# THE EFFECT OF BUILDING SPACE USAGE ON PARKING DEMAND[1]

J. TRUEMAN THOMPSON, *Professor and Head, Civil Engineering Department* and
JOSEPH T. STEGMAIER, *Graduate Student,*
Johns Hopkins University

No phase of highway transportation receives more attention today than does vehicular parking. It constitutes the major inconvenience of almost every automobile driver destined to an urban central business district and with increased automobile registration and usage, the demand for parking will continue to increase substantially. However, motor-vehicle transportation is not efficient unless adequate parking and terminal facilities are provided. Furthermore, the lack of such facilities seriously affects the entire community with respect to land usage, urban finances and municipal development.

It is generally agreed that the primary function of downtown streets is to move vehicles and not to provide space for their storage. Thus, to promote increased efficiency of mass transportation, fire engines, police cars and other emergency vehicles, as well as to alleviate traffic congestion, delays and accidents, curb parking should either be restricted or prohibited altogether. But if this is done the resulting lack of downtown curb parking spaces, generally where the demand for parking is greatest, places the burden almost completely upon off-street parking lots and garages. Unfortunately, due mainly to high land values, these facilities are utterly inadequate in both capacity and location.

These facts call attention to the urgent necessity for more off-street parking facilities. They should be properly located, their rates attractive and their size and number sufficient for both present and anticipated future demands. However, immediate remedies are retarded by a lack of data based upon adequate factual analyses.

Proper analysis of the parking situation necessitates not only the acquisition of local basic facts, but also their expert interpretation and effective application. Although comprehensive parking surveys have already been conducted in numerous municipalities, it has been pointed out that thus far nothing more than generalizations have been made concerning the parking characteristics of the shopping, employee, business, recreational and other groups[2]. Consideration must be given to the nature of demands by particular generators of traffic and these demands related to trip purpose, hour of parking, the length of time parked and the distance walked from the parking place to the ultimate destination. Such detailed information pertaining to stores as well as to office, industrial, educational, recreational, medical and other types of buildings, could be used to promote the proper location, design and operation of new terminals or the improvement of existing parking facilities.

*Statement of Purpose* - One of the purposes of this study was to investigate the possibilities of utilizing the parking survey data, collected in various

[1]Condensed from *A Study of the Traffic Generated and the Parking Demand Created by Buildings with Various Types of Space Usage* by J. T. Stegmaier; a dissertation prepared under the direction of the co-author in partial fulfillment of the requirements for the degree, Doctor of Engineering, at The Johns Hopkins University (Baltimore, 1948).

[2]Wilbur S. Smith and Charles S. LeCraw, *Parking*, ed. The Eno Foundation for Highway Traffic Control, Inc. (Saugatuck, 1946).

cities, to determine the parking habits of drivers destined to individual generators of different types. Past surveys, at least, were not planned to supply this kind of information and unless future ones are so planned, certain inherent difficulties are apparent. In the first place, only a few cities have conducted or indeed are likely to conduct parking surveys that are thorough enough to contain the basic information desired. Secondly, the area covered by such surveys customarily corresponds only to that of greatest demand, usually the downtown district, and therefore the selection of generator types is limited to those which lie within this area.

A second intent of the study was to look into the possibility of securing mass information about the parking demand created by various types of buildings from urban origin and destination data as a by-product.

And finally, a third purpose was to demonstrate how we may increase the usefulness of this mass information of generator parking demand, by relating it to the physical characteristics of the generators, that is, specifically, by correlating parking demand with such factors as the floor area of various buildings, the number of seats in theaters and other places of recreation, the guest capacity of hotels, the concentration of industrial employees, the number of beds in hospitals, etc. Correlations of this sort obviously would be useful in estimating the anticipated parking demands of new and future land uses and would thus help to provide adequate parking facilities where they belong. Heretofore the acquisition of this kind of data has been one of the most difficult phases of a parking investigation.

## PARKING HABITS

*Analysis of Data* - The data accumulated in the Baltimore City Parking Survey[3] were used as the basis for determining the parking habits of drivers destined to particular generators. This survey and the origin and destination survey conducted in Baltimore were financed jointly by the Public Roads Administration, the Maryland State Roads Commission and the City of Baltimore. The authors are deeply grateful to these sponsors and to members of their staffs too numerous to name, not only for permission to use the data, but for their advice and generous cooperation throughout the study.

It might be well to give a few details of this survey. It was conducted in the spring of 1946 and was confined to 127 blocks of the downtown business district. All of the parking facilities within that area were inventoried and the drivers using them were interviewed. These interrogations supplied information concerning the daily weekday parking pattern including the time of parking, length of time parked, destination after parking, distance walked and purpose of trip. The data were coded and then punched on business machine cards for mechanical tabulation. It is important to note that, while actual destinations were recorded on the questionnaires, the punch cards did not show where the parker went except to give the sector or block in which the generator was located. This was the smallest unit into which the study area had been subdivided and only infrequently did it fail to have in it buildings other than the one under analysis. For this reason the punch cards did not reveal the specific building to which the parker walked. This could only be obtained from the interview questionnaires. It should be stated that coding and punching to permit sorting by sectors was completely adequate for the original purposes of the parking survey. Had the use of the data for individual generator parking demand been visualized, it would have been possible to facilitate the identification of the questionnaire against the punch card by giving each individual

[3]Report of the Transportation Study, - Baltimore Metropolitan Area, PARKING SURVEY OF THE DOWNTOWN AREA - BALTIMORE CITY, Vol. IV, ed. Maryland State Roads Commission in cooperation with the City of Baltimore and the Public Roads Administration, Federal Works Agency, Baltimore 1946.

parking operation a serial number by which it could have been so identified.

However, for the purpose of locating curb parking facilities, the sector or block numbers had been assigned an additional digit which pin-pointed the side of the block. This made it possible to sort the cards for parking operations which were followed by trips to buildings fronting on the entire face of at least one side of a block. There were only three such generators under study. The punch cards which pertained to trips of each of these three were sorted and listings were made of all pertinent information recorded thereon.

*Presentation of Results* - Since the purpose here is merely to indicate a procedure and to give evidence of the reliability of the method, the results of only one such analysis will be presented. These pertain to a combination of two large contiguous department stores ("A" and "B") which front on one side of the same block. These two department stores are the largest such retail businesses in Baltimore's downtown shopping area and together created a demand for the parking of 1413 automobiles between 6 A.M. and 6 P.M. on the average weekday. Figure 1 shows that the purpose of nearly 81 percent of the trips was to shop and less than 13 percent to work. This varies by less than 3 percent from the weighted distribution of purposes for auto drivers destined to these two buildings, as analyzed from the O and D survey data, thus indicating a reasonable correlation of the results. Over 73 percent of the shoppers parked between 10 A.M. and 3 P.M., at the average rate of 172 vehicles per hour. Public lots and garages accommodated nearly 84 percent of the parked vehicles, the remaining 16 percent occupying curb spaces. Nearly all employee drivers parked at off-street facilities. Curb spaces were but little used prior to 10 A.M., probably due to parking restrictions, but from noon until 3 P. M. the curb was used as often as public garages. Throughout the day the relative use of various types of off-street facilities remained fairly constant.

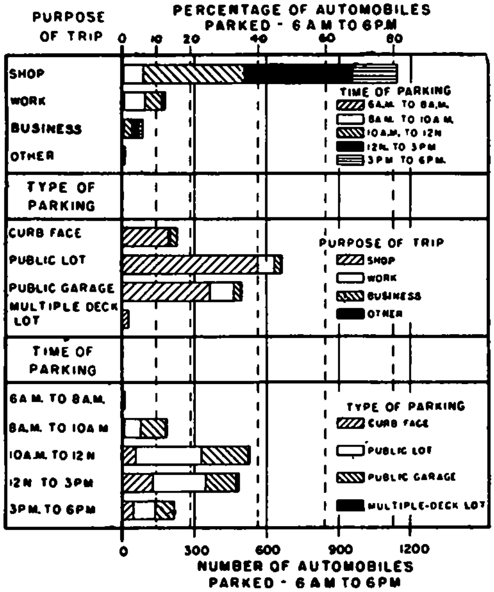


Figure 1. Analysis of Trips by Parkers Destined to Department Stores "A" and "B" by Purpose and Time and Type of Parking

Figure 2 clearly indicates that drivers working at the stores park for a long time.

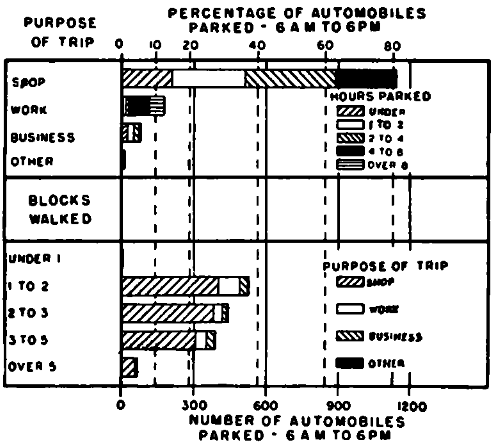


Figure 2. Analysis of Trips by Parkers Destined to Department Stores "A" and "B" by Purpose, Hours Parked and Blocks Walked

What may be surprising is the revelation that the weighted average length of time parked by shoppers was 2.8 hours. Recalling that 73 percent of these shoppers arrived within a five-hour period, it may be concluded that the shopper-parking turnover hardly exceeds two vehicles per day. It should be stated in this connection that some of these trips, resulting in long parking and reported as shopping visits to these stores, probably included walking trips to other stores, luncheon, the beauty parlor or the theater. A further interesting feature of Figure 2 is the distribution of distances walked from parked cars to the stores. Note that the suspected short shopper-walks and long worker-walks are not apparent. It is probable that a considerable number of workers reached the garage, which was close by, before the heavy influx of shoppers, thus pre-empting spaces which the latter desired.

Similarly, in Figure 3 it is seen that the short-time parker did not park any nearer his destination than the long-time parker. If anything, the opposite was the case. Also, a very large proportion of those parking on a public lot walked two to three blocks, while a larger percentage of the public garage parkers walked only one to two blocks. This was no doubt due to a lot and garage, respectively, which are located within these distances and which are particularly convenient to shoppers destined to these two stores. Owing to the existing restrictions on curb parking in the adjacent blocks, the distances walked from curb spaces were relatively long. Nevertheless, note the short-time nature of this on-street parking.

The parking patterns of these figures are consistent with patterns of trips originated by these same two stores when the trip data drawn from the Baltimore Origin and Destination Survey were analyzed and presented in a somewhat similar manner. Also, when the number of automobile drivers who came to the stores (exclusive of those who merely dropped off passengers), as revealed by the analysis of the O and D data, is compared with the number of parkers as revealed by the parking survey data, we find a remarkably close agreement. Auto drivers numbered 1333 and auto parkers 1413, a difference of only 5.6 percent. In the case of the second of three generators studied in this manner, an office building, drivers number 322 and parkers 359, a difference of 10.1 percent. However, in the case of the remaining generator so stud-

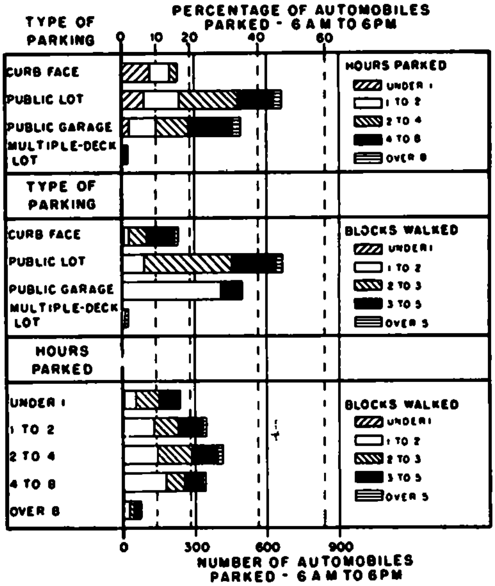


Figure 3. Analysis of Trips by Parkers Destined to Department Stores "A" and "B" by Type of Parking, Hours Parked and Blocks Walked

ied, a large general market, drivers total 488 per day and parkers 831, the difference being 41.3 percent. It is believed that the lack of agreement in the latter instance may be explained by the fact that the number of auto drivers was determined by the answers to questions concerning trips to the market on every weekday, whereas only two weekdays are market days. On the other hand, the number of parkers was developed from the parking survey and a very large proportion of those parking facilities near the market, which might well have been utilized by its patrons, were interviewed only on market days. This no doubt created an apparent parking demand much in excess of that which would occur on the average weekday. In view of these favorable correlations, it was considered reasonable to presume that each automobile driver represented a potential parker.

## PARKING DEMAND

*Analysis of data* - The origin and destination data of the Baltimore Transportation

Study[4] were used as the basis for determining the parking demands of various generators as a by-product of origin and destination surveys. Although the Baltimore Study followed the conventional pattern for such surveys it may be well to recall that the smallest unit into which the Metropolitan Area was subdivided was a sector, which varied in size from a city block in the central business district to several blocks in the outlying areas. For this reason sorting the coded punch cards on a given sector of destination gave no assurance that the sorted cards represented trips to a particular building within that sector. In a few instances, where only one generator was located in the sector, this was true; but in most cases, particularly in the downtown areas, reference had to be made to the original questionnaires in order to determine which trips were made to the selected generators.

The following fifteen buildings and one neighborhood shopping community were selected for study as generators of parking demand:-

Three Department Stores
A Railroad Passenger Station
A Retail and Mail Order Store
A Neighborhood Shopping Community
A General Market
An Industrial Plant
Two Office Buildings
A Theater
A Public High School
A University Campus
A Hotel
A Bus Terminal
A Private Hospital

Referance was made to the original questionnaires where necessary, and those punch cards were sorted out which definitely referred to trips to the selected generators. It was then assumed that each automobile driver trip (exclusive of those who merely dropped off passengers), destined to the respective buildings, constituted a demand for one parking space. This, of course, does not mean that one parking space is required and must or should be provided. Peak-hour demand and vehicle turnover per parking space must also be considered and these factors vary with the type and location of the generator as well as the purpose of the trip. Although peak hours were apparent, turnover factors could not be determined directly from O and D data since they contained no pertinent parking information. However, by taking into consideration all of the elements involved in each case, the turnover factors were estimated to range from one vehicle per space to a "to work" purpose to four vehicles per space for purposes other than to shop or work. The two vehicles per space turnover rate for retail department store shopping was based largely upon the results of the parking habits study presented above.

*Presentation of Results* - The parking spaces required to satisfy the parking demand created by the various generators are presented in Table I. The adaptability of these figures for determining such factors as floor area per parking space required, theater seats per parking space required, etc. is obvious. Equally as evident is the applicability of this information to the formulation of tenable zoning ordinances, which require that automobile parking spaces be provided for in conjunction with the construction of certain new buildings, as well as major structural alterations to existing buildings. These facilities should satisfy the parking needs in a convenient location to insure usage and should be off-street to prevent interference with moving traffic. Provisions for such facilities are recommended by numerous highway and traffic engineers and city planners. Many cities and other political subdivisions have already approached the parking problem by the incorporation of such ordi-

[4] Report of the Transportation Study,--Baltimore Metropolitan Area, TRANSPORTATION NEEDS, Vol. I. Also MANUALS OF INSTRUCTION, ed. Maryland State Roads Commission in cooperation with Baltimore City and the Public Roads Administration, Federal Works Agency (Baltimore, 1945-1946).

TABLE 1

Summary of Parking Space Demand Created on 24-hour Weekday by Various Generators and Relationships with Floor Area or Other Basic Units

| Generator | Purpose of Trip | Auto Driver Trips[a] | Estimated Turnover | Parking Spaces Required | Gross Floor Area or Other Basic Unit | Gross Floor Area or Other Basic Unit per Parking Space Required |
|---|---|---|---|---|---|---|
| | Work | 104 | 1 | 104 | 182,145 sq ft. | 283 sq ft |
| Department Store "A" | Shop | 1036 | 2[b] | 518 | (selling area) | (selling area) |
| | Other | 62 | 3 | 21 | 305,145 sq. ft. | 475 sq. ft |
| | Total | | | 643 | (total area) | (total area) |
| | Work | 146 | 1 | 146 | 185,000 sq ft. | 518 sq ft. |
| Department Store "B" | Shop | 415 | 2[b] | 208 | (selling area) | (selling area) |
| | Other | 10 | 3 | 3 | 245,000 sq. ft | 686 sq. ft. |
| | Total | | | 357 | (total area) | (total area) |
| RR Passenger Station | Total | 1187 | 1 2[c] | 989 | 93,583 sq. ft. | 95 sq. ft. |
| | Work | 286 | 1 | 286 | | |
| Retail and Mail Order Store | Shop | 808 | 2[b] | 404 | 1,300,000 sq. ft | 1,816 sq. ft. |
| | Other | 78 | 3 | 26 | | |
| | Total | | | 716 | | |
| | Work | 294 | 1 | 294 | 120 shops at 5,000 | 813 sq ft. |
| Neighborhood Shopping Community | Shop | 582 | 3[d] | 194 | sq. ft. each equals | |
| | Other | 1000[e] | 4 | 250 | 600,000 sq ft | |
| | Total | | | 738 | | |
| | Work | 5[f] | 1 | 5 | | |
| General Market | Shop | 399 | 2[b] | 200 | 45,000 sq ft | 199 sq ft |
| | Other | 64 | 3 | 21 | 650 stalls | 2 9 stalls |
| | Total | | | 226 | | |
| | Work | 144 | 1 | 144 | | |
| Department Store "C" | Shop | 735 | 2[b] | 368 | 100,000 sq ft. | 180 sq ft |
| | Other | 134 | 3 | 45 | | |
| | Total | | | 557 | | |
| | Work | 447 | 1 | 447 | 1,913,000 sq ft | 4223 sq ft |
| Industrial Plant | Other | 19 | 3 | 6 | 3138 employees | 6.9 employees |
| | Total | | | 453 | | |
| | Work | 313 | 1 | 313 | 591,000 sq. ft | 1628 sq. ft. |
| Office Building "A" | Other | 150 | 3 | 50 | (net rentable area) | (net rentable area) |
| | Total | | | 363 | | |
| | Work | 292 | 1 | 292 | | |
| Office Building "B" | Other | 49 | 3 | 16 | 252,000 sq ft | 818 sq ft. |
| | Total | | | 308 | | |
| | Soc-Cul & Recreation | 205 | 1 5[g] | 137 | 50,000 sq. ft. | 318 sq. ft |
| Theater | | | | | 3000 seats | 19.1 seats |
| | Work | 20 | 1 | 20 | | |
| | Total | | | 157 | | |
| | Work & School | 201 | 1 | 201 | 256,400 sq. ft. | 1263 sq. ft. |
| Public High School | | | | | 1527 students | 7 5 students |
| | Other | 7 | 3 | 2 | | |
| | Total | | | 203 | | |
| | School | 266 | 2[h] | 133 | 398,500 sq ft | 910 sq ft |
| | Work | 283 | 1 2[h] | 236 | (net academic area) | (net academic area) |
| University Campus | Home | 60 | 1 | 60 | 613,500 sq. ft | 1401 sq. ft |
| | Other | 26 | 3 | 9 | (total area) | (total area) |
| | Total | | | 438 | 3335 students | 7 6 students |
| | | | | | 4346 seats | 9.9 seats |
| | Work & Business | 100 | 1[k] | 100 | 162,000 sq ft. | 1013 sq ft. |
| Hotel | Recreation | 56 | 1 4[m] | 40 | 425 guest rooms | 2 7 guest rooms |
| | Other | 61 | 3 | 20 | 700 capacity | 4 4 capacity |
| | Total | | | 160 | | |
| | | | | | 25,000 sq ft | 1042 sq. ft |
| Bus Terminal | Total | 29 | 1 2[c] | 24 | (net terminal area) | (net terminal area) |
| | | | | | 46,000 sq. ft. | 1917 sq ft |
| | | | | | (incl garage area) | (incl garage area) |
| | Work, Home & Medical | 172 | 1 | 172 | 197,000 sq ft | 934 sq. ft |
| Private Hospital | Other | 78 | 2[n] | 39 | 400 beds | 1 9 beds |
| | Total | | | 211 | | |

[a]Except those to serve passengers
[b]Low due to peak-hour traffic
[c]Greater than unity due to 24-hour period
[d]Higher due to shorter time parked at specialty shops
[e]Also omits trips "to home".
[f]But many workers drive trucks
[g]Low due to evening peak hour.
[h]Higher due to evening and night classes
[k]Business not at hotel--actually "to room" purpose.
[m]Low due to evening peak hour
[n]Low due to visiting-hour peaks

nances. Others are considering or advocating this type of building regulation.

But in addition to the diverse opinions on the area of each parking space and the minimum distance between parking areas and generators, there exists a flagrant lack of conformity among the basic factors thus far advanced. This situation stems mainly from a deficiency of reliable criteria, the most credible data to date having been obtained from studies of only relatively homogeneous land uses, which provide a limited amount of information. The type of study outlined here, which investigates absolutely homogeneous areas, namely, individual generators, should provide data that will be entirely applicable and indispensable in formulating necessary ordinances.

Floor areas or other basic units were secured for each generator and this information was in turn related to the parking space requirements mentioned above to produce the basic factors which also appear in Table 1. Although discrepencies appear to be large among the factors for different buildings of the same type, that is, department stores and office buildings, it can be reliably stated that this variation is due to the different character of the traffic generated.

## CONCLUSIONS

1. This study demonstrates a method for obtaining detailed information, directly from urban parking survey data, concerning the parking habits of automobile drivers destined to various types of traffic generators with varying space usage.

2. It likewise demonstrates and establishes a method of securing, as a by-product of urban origin and destination surveys, mass information concerning the parking demand created by such generators.

3. The results which are presented should be regarded only as examples of the kind of information which such analyses may produce. They must be used with caution until substantiated or modified by further applications of the methods.

4. In order to insure that the samples are stable, generators must attract a considerable number of trips. From experience gained in this investigation the minimum number appears to be at least one thousand.

5. The heterogeneous buildings of neighborhood shopping communities, while not generating an appreciable traffic individually, may create a sizable parking demand when considered collectively. This is due to their mutual proximity and consequent added power of attraction.

6. Buildings of approximately the same size, which house activities that are similar in character, may create parking demands that are quite dissimilar. Therefore it is evident that sweeping generalizations are dangerous.

7. It is elementary that information emanating from studies of this type is indicative of demands only as they exist and does not disclose potential demands which may arise as a result of changing conditions.

## RECOMMENDATIONS

1. The procedures demonstrated in this study are recommended for use in connection with and as a by-product of urban origin and destination and parking surveys, wherever comprehensive parking information is sought pertaining to a considerable number of large generators. It is obvious that, if the number of generators is limited or if they are small, it will probably be less expensive and more accurate to conduct a spot-check survey by interviewing a large sample at the site.

2. In order to facilitate the application of these methods it is recommended that present O and D and parking survey techniques be revised to include the following:

a. Whenever the smallest subdivision of the O and D or parking survey area is occupied by more than one generator, specifically code the individual buildings selected for special study at the outset. This would prevent laborious scanning of the original questionnaires.

b. If this is not practicable, the

names or addresses of the buildings should be reported as destinations. In this case all of the original interview forms should be carefully listed and filed by serial number in such a way as to facilitate their matching with the punch cards.

c. When (a) is not practicable in the case of the parking survey, include a serial number on the original questionnaires and on the punch cards so that for each parking operation they may be readily associated.