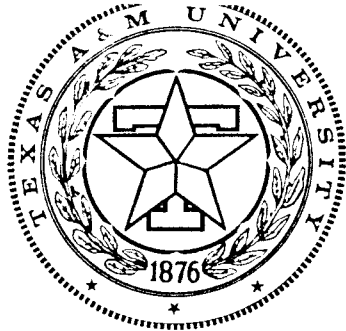


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HEAD-IN, ANGLE, AND PARALLEL PARKING

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Federal Highway Administration  
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HEAD-IN, ANGLE, OR PARALLEL PARKING

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Bibliography

compiled by

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## FOREWORD

This bibliography is limited in coverage to technical journals and reports and is not meant to be comprehensive but is selective. It is respectfully requested that any user keep in mind that it was designed specifically for the use of one group of researchers. The works of some major researchers may be omitted for the reason that the person who requested the bibliography was not only thoroughly familiar with these works, but had them in hand.

## HEAD-IN, ANGLE AND PARALLEL PARKING

1. PARKING REQUIREMENTS FOR SHOPPING CENTERS; A SURVEY. Urban Land Institute (1200 18th St., N.W., Washington, D.C. 20036), Tech. Bull. 53, Nov. 1965. 23pp. \$4.00. HR Abstracts, August 1966.

This study is a valid sampling of the existing shopping center ranges in type, size, and geographical distribution. It is based on actual experience in 270 shopping centers during the peaks of the 1964 pre-Christmas shopping season. In operational practice and hence for development planning purposes, where there is virtually no walk-in trade nor public transit usage, the provision of 5.5 car-parking spaces per thousand square feet of gross leasable area is adequate as a standard to meet the demand for parking space at shopping centers. This standard accommodates the need for parking spaces at shopping centers for all but the ten highest hours of demand during an entire year. These ten highest hours occur during the three peak days of the year. It is uneconomic to provide parking space for such limited peak demands. Office space usage of up to 20 percent of the gross leasable area can be added to the center's complex without a noticeable increase in the peak parking demand.

Where there is a significant volume of walk-in customers or arrivals by means of public transit, or where there are other mitigating circumstances such as a limited trading area or unusual arrays of tenant classifications that have unusually low parking requirements, then the parking space provision cited above can be reduced proportionately. As found in zoning ordinances at present, most of the regulations for shopping center parking call for a substantially greater amount of parking spaces than are found to be necessary in actual practice.

2. PARKING IN THE CITY CENTER. Wilbur Smith and Associates, New Haven, Conn., May 1965. 147pp. HR Abstracts, February 1966.

This guide to all concerned with downtown parking cites the various factors contributing to downtown parking demands and shows how the nation's cities can meet these demands through various private and public approaches. The economic contributions of parking to the city center are indicated throughout the report. Topics include evaluating downtown parking needs, downtown parking economics, recent trends in off-street parking, parking policy and downtown transportation planning, and case studies in downtown parking.

3. Bruder, W.H. THIS PARKING GARAGE USES AIRSPACE, ARCHITECTURAL EXCELLENCE AUTOMATED EFFICIENCY. American City, December 1965, p. 98-100.

White Plains, N.Y. has a long term parking program that makes advantageous use of air space to solve the city's burgeoning parking needs.

Located between two main thoroughfares near city hall, Main-Martine Parking Garage covers about 95,000 square feet of ground area. Visual studies resulted in generous 62-foot bay widths, 19-foot-long parking stalls and 24-foot-wide aisles. Three center bays have stalls laid out for diagonal parking at 70-degree angles. Ramps, located at each side of the structure, provide right-angle parking. Two-way traffic is maintained in all aisles and ramps. Entrance on three sides of the building aid circulation patterns. A fourth entrance can be blocked off or opened as traffic flow demands.

4. PARKING IN TOWN CENTRES. Gt. Brit. Ministry of Housing and Local Government. London, 1965. 46p. (Planning bulletin 7).

A comprehensive parking policy: effect of parking on traffic; effect of parking on environment; need for a comprehensive policy; scope of a parking policy; characteristics of different types of parking facilities.

How to set about it: main types of parking space; assessing present use and future demand; supply; capacity of streets; allocation of parking space.

Methods of providing parking space: on-street and off-street parking.

Use of car parking standards.

Charges.

Appendices: the central area parking survey and plan; preparation of a controlled parking scheme; statutory provisions relating to off-street parking places.

5. Seymer, Nigel. DESIGN OF PARKING GARAGES FOR EUROPEAN NEEDS. International Road Safety and Traffic Review (Great Britain), Autumn 1966, p. 19-30.

Ramp garages: characteristics of design vehicle; stall dimensions; "bin width" and column spacing; "basic area per stall"; aisle width; "end waste"; choice of parking angle; desirability of clear spans; design standards for ramps; gradient; ramp curvature; ramp systems; entrance and exit arrangements.

Mechanical garages: simple mechanical devices; horizontal movement only; stationary elevators and stationary stalls; stationary elevators and moving stalls; stationary elevators, stationary stalls and moving transfer platforms; moving elevators and stationary stalls; "ferris-wheel" systems.

References, p. 30.

6. A COMMUNITY GUIDE TO PARALLEL PARKING. Utah Highway Department. Salt Lake City, 1966. Unpaged.

Booklet prepared to provide factual information that would be useful to public officials in their determination as to the value of parallel parking.

7. Voorhees, Alan M. SHOPPING CENTER PARKING REQUIREMENTS. Alan M. Voorhees & Associates. Presented at the Highway Research Board meeting, January 1966.

Research work has been carried out for the Urban Land Institute to establish the parking standards for the design of shopping centers. This research examined the demand for parking facilities at 269 centers throughout the United States and Canada. It has shown that many factors are involved, such as parking habits, trading area, mode of travel, and the presence of nonretail uses in the shopping centers. At a shopping center where there is little walk-in or transit trade, 5.5 spaces per 1,000 sq ft of gross leasable area should accommodate customer and employee parking demands at the 10th highest hour of the year, with allowance for parking maneuvering. This is considerably lower than most zoning ordinances in effect throughout the country.

8. Baumann, Carl F. NOTES ON PARKING SPACE STANDARDS. New York State Planning News, March-April 1963, p. 10-11.

Includes diagrams of angle parking and straight-in parking.

9. SEATTLE CENTER PARKING FACILITY. American Concrete Institute Journal, September 1962, p. 1-10, (News letter).

Fifteen hundred-car parking garage facility serves Century 21 Exposition in Seattle. Traffic flows up two helical ramps through garage and exit via two similar down ramps. Cars are angle-parked on each side of 60-ft. ramps leaving a 21-ft. travelway throughout the garage.

10. 600-CAR PARKING GARAGE ERECTED IN 70 HOURS. Public Safety (New Jersey Department of Law and Public Safety), February 1962, p. 4.

Hempstead, Long Island, garage called "Tierpark." Unit designed for simple self-parking. Aisles and parking stalls are larger than standard, and garage was planned for angle parking and one-way traffic throughout, with short ramps.

11. Johnson, Bryan K. ANGLE VS. PARALLEL CURB PARKING: TIME AND STREET WIDTH REQUIRED FOR MANEUVERING. Condensation of a research report submitted. . . as partial fulfillment for the requirements for degree of Master of Engineering in Transportation. Division of Transportation Engineering, University of California, Institute of Transportation and Traffic Engineering (Berkeley, Calif.), Graduate Report, 1960. 15pp. HR Abstracts, February 1962.

It is readily apparent that angle parking accomodates more vehicles per unit of curb length than parallel parking. This advantage increases as the degree of angle increases, until at 90 deg. about two and one-half times as many parking stalls are possible.

Angle parking both simplifies and accelerates the act of parking; the driver can steer directly into a stall with no lost motion and minimum interference to moving traffic. Parallel parking involves a backing maneuver which is difficult for many drivers to perform without repeated attempts. Such time-consuming attempts delay moving traffic.

On the other hand, because of limited visibility, leaving an angle stall is more precarious than unparking from a parallel position; some drivers back excessive distances when leaving an angle stall, others back out too suddenly. Consequently, moving traffic is forced to swing side, and often into the path of adjacent traffic. The result is that traffic in the lane adjoining curb parking maintains a greater clearance from angle-parked cars than from those parked parallel to the curb.

Although angle parking accommodates more vehicles per unit of curb length than parallel parking, it is evident that angle parking requires a greater street width for both parking and maneuvering. In the commercial districts of most urban areas, street width is needed for moving traffic. Apart from removing curb parking entirely, many "before and after" studies have shown that conversion from angle to parallel curb parking greatly increases street capacity.

It is not the purpose of this report, however, to compare the direct effect of angle versus parallel curb parking on street capacity. Rather, this study was made to ascertain the amount of time and street width that is required for maneuvering by both types of curb parking. Research was also conducted to determine the effective street width that is utilized for parking by each type; that is, the street width directly required for parking plus that required as a result of the clearance maintained by traffic in the adjoining lane. Evaluation of these characteristics then provides a means of comparing the relative effect of angle versus parallel curb parking on traffic movement and street capacity.

The study was made entirely by the motion picture technique, and the desired parking characteristics were recorded on approximately 1,200 ft of 16-mm film.

The motion picture technique was selected as the best method for obtaining the data because of several distinct advantages. First, of all, it was possible to record a large number of observations for each part of this study simultaneously. Because the filming was done from an unobserved location, it was also possible to obtain unbiased data. In addition, the motion picture method afforded the opportunity to restudy specific parking characteristics for more accurate analysis.

The study of angle versus parallel curb parking indicated the following:

1. For angle parking it takes the average driver only 12 sec to back out of a stall and proceed forward in the traffic lane; for parallel parking the average driver takes 32 sec to back into a stall and clear the traffic lane.
2. For angle parking, the average street width required for parking plus maneuvering is 26.1 ft, while that needed for parallel parking is 17.8 ft.
3. The effective street width that is utilized for parking alone averages 19.1 ft for angle parking and 10.3 ft for parallel parking.
4. The average driver maintains a clearance of 5.0 ft from cars parked at an angle to the curb, and only 3.2 ft from parallel parked cars.
5. A car uses an average of 238 sq ft of street space when angle parked, and 204 sq ft when parked parallel to the curb.

8. PARKING ANALYSES. Highway Research Record No. 317. Washington, 1970. 47p.

Structuring a systems analysis of parking, by Raymond H. Ellis and Paul R. Rassam; a parking study through the use of origin-destination data, by Lawrence L. Schulman and Robert W. Stout; a parametric analysis of fleet parking terminal capacity, by Jason C. Yu; trends in CBD parking characteristics, 1956 to 1968, by R.W. Stout.

9. Spitz, S. and S.E. Rowe. SMALL CAR PARKING. Traffic Eng v 31 n 4 Jan 1961 p 23-4, 48.

Owing to increasing number of foreign and compact cars, present number of 20 ft parking stalls could be reduced by replacement with 18 ft stalls to yield net increase in parking capacity; existing and projected distributions of car lengths in California.

10. DESIGN OF OFF-STREET PARKING LOTS. Pub Works 87(1), 100-1, January 1956.

Arrangements for parallel, perpendicular, and angle parking at 45°; recommended design procedure; efficient regulation of off street lots.

11. Dant, N. BRITISH FLOOR SPACE INDEX USE IN CALCULATING PARKING DEMAND. Traffic Quarterly, 9(2), 237-52, April 1955.

Index is ratio between total area of all floors contained within building and area of plot of land on which building stands; method offers means of determining, comparing and controlling building accommodation contained or to be provided within land areas of any size from survey area or proposed central redevelopment area as whole, down to single plot or block.

6. Forshaw, V. and J.I. Whitehead. CAR PARKING. Surveyor, 112(3204), 519-21, August 1, 1953.

Standards of parking accommodation; number of car spaces is related to population, vehicles licensed, frontage and floor area of buildings; parking habits and duration of parking; off street parking facilities; principle of British Baldwin-Auger system which accommodates from 50 to 100% more cars on given parking area. Before Instn Municipal Engrs.

7. Lewis, H.M. and Morrow, C.E. LAYOUT AND DESIGN OF PARKING LOTS: AESTHETIC CONSIDERATIONS. Traffic Quarterly, 6(1), 27-39, January 1952.

Parking lot created as temporary means, investment or municipal project groups of people affected; good design essential; entrances and exits; use of zoning; lighting; landscape treatment; planting design; illustrative plant list.

8. Bruce, R. CAR PARKING PROBLEM: REQUIREMENTS OF ANY ADEQUATE SOLUTION. Instn Engrs & Shipbldrs in Scotland-Trans, 94(1), 7-18 (discussion), 19-24, 1950-51.

Problem of car parking in large urban centers is space problem; design of car park must be capable of embodiment in buildings both existing and new; it must secure safety of vehicle, afford maximum efficiency, be flexible in application, etc; car park evolved to meet such requirements is reviewed; car park economics examined.

9. Gallagher, J.A., Jr. DRIVER CHARACTERISTICS IN PARALLEL PARKING ON ONE-WAY STREETS. Traffic Eng, 20(7), 276-9, April 1950.

Report on study limited to determining on which side of street parking should be, considering only drivers' ability to park and unpark; method of study; parking time; maneuvers per parking operation; distance from curb, vehicle ahead, and from vehicle behind; miscellaneous information.

10. Orchard, D.F. PROBLMM OF CAR PARKING. Instn Mun Engrs--J, 76(3), 189-222, (discussion) 223-35, September 1949; see also Surveyor, 108(2998), 435-6 (discussion) 441, July 22, 1949.

Present state of law governing parking; undesirable effects of street parking and need for its elimination; different forms of parking and different ways of dealing with problem; illustrated examples of street parking, off street parking facilities, roof parking and multistory garages.

11. PARKING PROBLEM AS FACTOR IN ROADWAY DESIGN. Roads & Bridges, 81(2), 28-30, 54,56, and 58, February 1943.

Summary of extensive study carried out by Eno Foundation for Highway Traffic Control.

12. THE DESIGN OF OFF STREET PARKING LOTS. Public Works, 100-101, January 1956.

Two types of parking are considered, 90° and 45°. There is a chart to illustrate a parking lot designed in Michigan that utilizes both types of parking. It even discusses briefly parallel parking, perpendicular parking, and angle parking at 45°. It gives instructions for designing a lot.



- D. BONDS FINANCE WELL-PAVED PARKING LOT. Roads and Streets, 154-155, August 1955.

This article covers the subject of parking lot financing by bonds, design of the lot utilizing 90° parking, lighting, drainage, and curb and walk construction. There are illustrations of the completed lot and pictures showing various construction stages. There are also detailed cost figures based on 1955 construction costs.

- H. Michael, Harold L. LET'S CONTROL CURB PARKING SPACE. Public Works, 81-83, July 1954.

The author approaches the matter of parking from the type of parkers. He classifies them in four groups--the errand parkers, the shopping parkers, the employee parkers and the loader or the unloader. He has made a careful study of each type and has estimated the average number of minutes used by each one and the average number of times the space becomes available during the business day. There is a photograph, two figures and two tables to illustrate the article.

- I. Hitchcock, S.T. and Burrage, R.H. SOME TRAVEL AND PARKING HABITS OBSERVED FROM PARKING STUDIES. Public Roads, 25-32, June 1950.

Riding past the "full-up" parking lots and making endless circuits of the block in search of a vacant curb space, every motorist has become personally aware of the critical downtown parking problem. To resolve this problem, detailed information on all its ramifications is first needed; and in 46 cities, ranging in population from under 6,000 to more than a million, comprehensive parking studies of the central business districts have been undertaken or completed. From these studies, conducted according to a common basic pattern, some interesting observations on parking habits have been drawn.

It has been found that the number of available parking spaces and the number of vehicles parked, in proportion to population, decrease rapidly as the size of the city increases--there being seven times as many spaces and thirteen times as many parked vehicles, per 1,000 population, in the small cities as in the large cities. The central business districts of the small cities generate ten times as much traffic, in the peak half-hour, as those of the large cities, when proportioned to population. The percentage of traffic passing through the central business district during the day as a whole is about the same for all cities, but during peak periods 91 percent of the traffic in large cities does not stop to park. In the concentrated core of the central business districts, space-hour demands for parking exceed the supply by ratios ranging from 1.34 in small cities to 4.67 in the large cities.

- J. AUTOMOBILE PARKING IN THE UNITED STATES. Highway Research Board Bibliography No. 14. Washington D.C., 119pp, 1953.

A comprehensive bibliography for the years 1946-53 covers books, pamphlets and periodical articles and was issued as a supplement to the bibliography on automobile parking issued by the Bureau of Public Roads in December 1946. It contains a total of 1128 articles and has author index, a geographic index and a subject index. About half of the articles are annotated.