least equal to the proper radius. This should be 15 ft from the point the driveway crosses the back edge of the sidewalk for most cases and no closer than 5 ft to the beginning and ending of the radius, if more than a 10-ft radius exists.

Fire hydrants should be cleared by 15 ft to conform with the Model Traffic Ordinance.

PARKING METERS

Purpose and Application

The parking meter was developed in 1935 to regulate the parking of motor vehicles. It principally aids in the enforcement of time-limit restrictions. Correctly applied, meters simplify and reduce the cost of enforcement. In the process they may reduce overtime parking and increase parking turnover.

Data from over 900 municipalities indicated that overtime parking was reduced 75 percent or more in nearly half of the places after installation of meters (*10*). In addition, about one-fourth of the municipalities reported an increase in turnover of 100 percent or more, while an additional 39 percent reported an increase in turnover of 50 to 99 percent. In all, nearly 90 percent of the places that reported found meters useful in improving turnover.

Parking meters also produce revenue that is often used not only for the installation and operation of additional meters but also for other costs relating directly to a metered parking operation and for the accomplishment of an off-street parking program.

Effectiveness

Studies of the effectiveness of parking meters are particularly desirable before and after the time of their initial installation in a city. This will provide facts on which the effect of the meters may be fairly judged. One study should be made shortly before the meters are installed and a second about a month after. Each study should be made during the same hours, on the same days of the week, under similar weather conditions, and over a period long enough to be a substantially correct indication of parking-space use. An 8- or 10-hour period starting at 8:00 or 10:00 a.m. is preferable.

Such a study is essentially a continuous observation of how each parking space is used—the number of parkers who use the spaces, length of time parked, turnover in

Table 9.3—Comparison of overtime parking

Zones	Number of Cities Having—		Total Number of Cities	Percentage of Vehicles Parking Overtime	
	Posted Spaces	Metered Spaces		Posted	Metered
15-minute	14	7	21	31.2	25.2
30-minute	19	2	21	30.8	41.0
1-hour	12	11	23	22.3	18.2
2-hour	10	16	26	24.0	6.1
All zones	35	23	58	24.3	13.4

SOURCE: "Parking Guide for Cities," U.S. Bureau of Public Roads, 1956, Table 50, p. 108.

[a] In cities having only posted spaces or only metered spaces (with same time restrictions).
[b] The percentage, of all the space-hours available, used in overtime parking.

the use of space, extent of overtime parking, and amount of other illegal parking. From a comparison of these data before and after the installation of the meters, it is often possible to demonstrate that meters help to improve parking conditions.

The effectiveness of parking meters rests on enforcement of parking regulations. Enforcement officers who diligently patrol the metered area are necessary. The task of checking parking time is made easier with meters because violations can be detected from a moving police vehicle, and the laborious process of chalking tires is greatly reduced. Tire chalking can be used whenever there is indication of "meter feeding" or "re-feeds," i.e., depositing additional coins to extend the parking time beyond the legal limit. It is reported that only one-third to one-fourth the time formerly required is needed to patrol the same area after meters have been installed.

Parking meters clearly encourage better compliance with regulations. The fact that the parker has activated a mechanism that begins immediately to count time and will indicate exactly when the parking time has expired, and will advertise the fact by showing a red flag, tends to make the parker more conscious of his parking responsibility than the hit-or-miss system of possible detection by a patrolman.

The significant factors or criteria in assessing meter benefits are the proportion of overtime parkers, the proportions of available time used by them, the average parking duration of these violators, and the turnover. Improvement found in any one of the first three of these factors may be credited to the meters; however, if this improvement does not extend to the others, it may not constitute or signify any net improvement in conditions. An improvement in the turnover alone should not necessarily be credited to meters. An improvement in all four factors is reasonably conclusive evidence of the effectiveness of meters.

In 15- and 30-min zones, meters are not markedly effective unless strongly enforced. Although the desirability of enforcement in all zones is obvious, meters have a definitely beneficial effect in 1- and 2-hour zones, whether enforced or not, and these zones include 96 percent of all metered spaces on which information is available.

Data on the parking performance at posted spaces (unmetered but time-restricted) and metered spaces in 58 cities of various population groups, as observed in comprehensive parking studies,

at posted and metered parking spaces[a]

Percentage of Space-Hours Used in Excess of Time Limit[b]		Average Parking Time of Overtime Parkers (hours)		Daily Turnover		Percentage Difference in Turnover
Posted	Metered	Posted	Metered	Posted	Metered	
36.7	40.9	1.10	0.80	12.5	27.3	+118
37.7	50.7	1.70	1.22	9.5	13.8	+47
27.5	23.8	2.49	2.16	7.7	9.9	+29
26.5	9.9	4.17	3.71	4.2	8.8	+110
28.6	17.3	2.50	2.32	7.1	9.6	+35

are summarized in Table 9.3. The cities compared have either only posted spaces or only metered spaces; hence they offer the most reasonable comparison possible other than before-and-after studies.

The metered spaces show markedly better performance in the percentage of vehicles parked overtime in three of the four time limit zones, in the proportion of time used by violators in two of the four, in average duration by violators in all zones, and in turnover in all zones. For all time limits as a whole, the metered spaces were 45 percent lower in percentage of vehicles parked overtime, 39 percent lower in proportion of overtime used, 7 percent lower in average total parking time of those who parked overtime, and 35 percent higher in turnover. However, before-and-after studies of meter removal in St. Petersburg, Florida, showed no change in turnover (see Community Attitudes later in this chapter).

Types of Meters

There are two basic types of meters—manual and automatic. The manual type requires the motorist to crank a handle after inserting the appropriate coin. This handle deposits the coin and sets the allowable time limit by winding a clock mechanism. In the automatic meter, prewinding has been performed by maintenance forces. The motorist inserts the coin, which simply acts to "trigger" the beginning of the indicated time sequence.

Some excellent and durable meters are available in both manual and automatic type. As a general rule, the automatic tends to require more maintenance because it is a more complicated device than the manual type.

Meters that are specifically constructed to prevent easy illegal access are termed vandal-proof meters. Such meters are more expensive than standard meters but frequently the added cost is justified where vandalism is a major problem.

For many years, so-called parking validation plans have included features such as merchant dispensing of tokens that will operate meters. However, in the late 1960s a token-dispensing parking meter was developed (*11*). At validation plan stores, shoppers can received a refund of their parking fee by presentation of the tokens.

Collection

Parking meters may be equipped either with individually sealed containers or with locked cases from which the coins can be dumped into a coin collection cart. The latter type takes less time for coin collection and counting but does not provide a check on the use of small groups of meters.

Meter revenue is collected in many cities by representatives of the treasurer's office, in others by contract with collection agencies, and in still others by various municipal offices. It is always desirable to keep accurate time and material records so that the cost of collecting, accounting, and related financial activities concerning meter revenues can be accurately determined.

Time Limits and Fees

Many jurisdictions recognize demands from merchants for 15-min, 30-min, 1-hour, and 2-hour time limits. The time limit should be of a length that best serves a majority of the parkers and abutting developments. In all cases the walking distance from the metered area to the principal traffic generators should be considered when time limits are established.

The fees charged for the time made available should ordinarily be sufficiently high to accomplish reasonable parking turnover. The cost of a certain amount of meter time may be priced higher on-street than off-street. In this way the on-street spaces can be used by those who are

willing to pay a premium for the short duration required. This encourages high turnover.

Economics

The average amount of net revenue that can be received from a meter depends on (a) the demand for use at the meter and the rate charged; (b) the cost of maintenance and collection; and (c) amortization of the original meter cost including its installation. Net revenues of $100 per meter per year are found in certain high-use locations, whereas outright losses may be found in other areas.

One of the most important considerations in the use of parking meters is the disposition of meter revenues. Many cities have used the revenue to finance a program for installation of new meters. Other cities have used the moneys to build off-street parking facilities, with the ultimate goal of eliminating street parking. In many cases, however, meter revenues are simply turned over to the city general fund.

The use of meter revenues to finance off-street facilities in effect integrates curb and off-street facilities and creates a parking *system*. This is discussed in more detail in Chapter Four.

Post Installation

Parking meters at curbs are generally installed on 2-in. pipe posts. Ordinarily, the meter post is set 2 ft from the front end of each parking stall. It should have a setback from the curb face of approximately 18 in.

The use of "T" pipe connections provides for the mounting of two meters on the top of each post. This practice is more economical than the single-post installation, and it reduces the "clutter" along the roadway. The disadvantage is that the motorist may have difficulty identifying the appropriate meter. The double-post installation is most effectively used with parking on both sides of an island and in "paired" parking, as shown in Figure 9.1.

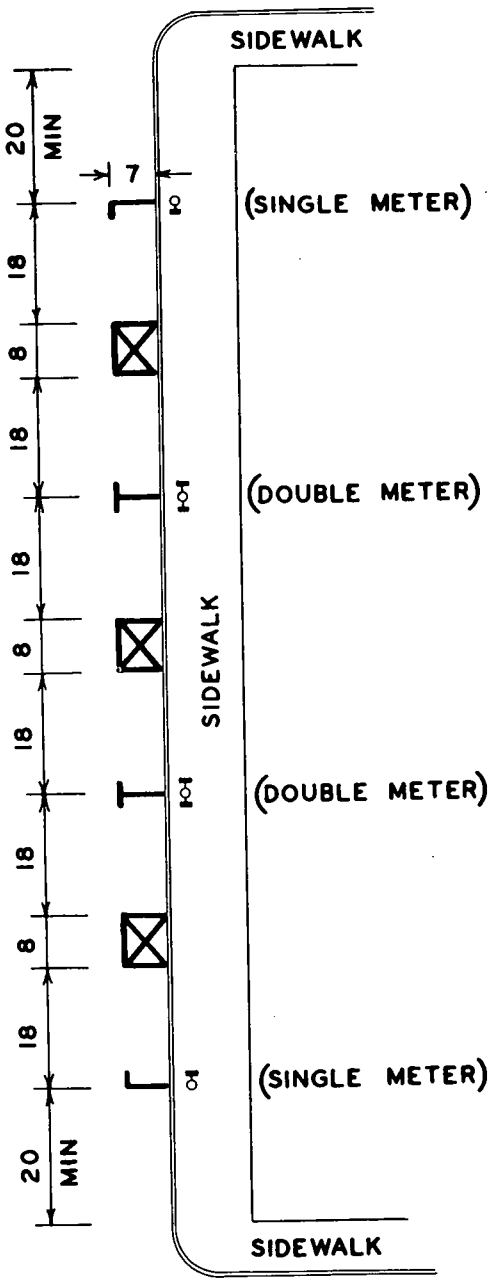


Figure 9.1. Example of paired parking meter layout.

Maintenance

The effectiveness of parking meters rests on their consistent mechanical operation. A comprehensive program of maintenance tends to ensure that the meters function properly.

Meter maintenance is facilitated by a good reporting system between enforcement, collection, and other city traffic forces. Reports on meter malfunction or vehicular damage should be *promptly* investigated. Where repairs cannot be made immediately, the crews should have sacks available to "hood" broken meters. A malfunctioning meter is infuriating to a driver.

Special tools are available to straighten meter posts. In addition to such self-evident routine work, signs and insert plates must be inspected and replaced when defaced or when wording is obliterated.

A preventive maintenance program for the mechanical parts of the meter is essential, and periodically a shop overhaul is needed. The frequency will depend on the particular brand of meter and its past maintenance record.

Advertising on Parking Meters

The matter of permitting advertising on parking meters probably has had to be faced by governing bodies in many cities where meters are in use. Few cities have permitted such use of meters, although at least five states have been known to adopt legislation approving the placing of advertising on meters. Other states have laws specifically prohibiting this practice.

Private advertising on parking meters placed within the rights-of-way of urban extensions of the federal-aid system is illegal. The federal government, in participating with the states in the construction of federal-aid systems, has provided that the rights-of-way of such highways shall be used exclusively for highway purposes, and no commercial signs, posters, billboards, or other private installations shall be permitted within the right-of-way limit.

Authority to permit erection and maintenance of structures in city streets for private advertising purposes is generally considered to be outside the province of municipal authority. In a Kansas case, a municipality was denied the right to permit advertising on traffic control signals, and in Illinois a court denied the privilege of a municipality to place public advertising on public waste-paper receptacles.

Community Attitudes

The attitudes of communities and particularly merchants toward proposed installation of parking meters have sometimes been hostile. Attitudes may change after installation and a reasonable test period. Favorable publicity before installation may help to ease tensions.

Several cities have, however, removed extensive parking meter installations and in some cases have reported excellent results. St. Petersburg, Florida, was the first large U.S. city (population 202,000) to banish parking meters from its downtown streets (*12*). More than 4,000 were removed in 1963. The 1,850 CBD spaces having variable time limits were replaced with uniform 2-hour parking. Before-and-after studies in this area found *no* change in turnover (11.5 vehicles per day with meters when adjusted for re-feeds and shifters, and the same without meters).

Questionnaires sent to 35 communities that had removed curb parking meters resulted in the following findings (*13*):

1. Most of the cities were under 50,000 population;
2. Removal was usually to encourage CBD shopping, but sales did not appear to be significantly affected;
3. The tendency was to remove permanently all meters;

4. More than half the cities made no change in enforcement.

5. Violations of parking time limits decreased in 16 cities, showed no change in 12, and increased in 7; and

6. Studies in three cities indicated that the number of parkers in the area increased, but no effect was observed on parking turnover or duration.

Another survey of nearly 1,100 municipalities found 87 to have removed all meters and 16 more to be planning removals (*14*). However, of the cities that had taken all meters out, 11 indicated that some had been reinstalled.

Because the parking meter is only a "tool" (unless used for direct revenue purposes), it is evident that the same job can be done by other techniques. Enforcement is required during meter operation, and, if an equal or higher level is used with signs, good turnover may also be achieved.

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APPENDIX A

GLOSSARY OF TERMS

Certain expressions and parking terms appear repeatedly in parking literature and reports. The following glossary of the less-obvious terms is intended to orient the reader to the "language" of parking as used herein.

CBD—Central business district.

CBD fringe—The area immediately surrounding the CBD, usually within 2 or 3 blocks.

Change-of-mode—The transfer from one form of transportation to another. An example is the auto driver parking his vehicle and riding transit for the remainder of his trip.

Cordon count—The simultaneous counting of all traffic entering and leaving a given area such as a CBD. It is generally a manual vehicle classification count supplemented with automatic traffic recorder counts.

Duration—The actual length of time a vehicle remains in one parking space.

Outlying—An area generally removed by a mile or more from a CBD.

Parking accumulation—The total number of vehicles parked within a given area at a specific time.

Parking demand—The number of vehicles whose drivers desire to park at a specific location or in a general area. It is usually expressed as the number of vehicles during the peak hour.

Parking supply—The number of parking spaces available for use, usually classified by curb, lot, and garage. Further differentiation of the types of parking is useful, such as those available to the general public, those private spaces earmarked for a specific business or retail store, or those reserved for some purpose such as loading.

Study period—The time during which the parking study is conducted, usually 10:00 a.m. to 6:00 p.m. However, increasing emphasis is being placed on inclusion of the morning and evening periods within the length of the study.

Trip purpose—The primary reason for the person coming to the study area. Typical purposes include shop, work, and business.

Turnover—The number of different vehicles parked at a specific parking space during the study period. Parking turnover measures utilization.

Walking distance—The actual distance traveled by foot from the parking facility to the parker's trip destination.

APPENDIX B

LEGAL ASPECTS OF PARKING AND PUBLIC USE

Because it is well established that every acquisition of private property and the expenditure of public funds by a governmental unit must be for or on account of a public use, it is important to know what constitutes a public use and whether off-street parking facilities can be deemed to be in that category. There appears to be little uniformity in the legal interpretation of this term.

Even though the right of declaring an acquisition to be for a public use is a judicial prerogative, an acquisition for public use is subject to review by the courts only if it is clearly arbitrary or in excess of power.[1] "Courts generally will not look for ulterior motives and will assume prima facie that a taking is for a public use unless there is evidence that the use is for the benefit of an individual.[2] Some jurisdictions limit the concept of public use to actual use or enjoyment by the public of the property acquired.[3] The more liberal courts broaden the interpretation to include whatever is of benefit to any substantial portion of the public.[4] Land has been acquired for public streets and highways under the power of eminent domain from time immemorial.

City authorities should be prepared to present any of their cases effectively and adequately in court should the occasion arise in order that the public interest may be served. National organizations concerned with the problem of street and highway safety and highway transportation are genuinely interested in fostering the provision of adequate parking facilities and will aid in the formulation of supporting data and materials that could be used effectively in litigation on the matter.

The public purpose that is inherent in the public provision of off-street parking facilities is fairly well established by the courts in a number of states. It should not be very difficult to satisfy any state court that public off-street parking facilities designed to relieve traffic congestion would be for a public purpose.

An Ohio case involved a project of the city of Columbus to provide off-street parking facilities for 4,500 vehicles in downtown areas and to finance the project largely by

[1] Walker v. Shasta Power Co., 160 Fed. 856; Nichols v. Central Virginia Power Co., 143 Va. 405, 130 S.E. 764.

[2] 18 Am. Jur. 972.

[3] Board of Health, Portage Tp. v. Van Hoesen, 87 Mich. 533.

[4] Talbot v. Hudson, 16 Gray (Mass.) 417; Strickley v. Highland Bay Gold Mining Co., 200 U.S. 527 (1905); Connolly v. Woods, 13 Idaho 591 (1907).

mortgage revenue bonds.[5] The excessive traffic congestion on city streets was cited in the ordinance providing for the issuance of the bonds, which declared that the project was necessary to relieve traffic conditions and facilitate the flow of traffic. The court said, in rendering its opinion:

> It is our conclusion that conditions in a city may be such as to necessitate the furnishing of off-street parking facilities by the municipality and that the furnishing of the same, under such circumstances, would constitute the performance of a public municipal function. The congestion in downtown areas of large cities and the difficulty of operating vehicles through the streets are matters of such common knowledge as to come within the scope of judicial notice. . . .
>
> It is the function of the legislative body of the city to determine what improvements and expenditures are necessary for the public welfare of the city and to determine what constitutes a public municipal purpose. A determination so made by the legislative body will not be rejected or reversed by the court unless manifestly arbitrary or unreasonable.

This is a companion case to another decided the same day in which it was held that the city of Columbus possessed the power to acquire and operate off-street parking facilities to be financed by the issuance of mortgage revenue bonds secured only by such parking facilities and revenue derived therefrom and that did not create a debt of the city and did not involve a pledge of general credit of the city.[6]

One of the principal issues in a case involving a small city in Kentucky was whether the acquisition and use of land by the city for a parking lot was a municipal purpose.[7] The judicial answer was in the affirmative, supported by the following reasoning:

1. The prime function of a municipality is to promote the safety, convenience, comfort, and common welfare of the citizens by establishing and maintaining those things that tend to be beneficial and by regulating or prohibiting those things that are harmful.[8]

2. It is a matter of common knowledge that in recent years the great increase of motor vehicles has created a situation that, even in smaller cities, is fraught with danger to persons using the streets and causes inconvenience to city residents.

3. Under the power to regulate the use of vehicles on their streets, cities may, and frequently do, prohibit parking on streets in congested areas, and the right to furnish parking space is a necessary adjunct to the right to regulate traffic; otherwise it would be impossible to achieve the general objectives of the statutory grant of power to regulate the use of streets by vehicles.

4. Accordingly, the provision of a parking lot for automobiles constitutes a legitimate municipal purpose.

It was held by the Supreme Court of California that public parking places, since they relieve congestion and reduce traffic hazards, serve a public purpose and are therefore public improvements for which special assessments may be levied.[9] The validity of a Michigan law and a parking system ordinance enacted thereunder was sustained by the court in a case in which off-street parking was deemed a public purpose that involved the public safety.[10] The New York Appellate Division, in dismissing an appeal from a lower court, held that, in modern times, a public parking lot is a necessary adjunct to a public beach.[11] A well-known case in Pennsylvania sustained the validity of a state statute authorizing organization of parking authorities, which were given the power to acquire, improve, maintain, and operate land and facilities for public parking of vehicles.[12] The law declared that the free circulation of traffic through the streets was necessary to the health, safety, and general welfare of the public, and that the purposes for which the authority was created were

[5] State ex rel. Gordon v. Jones, 156 Ohio St. 97, 100 N.E. (2d) 234, July 11, 1951.

[6] State ex rel. Gordon v. Rhodes, 156 Ohio St. 81, 100 N.E. (2d) 225, July 11, 1951.

[7] 301 Ky. 241, 191 S.W. (2d) 403 (1945).

[8] Nourse v. City of Russellville, 257 Ky. 525, 78 S.W. (2d) 761, 764.

[9] Whittier v. Dixon, 24 Calif. (2d) 664, 151 P. 2d 5 (1944).

[10] Parr v. Ladd, 323 Mich. 592, 36 N.W. (2d) 157 (1949).

[11] Pansmith v. Island Park, 73 N.Y.S. (2d) 636.

[12] McSorley v. Fitzgerald, 359 Pa. 264, 59 A. (2d) 142 (1948).

public uses for which public money might be spent and private property acquired by the exercise of the power of eminent domain.

Decisions by the Illinois and Massachusetts courts similarly found the concept of public purpose to be present in the provision of parking facilities.[13] In upholding the lease arrangement for the operation by private enterprise of a parking garage under Boston Common, the Supreme Judicial Court of Massachusetts found that the garage would be incident to a legislative plan to abate a public nuisance caused by serious traffic congestion.

The law first passed in Kansas, applicable only to Kansas City, authorizing condemnation and improvement of lands for parking purposes was declared unconstitutional in Kansas Supreme Court decision, which said that the parking problem was not peculiar to Kansas City but affected every first-class city in the state. Subsequently, in 1941, a general law was passed applicable to all cities of the first class in Kansas, authorizing such cities to condemn and improve property for public parking lot purposes, and to levy special assessments to pay for not less than 50 percent nor more than 90 percent of the cost of acquiring such property and improving it for this purpose.

In all condemnation proceedings it must be clear that the acquisition is for a public purpose and that the city has authority to issue bonds, make assessments, and levy the taxes necessary to procure the money needed.

CASE CITATIONS

General Laws

Oregon: MOTOR VEHICLE PARKING FACILITIES ACT, Oregon Revised Statutes Vol. 2, Title 21, Ch. 223, Secs. 223.805 to 223.879, incl. (Laws of 1949, Ch. 474, as amended; 1953, Ch. 668; 1957, Ch. 430.)

Iowa: MUNICIPAL PARKING LOTS, Iowa, Iowa Code, Ann., Vols. 20 and 21, with 1958 Cumulative Annual Pocket Parts, Ch. 390, Secs. 390.1-390.15, incl. (Acts of 1947, Ch. 206, as amended) and Ch. 404, Sec. 404.7(5) (Acts of 1951, Ch. 159, as amended.)

Parking Authorities

California: PARKING LAW OF 1949, West's California Streets and Highways Code, Annotated, Vol. 64, with 1958 Cumulative Pocket Part, Secs. 32500-33552, incl. (Added by Stats. 1951, Ch. 463, Part 2, as amended. Based on Stats. 1949, Ch. 1503, as amended.)

Pennsylvania: PARKING AUTHORITY LAW, Purdon's Pennsylvania Statutes, Annotated, Permanent Edition, Title 53, with 1958 Cumulative Annual Pocket Part, Pt. 1, Ch. 6 Art II, Secs. 341-356, incl. (Laws of 1947, P. L. 458, No. 208, as amended.)

Assessment Districts

California: VEHICLE PARKING DISTRICT LAW OF 1943, West's California Streets and Highways Code, Annotated, Vol. 64, with 1958 Pocket supplement, Secs. 31500-31907, incl. (Added by Stats. 1951, Ch. 463, Part 1, as amended. Based on Stats. 1943, Ch. 971, as amended.)

Kansas: Corrick's General Statutes of Kansas, Annotated, 1949, and 1957 Supplement, Ch. 13, Art. 13, Secs. 13-1374 to 13-1392, incl. (Laws of 1941, Ch. 128, as amended, and 1951, Ch. 175, as amended.)

Parking Systems

Florida: MUNICIPAL PARKING FACILITIES LAW OF 1951, Florida Statutes, Annotated, Vol. 9, with 1958 Cumulative Annual Pocket Part, Title XII, Ch. 183, Secs. 183.01 to 183.16, incl. (General Laws, 1951, Vol. 1, Ch. 26918, as amended.)

North Carolina: General Statutes of North Carolina, Vol. 3C, with 1957 Cumulative Supplement, Ch. 160, Art. 39, Secs. 160-497 to 160-507, incl. (Session Laws, 1951, Ch. 704.)

Revenue Bond Financing

Kentucky: Kentucky Revised Statutes 1959, Ch. 93, Secs. 93.351-93.356, incl., and Ch. 94, Sec. 94.750 (Acts of 1942, Ch. 15, as amended, and Acts of 1944, Ch. 129, Sec. 6.)

Michigan: REVENUE BOND ACT OF 1933, Michigan Statutes, Annotated, Vol.

[13] Poole v. Kankakee, 94 N.E. (2d) 146 (Ill. 1950); Lowell v. City of Boston, 322 Mass. 709, 79 N.E. (2d) 713 (1948).

4A, 1958 Revision, Title 5, Ch. 53, Secs. 5.2731 to 5.2766, incl. (Acts of 1933, Act 94, as amended.)

STATE ENABLING LEGISLATION

The provision and fostering of off-street parking accommodations must have an adequate foundation in law if they are to become a reality. Legal tools are needed to authorize the planning, financing, and construction of such facilities as the needs indicate. Other elements of a desirable urban parking program must also be authorized by state or local law. The various factors are discussed in the following paragraphs.

Declaration of Intent

It is essential that an appropriate declaration of legislative policy be made. This will serve as a valuable guidepost for the judiciary in legal contests that are likely to result from the extensive exercise of a relatively new public function.

Legal Definition

A few terms or phrases are necessary to describe the different functional or administrative types of parking facilities. These terms should be legally defined in order to establish a broad conception of parking facilities.

Administrative Authority

From the standpoint of administrative authority and jurisdiction, in the light of the present needs of a motorized nation, there is little justification for restricting the authority solely to establishing or fostering the provision of parking facilities. Legislation ought to grant administrative authority broadly to designated administrative agencies of the state, counties, and municipalities all in a single state enabling act. Desirable sanction would also make provision for the cooperation of any of these units with each other or with any federal agency.

Advance Planning

Legislation ought to include ample provision for the advance planning of parking facilities. The essence of desirable planning policy consists of the legislative provision for thorough investigation of the parking problem by an appropriate local administrative agency or a professional engineering firm, and the formulation, for public acceptance and support, of a master plan of parking facilities subject to alteration as necessary. A well-planned program of construction and a review of possible methods of financing are likewise necessary preliminaries to effective solution of a parking problem.

Comprehensive Financial Policy

Because of the variety of public fiscal practices and the financial complexities of different types of parking facilities, general state enabling authority ought to provide for a financial policy comprehensive in scope. The legislative bodies of the counties and municipalities should be authorized to finance the planning of parking facilities, acquisition of property, construction, alteration, enlargement, maintenance, and operation of parking facilities by any one or a combination of methods. These would include general obligation bonds or revenue bonds, direct support out of current revenues, or a combination of bonds and revenues. Revenue support may be found in any one or more of the following sources authorized in enabling legislation, whether bonds are used or not: general funds, ad valorem property taxes, special or benefit assessments, parking fees and special charges, parking meter revenues, and other miscellaneous means.

Land Acquisition

Adequate legislative provision for land acquisition would authorize the state, counties, cities, towns, or villages to acquire private or public, real or personal property and property rights necessary or desirable for off-street parking facilities in the same manner as such government units are now authorized by law to acquire such property or property rights in connection with highways or streets within their respective jurisdictions.

Construction

Desirable legislative provisions would authorize the respective government units to construct or cause to be constructed public off-street parking facilities, along with acces-

sories necessary or desirable for the safety and convenience of motorists using the facilities. Such facilities should be geared to present and future needs through their functional design. Construction should be permitted either by contract or by force account. Contracts exceeding an appropriate limit should be awarded to the lowest responsible bidder in the same manner as contracts awarded in connection with highways or streets within the jurisdiction of the government units.

Maintenance and Operation

Whatever the government unit involved, it ought to possess sufficient authority to maintain and operate parking facilities efficiently and in the public interest. Leasing by competitive bidding to any individual, firm, or corporation, upon such terms and conditions as the public interest may warrant, should be sanctioned. Necessary and qualified personnel ought to be employed in the same manner as the respective units are now authorized by law to employ.

Accounting and Records

It is sound business and government practice to require the respective administrative agencies charged with the responsibility for the provision of parking facilities to maintain proper accounting and financial records of all transactions and to provide annual financial statements. An annual report of activities should likewise be made to the respective legislative bodies.

Integration of Curb and Off-Street Parking

The provision of conveniently located off-street parking facilities, attractive in cost to users, cannot be undertaken successfully without the simultaneous public control of curb parking accommodations. Accordingly, the control of the establishment, financing, and operation of parking meters should be vested in the same administrative agency having jurisdiction over off-street facilities. It should be the responsibility of the agency to integrate properly the establishment, use, and regulation of curb parking with off-street parking facilities, pursuant to a master plan professionally evolved. But the enforcement of curb parking and parking-meter regulation should be specifically reserved to the police agencies of the respective jurisdictions, where such enforcement functions are traditionally lodged.

MODEL STATE GENERAL ENABLING STATUTES

Highway or Street (or Public Works) Department Form

An act to provide for the planning, design, location, financing, acquisition of property for, construction, alteration, enlargement, use, maintenance, operation, and fostering of off-street automobile parking facilities; for the creation of parking facilities divisions in the departments of highways or streets (or public works) of the state, counties, cities, towns, and villages; and for other purposes.

Sec. 1. Declaration of Policy—The legislature hereby determines and declares that excessive curb parking of motor vehicles on roads and streets in urban and metropolitan areas and the lack of adequate off-street parking facilities create congestion, obstruct the free circulation of traffic, diminish property values, and endanger the health, safety, and general welfare of the public; that the provision of conveniently located off-street parking facilities, attractive in cost, and the simultaneous public control of curb parking are therefore necessary to alleviate such conditions; and that the establishment of public off-street automobile parking facilities and fostering the provision of commercial and special-purpose off-street automobile parking facilities are deemed to be a proper public or municipal purpose.

Sec. 2. Definitions of Types of Parking Facilities—For purposes of this act, (1) *public off-street automobile parking facilities* [14] are defined as accommodatious provided by public authority for the parking of automobiles off the street or highways, and open to public use, with or without charge; such facilities may be publicly owned and publicly operated, or they may be publicly

[14] A possible alternative for the term "public" might be "municipal" but, if the latter term is preferred, it should be defined to include state, county, city, town, and village facilities.

owned and privately operated; (2) *commercial off-street automobile parking facilities* are defined as accommodations provided by private enterprise for the parking of automobiles off the street or highway, open to public use for a fee; (3) *special-purpose off-street automobile parking facilities* are defined as accommodations provided by public authorities, private groups, or individuals for restricted use in connection with public improvements, particular businesses, theaters, hotels, and other private enterprises, or combinations thereof, or as adjuncts to housing developments or private residences; such facilities may or may not be jointly established and operated; (4) *cooperative off-street automobile parking facilities* are defined as accommodations provided by joint action of public and private interests. Parking facilities may consist of lots, garages, or other structures, and accessories; they may be surface facilities or facilities above or below the ground.

Sec. 3. Creation of Parking Facilities Divisions—Each department of highways or streets (or public works) of the state, counties, cities, towns, and villages, or combinations thereof, hereinafter referred to as the highway department, is hereby authorized to create a parking facilities division within its organization, for the purpose of establishing public off-street automobile parking facilities and of fostering the provision of commercial and special-purpose off-street automobile parking facilities within its jurisdiction.

Sec. 4. Authority to Establish Parking Facilities—Each highway department, acting alone or in cooperation with other highway departments or with any federal, state, or local agency, is hereby authorized, through its respective parking facilities division, to plan, design, locate, finance, acquire property for, construct, alter, enlarge, use, maintain, operate, lease (either as lessee or lessor), otherwise provide, or foster the provision of public, commercial, or special-purpose off-street automobile parking facilities, wherever and to the extent that such facilities are deemed necessary or desirable within its respective jurisdiction. Said highway department, in addition to the specific powers granted by this act, shall also have and may exercise, relative to automobile parking facilities, any and all additional authority now or hereafter vested in such department, within its respective jurisdiction. Said department may regulate, restrict, or prohibit the use of off-street parking facilities in a manner consistent with the purpose for which such facilities are established.

Sec. 5. Planning for Parking Facilities—The highway department, after thorough investigation of the parking problem within its jurisdiction, shall formulate for public presentation a master plan of automobile parking facilities as a guide for the future provision of parking facilities, properly integrated with present and proposed traffic facilities, subject to alteration as necessary. A program of construction and methods of financing shall likewise be formulated. Planning for automobile parking facilities shall be reconciled, insofar as possible, with the overall master plan of the area. Provision of parking facilities under this act shall be properly integrated with the provision of parking facilities required by zoning ordinances, building codes, or subdivision regulations.

Sec. 6. Design of Parking Facilities—Each highway department is authorized to so design and locate any off-street automobile parking facility as to best serve the public purpose for which such facility is intended. Such facilities may consist of improved or unimproved lots, single or multilevel garages, other structures and accessories, or any combination of these features. They may be surface facilities or facilities above or below the ground.

Sec. 7. Financing of Parking Facilities—Each highway department is hereby authorized, subject to specific authorization and approval of its legislative body, to finance the planning, design, acquisition of property for, construction, alteration, enlargement, maintenance, or operation of parking facilities by any one or any combination of the following methods: (1) general obligation bonds within legal debt limitations, or revenue bonds payable solely out of revenue from parking facilities, in such amounts, at an interest rate, and upon conditions prescribed by the legislative bodies of the respective jurisdiction; (2) special or benefit

assessments, equal to the total cost of land and improvements or only a portion thereof, to be assessed against benefited property in proportion to benefit derived, to be paid in not to exceed 10 annual installments at interest not to exceed ____ percent per annum; such benefit assessments are to be determined in accordance with established state and local special assessment practice, after proper notice and hearing, subject to approval by the respective legislative bodies; (3) parking fees and special charges, to be levied at the discretion of the respective highway departments, derived from the use of off-street parking facilities by motorists, lessees, concessionaires, or others; all such fees and charges shall be reasonable and shall be imposed only to further the purpose of this act; (4) general fund appropriations, to the extent deemed necessary or desirable; (5) state and federal grants and local aids, to the extent available for the provision of off-street parking facilities; (6) parking-meter revenues; (7) general property taxes, not to exceed____cents per $100 assessed valuation of real property; (8) gift, bequest, devise, grant, or otherwise.

Sec. 8. Acquisition of Property and Property Rights—For the purpose of this act, each highway department is hereby authorized to acquire private or public, real or personal property and property rights above, at, or below the surface of the earth, necessary or desirable for off-street automobile parking facilities, by purchase, condemnation, gift, lease, bequest, devise, or grant, in the same manner as such department is now or hereafter may be authorized by law to acquire such property or property rights in connection with highways and streets within its jurisdiction. Wherever possible, property acquired under the provisions of this act shall be in fee simple. Court proceedings necessary to acquire property or property rights for purposes of this act shall take precedence over all other causes not involving the public interest in all courts, to the end that the provision of parking facilities be expedited. Said department may sell, encumber, lease, exchange, or otherwise dispose of property and property rights acquired hereunder if, by so doing, the interest of the public will be best served.

Sec. 9 Construction of Parking Facilities—Each highway department is hereby authorized to construct, or cause to be constructed, public off-street automobile parking facilities, above, at, or below the surface of the earth, including buildings, structures, equipment, entrances, exits, fencing, and all other accessories necessary or desirable for the safety and convenience of motorists using the facilities. Construction may be undertaken by contract or by force account. Contracts exceeding $1,000 are to be awarded to the lowest responsible bidder, in the same manner as contracts are now or hereafter may be authorized by law to be awarded in connection with highways or streets within the jurisdiction of the respective governmental units.

Sec. 10. Maintenance and Operation of Parking Facilities—Each highway department is hereby authorized to maintain and operate public off-street automobile parking facilities or to contract therefor, or lease the same by competitive bidding to any individual, firm, or corporation, upon such terms and conditions as the public interest may warrant. Reasonable regulations for the orderly use of parking facilities may be prescribed by the respective departments, as well as a schedule of parking fees and other charges. Necessary and qualified persons may be employed in the same manner as persons are now employed by the respective departments or may hereafter be employed.

Sec. 11. Records and Reporting—Each highway department, through its parking facilities division, shall maintain proper accounting and financial records of all transactions and provide annual financial statements. An annual report of activities shall be made by the respective departments to their respective legislative bodies.

Sec. 12. Authority of Departments to Consent—Each highway department is authorized to enter into agreements with other highway departments, or with the federal government, respecting the planning, design, location, financing, acquisition of property for, construction, alteration, enlargement, use, maintenance, operation, leasing, or fostering the provision of off-street automobile parking facilities in their respective jurisdictions, to facilitate the purposes of this act.

Sec. 13. Parking Meters—Exclusive control of the establishment, designation, installation, financing, acquisition, maintenance, regulation, and operation of parking meters is hereby vested in the highway departments of the respective jurisdictions. It shall be the responsibility of said departments to integrate properly the establishment, use, and regulation of parking meters with off-street parking facilities, pursuant to a master plan as evolved under section 5 of this act. Enforcement of curb parking and parking meter regulations are hereby reserved to the police agencies of the respective jurisdictions.

Sec. 14. Severability—If any section, provision, or clause of this act shall be declared invalid or inapplicable to any person or circumstance, such invalidity or inapplicability shall not be construed to affect the portions not so held or persons or circumstances not so affected. All laws or portions of laws inconsistent with the policy and provisions of this act are hereby repealed to the extent of such inconsistency in their application to the provision of automobile parking facilities authorized by this act.

Automobile Parking Agency Form

An act to provide for the planning, design, location, financing, acquisition of property for, construction, alteration, enlargement, use, maintenance, operation, and fostering of off-street automobile parking facilities; for the creation of automobile parking agencies of the state, counties, cities, towns, and villages; and for other purposes.

Sec. 1. Declaration of Policy—The legislature hereby determines and declares that excessive curb parking of motor vehicles on roads and streets in urban and metropolitan areas and the lack of adequate off-street parking facilities create congestion, obstruct the free circulation of traffic, diminish property values, and endanger the health, safety, and general welfare of the public; that the provision of conveniently located off-street parking facilities attractive in cost and the simultaneous public control of curb parking are therefore necessary to alleviate such conditions; and that the establishment of public off-street automobile parking facilities and fostering the provision of commercial and special-purpose off-street automobile parking facilities are deemed to be a proper public or municipal purpose.

Sec. 2. Definitions of Types of Parking Facilities—For purposes of this act, (1) *public off-street automobile parking facilities* [15] are defined as accommodations provided by public authority for the parking of automobiles off the street or highway, and open to public use, with or without charge; such facilities may be publicly owned and publicly operated, or they may be publicly owned and privately operated; (2) *commercial off-street automobile parking facilities* are defined as accommodations provided by private enterprise for the parking of automobiles off the street or highway, open to public use for a fee; (3) *special-purpose off-street automobile parking facilities* are defined as accommodations provided by public authorities, private groups, or individuals for restricted use in connection with public improvements, particular businesses, theaters, hotels, and other private enterprises, or combinations thereof, or as adjuncts to housing developments or private residences; such facilities may or may not be jointly established and operated; (4) *cooperative off-street automobile parking facilities* are defined as accommodations provided by joint action of public and private interests. Parking facilities may consist of lots, garages, or other structures, and accessories; they may be surface facilities or facilities above or below the ground.

Sec. 3. Creation of Automobile Parking Agencies—The state, counties, cities, towns, and villages, respectively, or combinations thereof, are hereby authorized to create automobile parking agencies, hereinafter referred to as parking agencies, answerable only to the respective legislative bodies, for the purpose of establishing public off-street automobile parking facilities and of fostering the provision of commercial and special-purpose off-street automobile parking facilities within their respective jurisdictions. Such parking agencies shall be constituted as pre-

[15] A possible alternative for the term "public" might be "municipal" but, if the latter term is preferred, it should be defined to include state, county, city, town, and village facilities.

scribed by the legislative bodies of the respective jurisdictions.

Sec. 4. Authority to Establish Parking Facilities—Each parking agency, acting alone or in cooperation with other parking agencies, or with any federal, state, or local agency, is hereby authorized to plan, design, locate, finance, acquire property for, construct, alter, enlarge, use, maintain, operate, lease (either as lessee or lessor), otherwise provide, or foster the provision of public, commercial, or special-purpose off-street automobile parking facilities, wherever and to the extent that such facilities are deemed necessary or desirable within its jurisdiction. Said parking agencies may regulate, restrict, or prohibit the use of off-street parking facilities in a manner consistent with the purpose for which such facilities are established.

Sec. 5. Planning for Parking Facilities—The parking agency, after thorough investigation of the parking problem within its jurisdiction, shall formulate for public presentation a master plan of automobile parking facilities as a guide for the future provision of parking facilities, properly integrated with present and proposed traffic facilities, subject to alteration as necessary. A program of construction and methods of financing shall likewise be formulated. Planning for automobile parking facilities shall be reconciled, insofar as possible, with the overall master plan of the area. Provision of parking facilities under this act shall be properly integrated with the provision of parking facilities required by zoning ordinances, building codes, or subdivision regulations.

Sec. 6. Design of Parking Facilities—Each parking agency is authorized to so design and locate any off-street automobile parking facility as to best serve the public purpose for which such facility is intended. Such facilities may consist of improved or unimproved lots, single or multilevel garages, other structures and accessories, or any combination of these features. They may be surface facilities or facilities above or below the ground.

Sec. 7. Financing of Parking Facilities—Each parking agency is hereby authorized, subject to specific authorization and approval of its legislative body, to finance the planning, design, acquisition of property for, construction, alteration, enlargement, maintenance, or operation of parking facilities by any one or any combination of the following methods: (1) general obligation bonds within legal debt limitations, or revenue bonds solely out of revenue from parking facilities, in such amounts, at an interest rate, and upon conditions prescribed by the legislative bodies of the respective jurisdictions; (2) special or benefit assessments, equal to the total cost of land and improvements, or only a portion thereof, to be assessed against benefited property in proportion to benefit derived, to be paid in not to exceed 10 annual installments, at interest not to exceed ____ percent per annum; such benefit assessments are to be determined in accordance with established state and local special assessment practice, after proper notice and hearing, subject to approval by the respective legislative bodies; (3) parking fees and special charges, to be levied at the discretion of the respective parking agencies, derived from the use of off-street parking facilities by motorists, lessees, concessionaires, or others; all such fees and charges shall be reasonable and shall be imposed only to further the purposes of this act; (4) general fund appropriations, to the extent deemed necessary or desirable; (5) state and federal grants and local aids, to the extent available for the provision of off-street parking facilities; (6) parking meter revenues; (7) general property taxes, not to exceed ____ cents per $100 assessed valuation of real property; (8) gift, bequest, devise, grant, or otherwise.

Sec. 8. Acquisition of Property and Property Rights—For the purposes of this act, each parking agency is hereby authorized to acquire private or public, real or personal property and property rights above, at, or below the surface of the earth, necessary or desirable for off-street automobile parking facilities, by purchase, condemnation, gift, lease, bequest, devise, or grant, in the same manner as such governmental unit is now or hereafter may be authorized by law to acquire such property or property rights in connection with highways or streets within its jurisdiction. Wherever possible, property acquired under the provisions of this act shall be in fee simple. Court proceedings

necessary to acquire property or property rights for purposes of this act shall take precedence over all other causes not involving the public interest in all courts, to the end that the provision of parking facilities be expedited. Said parking agencies may sell, encumber, lease, exchange, or otherwise dispose of property and property rights acquired hereunder if, by so doing, the interest of the public will be best served.

Sec. 9. Construction of Parking Facilities—Each parking agency is hereby authorized to construct or cause to be constructed public off-street automobile parking facilities, above, at, or below the surface of the earth, including buildings, structures, equipment, entrances, exits, fencing, and all other accessories necessary or desirable for the safety and convenience of motorists using the facilities. Construction may be undertaken by contract or by force account. Contracts exceeding $1,000 are to be awarded to the lowest responsible bidder, in the same manner as contracts are now or hereafter may be authorized by law to be awarded in connection with highways or streets within the jurisdiction of the respective governmental units.

Sec. 10. Maintenance and Operation of Parking Facilities—Each parking agency is hereby authorized to maintain and operate public off-street automobile parking facilities or to contract therefor, or lease the same by competitive bidding to any individual, firm, or corporation, upon such terms and conditions as the public interest may warrant. Reasonable regulations for the orderly use of parking facilities may be prescribed by the respective parking agencies, as well as a schedule of parking fees and other charges. Necessary and qualified persons may be employed in the same manner as persons are now employed by the respective governmental units or may hereafter be employed.

Sec. 11. Additional Powers of Parking Agencies—Each parking agency is hereby authorized to exercise all powers necessary or desirable to carry out the purposes of this act. In addition to the powers set forth in the preceding sections, such agency shall have the power to sue and be sued and the power to be a party to a contract.

Sec. 12. Records and Reporting—Each parking agency shall maintain proper accounting and financial records of all transactions and provide annual financial statements. An annual report of activities shall be made by the respective parking agencies to their respective legislative bodies.

Sec. 13. Authority of Parking Agencies to Consent—Each parking agency is authorized to enter into agreements with other parking agencies, or with the federal government, respecting the planning, design, location, financing, acquisition of property for, construction, alteration, enlargement, use, maintenance, operation, leasing, or fostering the provision of off-street automobile parking facilities in their respective jurisdictions, to facilitate the purposes of this act.

Sec. 14. Parking Meters—Exclusive control of the establishment, acquisition, maintenance, regulation, and operation of parking meters is hereby vested in the parking agencies of the respective jurisdictions. It shall be the responsibility of said agencies to integrate properly the establishment, use, and regulation of parking meters with off-street parking facilities, pursuant to a master plan as evolved under section 5 of this act. Enforcement of curb parking and parking meter regulations are hereby reserved to the police agencies of the respective jurisdictions.

Sec. 15. Severability—If any section, provision, or clause of this act shall be declared invalid or inapplicable to any person or circumstance, such invalidity or inapplicability shall not be construed to affect the portions not so held or persons or circumstances not so affected. All laws or portions of laws inconsistent with the policy and provisions of this act are hereby repealed to the extent of such inconsistency in their application to the provision of automobile parking facilities authorized by this act.

EXCERPTS FROM 1950 GRAND RAPIDS ORDINANCE ESTABLISHING A PARKING SYSTEM

1284. An ordinance providing for the establishment of an automobile parking system for the city of Grand Rapids; authorizing the acquisition and construction of auto-

mobile parking facilities; authorizing the issuance of self-liquidating revenue bonds under the provisions of Act 94, Public Acts of Michigan, 1933, as amended, to pay the cost of said facilities; providing for the retirement of said bonds from the revenues of said automobile parking system; creating a statutory lien on such revenues; and providing for other matters relative to said bonds, the parking facilities, and the revenues therefrom . . . .

Sec. 1. It is hereby determined and declared to be necessary for the public benefit and welfare of the city of Grand Rapids for the purpose of relieving traffic and parking congestion on its public streets and effectuating traffic control and public safety, to acquire and construct the parking structures, as described in the preamble hereto.

Sec. 2. From and after the effective date of this ordinance, all street parking spaces where parking fees or charges are collected by means of parking meters, the off-street parking structures herein authorized to be acquired and constructed, and any other off-street spaces where fees or charges are collected for the use thereof, which might hereinafter be acquired, shall be maintained and operated by the city as one separate municipal system to be known as the City of Grand Rapids Automobile Parking System and shall include all parking meters, buidings, facilities, equipment, or accessories used or useful in connection therewith: *Provided, however,* That the revenues derived from on-street parking through meters shall be considered a portion of the revenues of the system, subject to the pledge and allocation as hereinafter provided, from and after July 1, 1951.

Sec. 3. The estimated cost of the complete acquisition and construction of the off-street parking structures referred to in the preamble hereto, including engineering expense, interest for a period of two (2) years during construction, legal and financing expenses, repayment of federal planning loans and advances from city general funds, and contingencies, which estimate has been prepared under the direction of the Automobile Parking Authority and is in the amount of $1,600,000, is hereby approved, and the City Commission does hereby estimate the period of usefulness of said off-street parking structures to be at least thirty (30) years.

Sec. 4. To pay the cost of acquiring, constructing, and making available for public use the new municipal off-street parking structures herein referred to, and to pay engineering expense, interest for a period of two (2) years during construction, legal and financing expenses, repayment of federal loans and advances from city general funds, and other expenses and contingencies incident thereto, it is hereby determined that there be borrowed, upon the credit of the income and revenues of the City of Grand Rapids Automobile Parking System, the sum of $1,600,000 and that, in evidence thereof, there be issued the negotiable revenue bonds of the city in the principal amount of $1,600,000 under and in accordance with the provisions of Act 94, Public Acts of Michigan, 1933, as amended . . . .

Sec. 5. (Amended July 17, 1950). Said bonds shall be designated City of Grand Rapids Automobile Parking System revenue bonds, and shall be, not general obligations of the city of Grand Rapids, but revenue bonds, payable out of the net revenues of the system after provision has been made for payment of expenses of operation and maintenance and shall consist of 1,600 bonds of $1,000 each, numbered in direct order of maturity from 1 to 1,600, inclusive, dated August 1, 1950, and payable serially as follows: . . . .

Sec. 6. Said bonds shall not be a general obligation or indebtedness of the city of Grand Rapids, but shall be payable solely from the net revenues derived from the operation of the system and, to secure such payment, there is hereby created a statutory first lien upon the whole of the net revenues of the system, to continue until the payment in full of the principal and interest on said bonds.

Sec. 7. The holders of said bonds or coupons representing in the aggregate not less than twenty percent (20%) of the entire issue then outstanding may, upon the conditions hereinafter provided, either at law or in equity, by suit, action, mandamus, or other proceedings, protect and enforce the statutory lien upon the revenues of said system and may, by suit, action, mandamus,

or other proceedings, enforce and compel performance of all duties of the officers or agencies of the city, including the fixing of sufficient rates, the collection of revenues, the proper segregation of the revenues of said system, and the proper application thereof: *Provided, however,* That the statutory lien upon said revenues shall not be construed to give the holder or holders of any bonds or coupons authority to compel the sale of the said system.

If there be any default in the payment of the principal of or interest upon any of said bonds, any court having jurisdiction in any proper action may appoint a receiver to administer and operate said system on behalf of the city and under the direction of said court and by and with the approval of said court to perform all of the duties of the officers or agencies of said city more particularly set forth herein and in Act 94, Public Acts of Michigan, 1933, as amended.

The holder or holders of any such bonds or any coupons therefrom shall have all other rights and remedies given by said Act 94, Public Acts of Michigan, 1933, as amended, for the collection and enforcement of said bonds and the security therefor.

Sec. 8. The system shall be operated on the basis of an operating year commencing on July 1st and ending on June 30th.

Sec. 9. The acquisition, construction, management, operation, and control of the parking facilities of the system shall be under the supervision and management of the Automobile Parking Authority of the City of Grand Rapids, subject, however, to the rights, powers, and duties in respect thereto which are reserved by law and the city charter to the city commission and other departments of the city of Grand Rapids.

Sec. 10. The parking fees, rates, and charges to be collected for use of street parking spaces by means of parking meters of the system shall be as established and now in effect, pursuant to the provisions of Ordinance No. 1015, as amended, of the city of Grand Rapids. Rates for use of additional street parking spaces where meters shall hereafter be located shall be established in the first instance pursuant to the provisions of said ordinance.

The initial fees, rates, and charges for services furnished by the off-street parking structures acquired under the provisions of this ordinance are established as follows. . . .

Such rates and fees shall be subject to revision from time to time as may be necessary consistent with the obligations assumed by the city in the adoption of this ordinance.

Sec. 11. No free parking, storage, or other service shall be supplied by the system to any person, firm or corporation, public or private, or to any public agency or instrumentality, but all such service furnished shall be paid for in accordance with the foregoing schedule of rates or any revision thereof in compliance with the provisions of this ordinance.

Sec. 12. The parking fees, rates, and charges heretofore fixed for street parking to be collected through parking meters and for parking in the three parking structures are estimated to be sufficient to provide for the payment of the expenses of administration and operation and such expenses for maintenance of the system as are necessary to preserve the same and all its component facilities in good repair and working order, to provide for payment of the interest upon and principal of all bonds as and when the same become due and payable, and to provide for such other expenditures and funds for said system as are required by this ordinance. The parking fees, rates, and charges shall be fixed and revised from time to time as may be necessary to produce these amounts and it is hereby covenanted and agreed at all times to fix, maintain, and collect such parking fees, rates, and charges for parking service furnished by the system as shall be sufficient to provide for the foregoing.

Sec. 13. The revenues of the system are hereby ordered to be set aside, as collected, and deposited in the Michigan National Bank, Grand Rapids, Mich., a bank duly qualified to do business in Michigan, in an account to be designated "Automobile Parking System Receiving Fund" (hereinafter referred to as the "receiving fund") and said revenues so deposited are pledged for the purposes of the following funds and shall be transferred from the receiving fund periodi-

cally and in the manner and at the times hereinafter specified. [*The ordinance specifies setting aside funds under the following* headings: *Operation and Maintenance Fund, Bond and Interest Redemption Fund, and Replacement Fund.*]

Sec. 14. Any revenues in the receiving fund at the end of any operating year after satisfying all requirements of the operation and maintenance fund, bond and interest redemption fund (including the reserve account), and the replacement fund shall be deemed to be surplus and may, at the option of the city commission, be used for any of the following purposes:

(1) Transferred into a separate depositary account to be designated "improvement fund" and used for the acquisition of additional parking facilities, or for extensions, improvements, and additions to existing facilities and equipment.

(2) Transferred into the bond and interest redemption fund and used for the redemption of callable bonds.

(3) Transferred to the general fund of said city and used for the regulation and control of traffic on the streets and boulevards of said city, the acquisition of necessary traffic control devices deemed essential for such purposes, payment of the costs of enforcement of traffic and parking regulations lawfully established, and for any other purposes for which revenues derived from street parking meters may be used under the laws of the State of Michigan. In the event the moneys in the receiving fund are insufficient to provide for the current requirements of the operation and maintenance fund and the bond and interest redemption fund (including the reserve account), any money and/or securities in other funds of the system shall be transferred, first, to the operation and maintenance fund to the extent of any deficit therein, and second, to the bond and interest redemption fund (including the reserve account) to the extent of any deficit therein. Any amount so transferred shall be replaced as soon as possible.

Sec. 15. Said bonds shall be sold and the proceeds applied in accordance with the provisions of Act 94, Public Acts of Michigan, 1933, as amended.

Sec. 16. The moneys in the bond and interest redemption fund over and above those being accumulated for the payment of the next maturing principal and interest and moneys in any other fund except the receiving fund and operation and maintenance fund may be invested in United States government obligations and the income derived from such investments shall be credited to the fund from which such investments were made. In the event of any such investment, the security representing the same shall be kept on deposit with the bank having the deposit of the fund or funds from which such purchase was made.

Sec. 17. The proceeds of sale of said bonds shall be deposited in the Michigan National Bank, Grand Rapids, Michigan, a Federal Reserve System member bank, and there shall be set aside in the bond and interest redemption fund a sum necessary to pay the interest for a period of two (2) years during construction, and the balance shall be used to pay all acquisition, construction and improvements costs including acquisition of the necessary equipment for the parking structures hereinbefore referred to in accordance with the plans and/or specifications therefor. Any unexpended balance of the proceeds of sale remaining may, in the discretion of the city commission, upon recommendation of the Automobile Parking Authority and to the extent of Two Hundred Forty Thousand Dollars ($240,000), be used for further improvements and extensions to the Automobile Parking System or the acquisition of additional facilities therefor: *Provided, however,* That at the time of such expenditure, such use be approved by the Municipal Finance Commission. Any remaining balance after such expenditure, or in the event no such expenditure is made, the entire unexpended balance shall be paid into the bond and interest redemption fund and shall be used for the redemption of callable bonds.

Sec. 18. The city of Grand Rapids covenants and agrees with the successive holders of the bonds and coupons that, so long as any of the bonds remain outstanding and unpaid as to either principal or interest:

(*a*) The city will maintain the system in good repair and working order and will operate the same efficiently and will faithfully and punctually perform all duties with reference to the system required by the con-

stitution and laws of the State of Michigan, including the making and collecting of sufficient rates for parking and other services furnished, and the segregation and application of the revenues of the system in the manner provided in this ordinance. The city will, from time to time, make all needful and proper repairs, replacements, additions, and betterments to the equipment and facilities of the system, so that it may at all times be operated properly and advantageously and, whenever any parking meter or any other equipment or facility of the system shall have been worn out, destroyed, or otherwise become unfit for proper use, it shall be promptly replaced or repaired, so that the value and efficiency of the system shall at all times be fully maintained and its revenue unimpaired by reason thereof. The city will maintain and enforce parking facilities of the system in such manner that these requirements will be met.

(*b*) The city will maintain and keep proper books of record and account separate from all other records and accounts, in which shall be made full and correct entries of all transactions relating to the system. Not later than three (3) months after the close of each operating year, the Automobile Parking Authority will cause to be prepared, on forms furnished by the Municipal Finance Commission, if such forms be available, a statement in reasonable detail, sworn to by its chief accounting officer, showing the cash income and disbursements of the system at the beginning and close of the operating year and such other information as may be necessary to enable any taxpayer of the city, user of the services furnished, or any holder or owner of the bonds or anyone acting in their behalf to be fully informed as to all matters pertaining to the financial operation of the system during such year. A certified copy of such statement and books of record and account shall, at all reasonable times, be open to inspection by any taxpayer of the city, user of the services furnished, or holder or holders of any bonds or anyone acting in their behalf. A certified copy of such statement shall likewise be sent to each member of the group or syndicate purchasing the bonds within three (3) months after the close of such operating year.

(*c*) The city will maintain and carry sufficient insurance covering the operation of its various parking facilities to protect the system against substantial loss or damage.

(*d*) The city will not sell or dispose of the system or any substantial part thereof until all of the bonds have been paid in full, both as to principal and interest. The city will operate and maintain the system and all its component parts, including parking meters, parking structures, and other equipment and facilities, in accordance with the provisions of this ordinance until all of the bonds have been paid in full, both as to principal and interest, and will take no action in relation to such system which would unfavorably affect either the security of the bonds or the prompt payment of principal and interest thereon.

(*e*) The holders of the bonds from time to time shall be entitled to exercise all rights and powers for which provision is made in Act 94, Public Acts of Michigan, 1933, as amended, including the right to apply for the appointment of a receiver for the system, in all respects as though said rights and powers were herein set out in full.

(*f*) The city maintain parking meters, enforce parking regulations, and collect rates therefrom in manner required by this ordinance on all public streets where said parking meters are located as of the date of the passage of this ordinance, on such streets where the parking meters herein authorized to be purchased shall be located, and on all other streets where parking meters shall hereafter be located until all of the bonds have been paid in full as to both principal and interest. This covenant shall not be construed to prohibit necessary changes in location of said parking meters made necessary by street widenings or street closings or to meet other traffic control requirements, reasonable variation of time limits for parking, or substitutions or changes in location of parking meters which would not materially lessen the income and revenues derived from the System.

Sec. 19. The statutory lien on the revenues for which provision is made in Section 8 of Act 94. Public Acts of Michigan, 1933, as amended, is hereby recognized and created in favor of the holders of the bonds and the

interest coupons pertaining thereto. Such lien shall continue in existence until the payment in full of principal of and interest on the bonds and may be enforced in the manner for which provision is made in Section 9 of Act 94, aforesaid.

Sec. 20. The parking structures herein authorized may be constructed and/or acquired at separate times, and for that purpose the bonds herein authorized may be issued and sold in blocks from time to time as may be necessary to finance that portion of the parking facilities being acquired and/or constructed at such particular time. Where bonds are to be issued and sold in blocks as herein authorized, the City Commission shall, by resolution, specify the parking structure or portion thereof to be acquired with the proceeds of the sale and said blocks of bonds, and specify the specific maturities to be sold as a part of each of said blocks of bonds. . . .

Sec. 22. The right is reserved, in accordance with the provision of Act 94, Public Acts of Michigan, 1933, as amended, to issue additional bonds payable from the revenues of the system, which shall be of equal standing with the bonds herein authorized for the following purposes and in accordance with the following conditions:

(*a*) For completing the acquisition and construction of the parking structures herein authorized in the event the funds realized from the sale of the bonds herein authorized proves to be insufficient therefor.

(*b*) Prior to, but not subsequent to July 1, 1953, acquiring, improving, and making available for public use any or all of the following described four (4) off-street parking lots: . . .

MILWAUKEE RESOLUTIONS PERTAINING TO DEVELOPMENT OF PARKING FACILITIES

Purchase, Development, Maintenance, and Operation of City-Owned Off-Street Parking Lots in Residence Districts

Resolved: By the Common Council of the City of Milwaukee, that the following procedures shall apply to the purchase, development, maintenance and operation of all city-owned parking lots in residential districts, and all city officers and employees shall be guided thereby:

Purpose—The purpose of the residential area parking program is to provide for the creation and development of off-street parking lots in areas where the need of all-night parking facilities is the greatest in order to clear the streets of parked cars at night for the purpose of providing better and more economical snow plowing, snow removal, street cleaning and law enforcement.

General—The establishment of off-street parking in residential areas for the purpose described is new and the details of procedure and operation may have to be altered as experience and experimentation may determine. Also, some of the details of future procedures may be influenced by the number of off-street parking facilities which may be established.

Location—The location of these parking lots shall be determined by the Common Council after a report has been made by the Parking Commission and the Board of Public Land Commissioners on the need of off-street parking in the area and recommended sites for that purpose.

Land Acquisition—The City of Milwaukee is to assemble and acquire the necessary land for the development of off-street parking lots in residential areas. This shall be the responsibility of the Board of Public Land Commissioners and the City Real Estate Agent as directed by the Common Council.

Improvements—The City of Milwaukee shall provide for the grading and drainage of the premises in an approved manner so as to prevent water flowing onto the street, walks or onto adjacent premises and shall pave the premises with a material which will maintain a dustless surface.

The City of Milwaukee shall install such illumination as may be required for night parking purposes—same to be installed in such a manner so as to reduce to a minimum reflection or glare onto adjoining premises.

The City of Milwaukee shall also provide such masonry walls, fencing, shrubbery and wheel or bumper guards as may be deemed necessary and to provide the necessary driveways for ingress and egress from the public highways.

The City of Milwaukee shall also provide signs indicating entrances and exits to the parking lot, and the name, address, and telephone number of the lessee and the rates charged.

The City of Milwaukee shall do the necessary painting on the pavement showing the location of the parking stalls and shall renew this painting as required.

The design and improvement of the lot and the removal or demolition of buildings shall be the responsibility of the Department of Public Works, subject to review and comment by the Parking Commission.

Snow Plowing and Snow Removal—The Lessee shall be responsible for the plowing of snow from the public walks adjacent to the parking lot and the Lessee shall be responsible for the plowing and removal of all snow from the driveways and the parking lot as may be necessary.

Operation—During the course of design and construction, arrangements shall be made by the Board of Public Land Commissioners and the City Real Estate Agents subject to review and comment by the Parking Commission and at the direction of the Common Council, for the leasing of these lots to private operators for a period of one year if reasonable terms and conditions can be reached. Leases may be extended for increments of one year, without limit as to the number of such extensions, provided the terms, conditions of operation and financial arrangements at the end of each year are satisfactory to both parties. Otherwise, it shall be terminated at the end of the one-year period.

In order to minimize confusion, lessen details and make for a better operating set-up, it is deemed desirable that a group of lots in the same neighborhood be leased as a unit to one operator.

The number of spaces rented for occupancy at any one time shall not exceed the design capacity of the lot. Parking shall be for passenger automobiles only. No trucks or other vehicles shall be permitted to park on the lot. Parking shall preferably be of the non-attendant type, each car operator parking his or her car. The City of Milwaukee shall not be responsible for any property loss or damage or personal injury occurring on the parking lot. The Lessee shall provide and maintain a policy of public liability insurance, naming the City of Milwaukee as assured, to save and hold harmless the City from any and all claims for personal injuries or property damage arising from the use and occupancy of the premises. Said policy shall provide that it will be cancelable only after ten days notice in writing shall have been given the Real Estate Agent of the City of Milwaukee. Certificate of Insurance or copy of said policy shall be filed with the City Real Estate Agent.

The Lessee shall have a telephone and premises within a reasonable distance from the parking lot where arrangement for renting stalls and payments therefor can be made at specified times.

The collection of rents from the Lessee is to be under the jurisdiction of the Board of Public Land Commissioners and deposited in the proper fund. The costs of land purchase, improvements, maintenance and operation shall be paid out of funds set up by the Common Council for those purposes and cost accounting shall be under direction of the City Comptroller.

The Traffic Engineer shall appraise from time to time the operation of these parking lots and the street parking conditions in the vicinity thereof and make public reports to the Parking Commission as to the effectiveness of each lot, character of service rendered, adequacy of maintenance, parking conditions in the vicinity of the lot, income and expenditures, with recommendations for such changes in the operation or maintenance as may appear desirable.

If reasonable terms and conditions cannot be obtained from private operators, then the City shall make arrangements for the operation of these lots either by the direct renting of the parking stalls for a definite period of time or by the installation of parking meters or a combination thereof as may be determined by the Common Council.

Maintenance of Premises—The Lessee shall be responsible for keeping the premises clean and free from the accumulation of refuse or debris, and at locations where there is a grass plot between the sidewalk and the curb or between the sidewalk and the lot line or in the lot or between the lot line and

the boundaries of the parking area, shall keep such grass cut and in a condition comparable with that on adjacent properties.

Repairs—The City of Milwaukee shall repair and keep in safe and presentable condition the parking lot surface, wheel or bumper guards, fencing, street lighting, driveways, and the public walk. This work shall be the responsibility of the Department of Public Works, the cost of same to be paid out of funds set up for the operation of off-street parking facilities.

Operation and Maintenance of Lighting—The lighting required for night operation is to be operated and maintained by the Department of Public Works of the City of Milwaukee, the cost of same to be charged to the funds set up for the operation of the off-street parking facilities.

Rates To Be Charged—The maximum rates to be charged for parking on city-owned parking lots in residence districts shall not be in excess of the following:

The maximum rate for 24-hour parking every day shall not be in excess of $7.00 per month or $2.00 per month more than the permit fee for all-night, on-street parking, whichever is the greater.

The maximum rate for 12-hour night parking every night shall not be in excess of $5.00 per month or $1.00 per month more than the permit fee for all-night on-street parking, whichever is the greater.

The maximum rate for 12 hours all-day parking every day shall be the same as prescribed for 12 hours all-night parking every night.

The maximum rate for one 24-hour period shall be 75 cents.

The maximum rate for 12 hours parking for one day shall be 50 cents.

The maximum rate for 12 hours parking for one night shall be 50 cents.

All-Night Street Parking Permits—In the vicinity of any city-owned parking lots, all-night parking permits shall not be issued within the capacity of the lots in an area defined in detail for each individual lot.

Resolution Amending and Clarifying Procedures

Whereas, Due to the passage of time and changes in administrative procedures and departmental organization, it is necessary and in the best interest of the City to restate the procedures and respective responsibilities of various City departments and commissions as they relate to the purchase, development, maintenance and operation of parking facilities in residential areas; now, therefore, be it

Resolved, By the Common Council of the City of Milwaukee, that Resolution File No. 52-2170-a, adopted January 27, 1953, and Resolution File No. 52-2170-b, adopted March 24, 1953, be and hereby are amended to read as follows:

Resolved, By the Common Council of the City of Milwaukee, that the following divisions of City government be and hereby are designated as responsible for the various phases of work relating to off-street parking facilities developed with parking funds in residential areas, as follows:

1. Location and needs: Parking Commission and City Plan Commission, subject to approval by the Common Council
2. Surveys, studies and justifications: Department of Public Works—Review by Parking Commission
3. Programming and recommended financing: Parking Commission—Review by Capital Improvements Committee and City Comptroller
4. Land acquisition: Department of City Development
5. Details of plan, grading, drainage, surfacing, lighting, planting, estimates of cost, layout, wrecking of buildings: Department of Public Works—Review by Parking Commission
6. Letting contracts, inspection or construction by city forces: Department of Public Works
7. Repair and replacement of surfacing, wheel and bumper guards, fencing, meters, driveways, public walks, and lighting system; supply lighting current: Department of Public Works
8. Operation and housekeeping, including snow removal, from the parking facilities, driveways, and public walks adjacent thereto, including the maintenance of planted areas and shrubs in the parking facility proper and adjacent thereto: Lessee

9. Modification of plans affecting private property or within the parking facility: Department of Public Works—Review by Parking Commission
10. Rights of abutting property owners for ingress, egress, loading or unloading: Department of Public Works—City Attorney—Review by Parking Commission
11. Leasing: Parking Commission and Department of City Development—Review by City Comptroller
12. Billing for rents: Department of City Development
13. Collection of coins from parking meters and gates: Same collector who collects from parking meters on the streets
14. Departmental fund control, keeping of records and accounts: Department of Public Works
15. Auditing: City Comptroller

and be it

Further Resolved, That in addition to the above, the following principles and standards shall apply to parking facilities in residential districts:

Parking facilities in residential districts shall preferably be constructed without parking meters or gates unless otherwise authorized by the Common Council and shall preferably be of the non-attendant type, each automobile operator parking his or her own car. Such residential parking facilities shall be leased to private operators for a period of one year if reasonable terms and conditions can be reached.

The number of spaces rented for occupancy at any one time by the lessee shall not exceed the design capacity of the facility. Parking shall be for passenger automobiles only; no trucks or other vehicles shall be permitted to park in the facility unless specifically provided for in the design.

The lessee shall provide and maintain a policy of public liability insurance naming the City of Milwaukee as assured, to save and hold harmless the City of any and all claims for personal injuries or property damage arising from the use and occupancy of the premises. Said policy shall provide that it will be cancelable only after ten (10) days' notice in writing shall have been given the Department of City Development of the City of Milwaukee. Certificate of insurance or copy of said policy shall be filed with the Department of City Development.

The lessee shall have a telephone and premises within a reasonable distance from the parking facility where arrangements for renting stalls and payments thereof can be made at specified times.

The Commissioner of Public Works shall appraise from time to time the operation of these parking facilities and the street parking conditions in the vicinity thereof and make reports to the Parking Commission as to the effectiveness of each facility, character of service rendered, adequacy of maintenance, parking conditions in the vicinity, income and expenditures, with recommendations for such changes in the operation, maintenance or leasing as may appear desirable.

The rates to be charged by the lessee of the parking facility shall be such as have been mutually agreed upon and incorporated in the lease document.

Leases may be extended for increments of one year provided the terms, conditions of operation, and financial arrangements at the end of each year are satisfactory to both parties.

If reasonable terms and conditions cannot be obtained from private operators, then the City shall make arrangements for the operation of these facilities either by the direct renting of the parking stalls for a definite period of time, by the sale of special privilege parking permits, by the installation of parking meters or parking gates, or by a combination thereof as may be approved by the Common Council; and be it

Further Resolved, That in the vicinity of any City-owned residential parking facility the Police Department shall not issue special privilege all night on-street parking permits within the capacity of the parking facility; and be it

Further Resolved, That the appropriated funds for the maintenance and operation of these parking facilities, other than those for payment in lieu of taxes and for sinking fund purposes, shall be under the control of the Bureau of Traffic Engineering and Electrical Services—Parking Division and all other Departments and Bureaus shall invoice said Bureau for maintenance and operation

services and materials on duly authorized requests only; and be it

Further Resolved, That these provisions shall not apply to other City-owned lots or facilities in residential areas not acquired or developed with parking funds which are used by or rented to others temporarily for parking purposes; these shall continue to be maintained by the Department of City Development in accordance with specific rental agreements.

Adopted by the Common Council of the City of Milwaukee on March 20, 1962.

MILWAUKEE ORDINANCE REGULATING ALL-NIGHT PARKING OF VEHICLES

101-135. All-Night Parking

(a) Prohibited. No person, firm, partnership or corporation, nor any officer, member, agent, servant, or employee of any firm, partnership or corporation shall suffer any vehicle of any kind or description to be parked on any public highway of the City of Milwaukee for more than two hours between the hours of 2:00 a.m. and 6:00 a.m., except as otherwise restricted or permitted herein.

(b) Special Permit. In congested areas, as designated by the Police Department, vehicles may be parked during such hours; provided they shall first obtain a special privilege permit from the Police Department after filing an application with said department and paying a permit fee to the Police Department, all as required under this section, and shall be parked as authorized by such permit.

(c) Alternate Side Parking. Any vehicle parked pursuant to the provisions of (a) and (b) above shall be parked only on the even numbered side of the street on those nights bearing an even calendar date during the portion thereof before midnight, and on the odd numbered side of the street on those nights bearing an odd calendar date during the portion thereof before midnight, except that where parking is normally permitted only on one side of the street, vehicles parked pursuant to the aforesaid provisions may be parked on that side of the street only, on every night of the week.

(d) Ineligible Vehicles. Motor trucks, motor buses, motorcycles, motor delivery wagons, trailers, semi-trailers, cabin trailers and tractors shall not be eligible for such special privilege parking permits.

(e) Application and Permit.

1. The application form shall contain the name and address of the owner of the vehicle, the license number, make and year of the vehicle, the name of the month of issuance and the date of expiration and a statement that the owner resides in the designated congested area and is unable to find reasonable accommodations.

2. The permit shall contain the number of the permit, the name and address of the owner of the vehicle, the make, year and license number of the vehicle, the location where the vehicle is to be parked, the month of issue, and date of expiration. The permit shall be a different color each month. All permits shall be numbered consecutively.

3. The permits shall be placed in the lower right hand corner of the windshield or in such other conspicuous place as the Police Department may designate, while the motor vehicle is in a parked position.

(f) Permit Fee. The special privilege permit fee shall be four dollars per month; provided, however, that if any permit is granted after the 15th day of the month the permit fee shall be two dollars for the remainder of said month.

(g) Separate Fund. All moneys received from said permit fees shall be placed in a separate fund for off-street parking purposes only, except that costs for the printing of application forms and permits, stationery, postage, office supplies, and for any other kindred forms and the printing thereof in connection with the administration of this section shall be paid out of this fund.

(h) Exceptions.

1. The provisions of this section shall not be effective and in force on the morning of the 1st day of January (New Year's Day), May 30 (Memorial Day), July 4 (Independence Day), 1st Monday in September (Labor Day), 4th Thursday in November (Thanksgiving Day), December 25 (Christmas Day) and the 1st day of each week (Sunday), in any year. Provided, further, that in case of night workers who are not

provided with off-street parking facilities by their employers, such condition shall constitute an emergency and the Chief of Police shall, subject to the approval of the Common Council, designate suitable locations where, notwithstanding the provisions of this section, such night workers shall be permitted to park their automobiles during the period of their employment, and on permit of the Chief of Police which permit shall be displayed in the lower right hand corner of windshield.

2. This section shall not apply to licensed physicians and surgeons in emergency situations.

3. This section shall not supersede any of the provisions contained in sections 101-137 and/or 101-126 of the Milwaukee Code.

(i) Winter Regulations. From the 16th day of November to the 15th day of April, inclusive, of the year following, no special permits shall be issued for parking upon any thru highway, except as provided in subsection (j), or upon those portions of any street upon which there is operated a trackless trolley or motor bus route.

(j) Exceptions to Winter Regulations. The provisions of subsection (i) of this section shall not apply to the following portions of through highways. (Specific locations to which this section applies are to be found in the Common Council proceedings, the official record on file in the City Clerk's Office, and the code on file in the Municipal Reference Library.) (Cr. Ord. No. 588, 4/18/50; Am. Ord. No. 44, 5/16/50; Am. Ord. No. 47, 5/16/51; Am. Ord. No. 525, 12/27/51; Am. Ord. No. 599, 2/6/52; Am. Ord. No. 615, 2/6/52; Am. Ord. No. 785, 4/7/54; Am. Ord. No. 205, Sept. 1957; Am. Ord. No. 569, 12/26/62; Am. Ord. No. 595, 12/20/63).

APPENDIX C

CHANGE-OF-MODE FACILITIES

The following material has been supplied by various transit agencies and describes characteristics of some of their facilities. Examples are given of parking facility operation for both bus and rail transit. Changes and improvements may have occurred since the material was compiled, and the listing is intended to be illustrative only.

RAIL RAPID TRANSIT IN CLEVELAND

The Cleveland Transit System, a municipally owned operation, uses grade-separated railroad rights-of-way to serve commuters in both directions beyond the central city. A 4-mile extension of the west side route to the Cleveland Hopkins International Airport, completed in the late 1960s, was acclaimed as the nation's first rail rapid transit between a downtown area and municipal airport. A total of 6,730 parking spaces have been built at nine rail rapid stations. In addition, 135 pickup and dropoff spaces are provided at eight stations. All lots are paved, striped, and lighted. Sawtooth bus loading platforms have been built at two lots to facilitate bus maneuverability.

The average construction cost was less than $300 per car space. Metered parking at 77 spaces has been provided at one lot for short-term shopper parking. The balance of parking is free.

The rail rapid transit stations are spaced an average of more than a mile apart. At each station, transfer may be made to surface lines. Some 58 bus lines provide feeder service to the rapid transit route. Half the stations have special off-street bus terminals with a sheltered connection to the rapid transit.

A complete review of the Cleveland system—territory served, operating characteristics, parking facilities, construction costs, stations, and bus loading platforms—is given in Highway Research Circular No. 91 (1969).

EXPRESS RAIL SHUTTLE IN SKOKIE, ILLINOIS

The Skokie Swift was developed as one of the first mass transit demonstration projects in the United States involving the cooperative sponsorship of the federal government, a transit operator, and the local community. Operation was begun in April 1964 by the Chicago Transit Authority. It was continued as a regular service at expiration of the demonstration grant period. Five miles of an abandoned electrified rail route were rehabilitated and utilized for the shuttle service. The line runs from a major rapid transit terminal at Chicago's northern city limits to an outer terminal in the suburb of Skokie. An old 100-space cinder parking

area was located next to the rail right-of-way. This was enlarged into a new 385-car lot designed to modern standards. The area was graded, paved, and lighted. Guardrail was provided to delineate the boundary, and curbing was constructed at entrances and exits. Parking gates were installed to provide free entrances at two points, and two other coin-operated gates were installed for exit.

The lot was later enlarged twice during the 2 years of the demonstration project to a capacity of 555 cars. The parking charge is 25 cents. This lot is used to capacity on weekdays and at other times of heavy travel. It includes a pickup and dropoff area with short-term waiting stalls. Space is provided for loading and unloading feeder buses and for taxi loading. During the early years of service, an airport limousine stop was also incorporated. In 1970, an interstate bus connection was inaugurated.

INTER-URBAN RAIL TRANSIT IN PHILADELPHIA

An electric rail line on grade-separated right-of-way is operated by the Southeastern Pennsylvania Transportation Authority (formerly the Philadelphia Suburban Transportation Company). The rail line carries commuters between the city of Norristown or intervening communities and the 69th Street transit terminal, where connection is made to the Market Street subway-elevated line running to downtown Philadelphia. Nearly 700 free parking spaces were provided at 17 lots in suburban communities beyond the 69th Street terminal.

EXPRESS BUS FOR NEW YORK CITY

From North Bergen, New Jersey, the Public Service Coordinated Transport Company operates express bus service through the Lincoln Tunnel to the bus terminal in New York City.

A park-and-ride lot owned by the Port of New York Authority is located across the Hudson River from Manhattan. It has a capacity of 1,554 all-day parking spaces.

The lot serves both commuters and shoppers and is usually filled by 11:00 a.m. No pickup and dropoff facilities are available. During the heaviest inbound hour, 550 vehicles enter the lot.

The auto driver pays at a toll booth upon entering the lot. As of 1970 the charge was $1, which included parking and round-trip bus transportation. The transit fare for additional passengers was 35 cents one way or 70 cents round trip. Motorists find it advantageous to use the park-and-ride facility, avoiding payment of a 50-cent tunnel charge plus expensive parking fees in Manhattan. Furthermore, the buses get preferential tunnel entry.

EXPRESS BUS IN MILWAUKEE

As of August 1970, the Milwaukee and Suburban Transport Corporation operated six "Freeway Flyer" bus routes on existing freeways. Outlying park-and-ride lots were made available without charge by privately owned shopping centers.

The first Freeway Flyer line, operating between the Mayfair Shopping Center on the west side of Milwaukee and downtown, commenced operation in March of 1964. A second express bus line, operating from the Bay Shore Shopping Center on the north side of town, began in November of 1965. Surveys of these first two services revealed the following:

1. Four out of five users are licensed drivers, and two out of three have one or more automobiles available for use.
2. Of the users who formerly made this trip by either driving or as a bus passenger, over 60 percent had been auto drivers.
3. Of total inbound riding of 333 at Bay Shore and 418 at Mayfair, 119 parking spaces out of 200 were occupied at Bay Shore and 157 of 450 spaces were occupied at Mayfair in June 1967.
4. Home to work and home to school, and reverse, are almost the only trip purposes.
5. One-half of the riders indicate that they have increased their shopping at the shopping center providing the parking because of this service.
6. The Mayfair Flyer stated with 119 riders, reached a peak of about 1,000 one-way trips per day, and then declined to 820

after another Flyer route was started. The Bay Shore Flyer began with about 200 one-way trips daily, and reached stability with about 600 daily.

Other Freeway Flyer lines were begun in November 1967, April 1969, and July 1970. As of mid-1970, transit fare to the CBD was 50 cents (55 cents on one route). Peak-hour travel time was 10 to 22 min (average 18 min) for distances of 7 to 14 miles (average of 10 miles).

The various Freeway Flyer operations show that buses can operate on the freeways as fast as automobiles and, when taking parking time into account, may provide faster door-to-door service. The parking space made available by the shopping centers during commuter hours can be efficiently used in a park-and-ride bus service, resulting in increased business for the shopping center. Bus rapid transit making use of freeways can be financially successful and can convert auto drivers to bus riders.

BUS SERVICE IN WASHINGTON, D.C.

A successful change-of-mode program in the District of Columbia metropolitan area is conducted by the D.C. Motor Vehicle Parking Agency (MVPA) in cooperation with local bus companies. These facilities have experienced a steady growth in patronage since their opening in the mid-1950s and serve more than 1,200 vehicles daily. Each lot is well paved, lighted, and signed. The MVPA has provided comfortable shelters, seats, heat, and telephones for passengers waiting for buses.

The largest and most used lot operated by MVPA is located at the Carter Barron Amphitheater in the northwest section of the District. The lot was originally constructed to accommodate patrons attending performances at the amphitheater and is still used for that purpose. In early 1955, however, the MVPA made an agreement with the National Capital Park Service which provided for commuter use of 625 car spaces during weekdays. The MVPA provided a bus roadway, passenger shelters, signs, and, in addition, agreed to pay for maintenance, snow removal, and lighting costs associated with the lot. MVPA also provides a guard during weekday hours.

Excellent bus service to most of the downtown employment area is provided by D.C. Transit Company. In addition to 11 regular buses, 16 express buses originate at the lot each morning. Still more bus service is provided on the regular nearby routes, although passengers must walk several hundred feet to 16th Street to use it. Lot use has steadily grown to the point that capacity is being approached.

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