To the Graduate Council:

I am submitting herewith a thesis written by William Hollis Loveday entitled "The Effects on Parking in Knoxville's Central Business District During the 1982 World's Fair." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Civil Engineering.

Frederick J. Wegmann, Major Professor

We have read this thesis
and ~~recommend~~ its acceptance:

Accepted for the Council:

L Evans Roth
Vice Chancellor
Graduate Studies and Research

Thesis
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THE EFFECTS ON PARKING IN KNOXVILLE'S CENTRAL BUSINESS DISTRICT DURING THE 1982 WORLD'S FAIR

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

William Hollis Loveday

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3066091

DEDICATION

This project is dedicated to my wife, Betsy Beam Loveday, for her many hours of assistance and support during this project. Without her love and understanding this project would not have been possible.

ACKNOWLEDGMENTS

The author would like to express his appreciation to his major professor, Dr. Frederick J. Wegmann, for his advice and encouragement during the preparation of this thesis. Thanks are also extended to Dr. Arun Chatterjee and Dr. Jack Humphreys, who served on the author's committee.

The author would also like to extend his gratitude to his wife Betsy, Miss Leanne Cox, and Miss Tamra Hipp for the many hours spent collecting data.

Special thanks also to the author's parents for their love and patience during this study.

ABSTRACT

The objective of this research was to determine what effect the 1982 World's Fair would have on parking characteristics in Knoxville's Central Business District. This study utilized 13 parking facilities located in a corridor three blocks wide and extending 4800 feet from the fair site to the Coliseum Parking Garages. It also included one facility located one block from the East Gate which was occupied by World's Fair parkers exclusively.

Data were collected in the corridor before the fair opened and during operation of the fair at each of these facilities for four time observations: 9 a.m., 12 noon, 3 p.m., and 7 p.m. For each facility in the corridor the total number of vehicles and a sample of license plates were recorded. For the parking facility used exclusively by fair visitors, data were collected on vehicle arrival rates, turnover rates, and vehicle occupancy rates.

These data were analyzed and it was determined that parking characteristics in the study corridor did indeed change. The following summarizes the corridor changes:

1. An aggregate increase in total vehicles.
2. An aggregate increase in external vehicles.
3. An aggregate decrease in local vehicles.
4. External vehicles in the corridor for the World's Fair were more prevalent, and replaced some local vehicles, closer to the fair site.

5. Visitors of the World's Fair were more sensitive to walking time than parking rates.
6. Approximately 75 percent of the local vehicles displaced were commuters.

The above described changes in parking characteristics in the corridor can be attributed to the 1982 World's Fair. In addition, the following conclusions were reached based on data collected at the exclusive World's Fair parking facility:

1. The average vehicle occupancy for this event was as high as 4.0 persons per vehicle.
2. World's Fair patrons began arriving as early as two hours before the opening time of the fair.
3. The most frequent arrival period was between 8:45 a.m. and 9:45 a.m. (The fair opened at 10 a.m.)
4. Turnover rates were minimum, as most patrons stayed twelve hours.

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CHAPTER I

INTRODUCTION

Statement of the Problem

Normally daily traffic volumes on urban highways are predictable and fluctuate in a repetitive fashion depending on the time of day, day of week, and month of the year. Knowing this information, engineers and planners can determine an estimate of both immediate and potential deficiencies in the transportation system. If a particular facility is operating at level of service "F" during the morning and afternoon peak periods, engineers can develop a solution and implement the improvements as funds become available. Likewise, if a facility is expected to operate at level of service "F" at some future date, engineers may choose to make improvements as preventative measures. This type of planning is advantageous because it helps eliminate problems before they occur.

Planning for future transportation needs is more difficult to accomplish with special events. Engineers and planners rationalize that some special events are infrequent occurrences or have such unpredictable demand that it is difficult to develop transportation plans for them.

A special event is defined in this study as an event that is not held on a continuous basis, such as a football game or fair, and is of sufficient magnitude to cause severe transportation problems. Table 1.1 presents some special events and the respective facilities where these

TABLE 1.1. Examples of Special Events Common to These Facilities

	Football/Baseball Stadium	Auditoriums- Multipurpose	Exhibition Hall	Special Facility
Sports				
Football	x			
Baseball	x			
Boxing	x	x	x	x
Basketball	x	x		
Soccer	x	x		
Hockey		x		
Car Racing				x
Wrestling	x	x	x	x
Rodeo	x	x		x
Roller Derby	x	x		
Live Entertainment				
Concerts	x	x	x	x
Ice Shows		x		
Circus		x		x
Broadway Shows		x	x	
Worlds Fairs				x
Meetings				
Exhibitions		x	x	x
Trade Fairs		x	x	x
Political Events	x	x	x	x
Church Events	x	x	x	x
Conferences and Conventions		x	x	x

Source: Traffic Considerations for Special Events (Institute of Transportation Engineers Informational Report, 1976).

events are held. This table divides special events into three major categories: sports, live entertainment, and meetings. Each of these special events have specific demographic characteristics associated with them and thus will require different transportation considerations. Some of these demographic characteristics include:

1. Time of day the special event takes place.
2. Day or days the special event takes place.
3. Duration of the special event.
4. Length of the special event.
5. Location of the special event.
6. Transit dependency depending on age of crowd.

These are all important characteristics when developing a transportation plan for the special event. For example, if the special event is located near the central business district and operates during working hours, transportation problems could be severe. On the other hand, transportation problems will be less severe if the special event operates during non-business hours. However, the unique combination of demographic factors, such as time of day and location, makes all special events more difficult to plan for than day-to-day traffic.

The uniqueness of each special event is another reason why adequate planning is difficult to achieve. Few previous transportation plans for special events are available; and if they are, it is unlikely that a critique was performed to determine weaknesses. Without this information, engineers have difficulty transferring information from one event to another. However, it is prior experience which is essential for effective planning of special events.

Some special events occur very infrequently, such as world's fairs, which makes the development of transportation planning infrastructure difficult. This is especially true since the size of world's fairs vary depending on the funds available and the size of the cities hosting them.

However, it is clear that implementation of a good special event transportation plan will have the immediate benefits of eliminating congestion and accidents, and will encourage attendance. It will also encourage other special events to take place in the urban area, which will increase revenue and initiate favorable community publicity.

Knoxville, Tennessee, World's Fair

Knoxville, Tennessee, was the site of the 1982 World's Fair. This special event had a duration of six months, May 1 through October 31, 1982, and was located on a 72-acre site adjacent to the Central Business District and the University of Tennessee. It was initially expected the fair would attract eleven million visitors for an average daily attendance of 61,000. This event was unusual because it operated seven days a week between 10 a.m. and 10 p.m. Because of the six-month duration and long operating hours, the fair was expected to have a large impact on Knoxville traffic. This motivated the City of Knoxville to plan for the special event and then make many temporary and permanent transportation improvements and changes.

The developers of the Fair, Knoxville International Energy Exposition (KIEE), began by contracting Barton-Aschman Associates Incorporated in association with McCarty Bullock Holsaple Incorporated, and Barge, Waggoner, Sumner, and Cannon to develop the Transportation

Plan for the 1982 World's Fair.[1] In the Transportation Plan Barton-Aschman first began by using the predicted annual attendance as a base, and then converting it into a daily transportation travel demand with a peak-hour equivalent. Next, the daily attendance records for two other similar World's Fairs, Spokane and Seattle, were analyzed. On this basis, Barton-Aschman recommended that the 90th percentile level be used to estimate daily transportation demands. The 90th percentile level would accommodate all normal weekday traffic of 80,000 persons or less. During weekends and holidays transportation facilities would be utilized less; therefore, while the number of persons attending the fair may increase, the facilities should remain adequate. Barton-Aschman then estimated the number of persons each transportation mode would likely handle each day. They did this by combining the knowledge of earlier World's Fairs and using parametric analyses that established the potential for each mode. They estimated that 2,100 or 2.6 percent of the patrons would walk to the World's Fair, 24,100 or 30.1 percent of the patrons would arrive by bus, and 53,800 or 67.3 percent would arrive by automobile.

Next Barton-Aschman used previous experience to predict the vehicle occupancy rate. With their prediction of 3.5, the number of additional automobiles which would be using Knoxville's roadways and parking facilities was estimated to be 15,400.

Because of varying arrival times of fair patrons, Barton-Aschman felt that Knoxville's roadways could manage the additional traffic adequately. However, parking facilities in Knoxville were determined to be inadequate. Of the 15,400 additional vehicles attracted to the fair,

Barton-Aschman estimated that up to 85 percent or 13,100 automobiles would be parked at one time. They also estimated that about 1,000 spaces would be needed for employees of the fair. Therefore, the total number of parking spaces needed would be 14,100. An inventory of parking supply around the World's Fair site was conducted, and it was determined that 8,000 spaces were available during weekdays for use by visitors and employees. Of these 8,000 spaces, 3,000 would be available at the University of Tennessee, 2,000 at the Mountain View parking garages (in the Coliseum area), and 3,000 in the downtown and surrounding area. Barton-Aschman determined a net need of 6,100 parking spaces (14,100 spaces needed minus 8,000 existing spaces).

Because of limited research on transportation planning for special events, the transportation plan developed by Barton-Aschman was based on numerous assumptions. The basis of the plan, the attendance predictions, were based on two previous world's fairs and the population residing within one day's driving distance. Barton-Aschman assumed that attendance at Knoxville's World's Fair would be similar to those of former world's fairs although held in different geographic areas of the nation. Barton-Aschman also assumed a vehicle occupancy rate of 3.5. This assumption was based on previous experience of family oriented special events. Finally, Barton-Aschman assumed a mode split which was based on estimation of such factors as: number of expected tour buses, number of expected shuttle buses, local transit potential, walk-in potential, and automobile potential.

The expected walk-ins were based on the location of the fair site in relation to downtown Knoxville, the University of Tennessee campus,

and a major urban neighborhood, Fort Sanders. Tour and shuttle bus predictions were based on the effort KIEE made to book them. Transit ridership predictions were based on Barton-Aschman recommendations for utilization. The remaining daily person trips would be by private automobiles. Any deviation from the assumptions could have substantial ramifications on the adequacy of the transportation facilities.

So many assumptions make it difficult to develop accurate predictions for special event plans. Because of the analogy, planning of special events is vital to determine which assumptions were valid and which were not.

Objectives of the Study

The purposes of this study were to determine the impact of the 1982 Knoxville World's Fair on parking characteristics in a section of downtown Knoxville and to provide some transportation planning guidelines which will be helpful for other communities in preparing for similar special events.

CHAPTER II

LITERATURE REVIEW

Introduction

Because it is a rather unusual occurrence, little information is available on transportation planning for special events. Many officials take the viewpoint that they are willing to tolerate severe transportation problems if they occur relatively infrequently, such as college football games. It is this type of viewpoint that has caused difficulties for transportation planners when attempting to plan for special events. For example, the publication Parking, by the Eno Foundation for Highway Traffic Control, does not mention parking problems for special events.[2] Another publication, Parking Principles, by the Highway Research Board, only briefly mentions special event parking problems when dealing with sports stadiums and auditoriums.[3]

When special events are discussed, it is usually in the context of repetitive events, such as sporting events, held in stadiums and auditoriums. There are few publications that address transportation problems for special events such as the 1982 World's Fair.

In the mid 1960's, the Houston Astrodome was built, initiating a boom in the construction of new sports stadiums. Shortly thereafter many other cities, such as Cincinnati, St. Louis, Pittsburgh, Atlanta, and New Orleans, saw the advantages of multi-use sports stadiums and began constructing their own.[5] In each case they located the stadium in the downtown area in order to take advantage of hotels, restaurants,

shops, and transportation facilities. Locating a facility such as a sports stadium in the downtown area, attracting an attendance of 10,000 to 70,000 for over 100 games per year, will cause special transportation planning problems; and it is natural that planning for such facilities represents much of the literature for special events.

The published material on transportation planning for sports stadiums generally follow similar guidelines. These guidelines provide the bases of all transportation plans for sports stadiums as well as other special events. The following are a list of these guidelines in progressive steps.

1. Determine the demographic and transportation characteristics of stadium facilities. These could include time of day, time of year, or time of week event takes place.
2. Determine the design crowd. The design crowd is usually a certain percentage of the capacity of the site or facility.
3. Determine the mode split. The mode split is the percent of patrons that will arrive at the special event by each available transportation mode.
4. Determine the vehicle occupancy. The vehicle occupancy is the mean number of persons per automobile attending the special event.
5. Determine arrival and departure times. This information will determine how "time concentrated" special event traffic will be.
6. Determine the parking needs. By knowing the expected number of automobiles for the special event, the required number of

parking spaces can be determined. The location of these spaces in relation to the special event site must also be determined.

These basic steps are common to most transportation plans for special events. The following is a more detailed description of these steps.

Demographic and Transportation Characteristics of Stadium Facilities

Demographic and transportation characteristics for special events must be known. Table 2.1 lists significant demographic characteristics useful for transportation planning whether they pertain to football stadiums, multipurpose entertainment centers, or exhibition halls.[6] Perhaps the most important of these characteristics are: day of the week, times of day, and presence of consecutive events. If a special event takes place at certain times of the day, a conflict could arise with normal peak traffic or normal peak parking. Back-to-back events could result in an outbound/inbound conflict at the special event site.

Determining the Design Crowd

In order to determine transportation needs for special events, the number of people attending a special event must be estimated. A study by James M. Hunnicutt, Parking Demand for a Large Downtown Stadium, addresses this issue for the construction of a new stadium in downtown Seattle, Washington.[4] The stadium will house professional football, baseball, and soccer, as well as many large exhibitions. Hunnicutt developed an estimated design crowd for baseball based on average major league attendance, analysis of the Atlanta Braves games,

TABLE 2.1. Demographic and Transport Characteristics Common to Basic Stadium Facilities

Characteristic	Football Stadium[1]	Multipurpose Entertainment Center	Exhibition Hall
Events Year Round		x	x
Severe Peak Flows	x	x	
Adult Sports Crowd	x	x	
Any Day of Week[2]		x	x
Various Times of Day[2]		x	x
Back-to-Back Events[3]		x	x
High Proportion Children		x	
High Proportion Elderly		x	
Numerous Handicapped	x	x	
Alcoholic Beverages	x	x	
Weather Strong Factor	x		
Auxiliary Loadings[5]		x	x

Note: "x" indicates the characteristic could apply to the facility.

1. Assumes uncovered stadium.

2. Can mean clash with normal peak transport demands, terminals, facilities, etc.

3. Can result in simultaneous "Peak in" and "Peak out" occurring with high demand in reservoir areas, ticket areas, etc.

4. Proportionally can be especially significant.

5. Vehicles and goods not associated with patrons (i.e., circus vans, equipment displays, and so forth).

Source: Traffic Considerations for Special Events (Institute of Transportation Engineers Informational Report, 1976).

and publicity and sales promotions. The analysis utilized the Atlanta Braves as an analogy because of the similarities in stadium locations and metropolitan populations. Hunnicutt also developed an estimate of a design crowd for football based on attendance in other football cities. He discovered that, regardless of the teams' won/lost record, most professional football games were sold out. For this reason the design crowd for football was determined to be the capacity of the stadium.

A similar study, Transportation Planning Considerations for New Stadia, was also developed in 1973 by John E. Ashwood.[5] Ashwood used the guidelines developed by Hunnicutt to develop a design crowd for the proposed downtown Baltimore stadium.

An Institute of Transportation Engineers Informational Report, Traffic Considerations for Special Events, includes attendance data for various football and baseball stadiums.[6] They subdivide each stadium by the events held there, and then list the attendance as a percent of capacity. They determined that "professional football consistently placed maximum demands on the parking and circulation systems." For example, in Atlanta, professional football games attract crowds of 90-100 percent of the seating capacity. Professional baseball games, on the other hand, attract crowds of 8-100 percent of the seating capacity. Moreover, seating capacities for football games can be up to 30 percent greater than for baseball. For special events such as world's fairs, there is no seating capacity. However, there is a practical site capacity, but it is difficult to estimate due to the physical nature of the site. There has been little research done in

this area; therefore, it is also unknown what type of demands it would place on the circulation system.

Determining the Mode Split

Estimating the mode split for special events helps the transportation planner determine parking needs, pedestrian needs, and bus pickup and drop-off needs. The types of modes utilized for special events include rail transit, local bus transit, shuttle bus, charter bus, automobile, walking, and taxi. Hunnicutt points out that the mode split can be substantially altered by effective publicity promoting bus and rail transportation.[4] Hunnicutt has two different mode splits, one for the baseball design crowd of 25,000 and one for the football design crowd of 50,000.[4] His theory is that the makeup of a typical baseball crowd differs from that of a typical football crowd; therefore, there will be a difference in mode split. It appears that typical baseball crowds have lower average incomes than football crowds. For this reason they will utilize public transportation more frequently. Ashwood also develops two mode splits, one for football and one for baseball. He suggests that mode splits can be determined by market projections and surveys at similar stadiums or at the stadium that is being replaced.[5]

Another factor which influences mode split is the magnitude of the crowd. In Traffic Considerations for Special Events, the authors have compiled data which indicate that more patrons arrive by automobile for a baseball game than a football game.[6] These data do not contradict Hunnicutt's concept of the makeup of a crowd because here they are speaking about person-trips, not vehicle trips. They suggest that smaller crowds and less congestion encourages patrons to use their

automobiles, while larger crowds and more congestion encourages patrons to use public transportation.

A mode split determination must also consider the modes available. For example, most metropolitan areas do not have rail transit; therefore, patrons must choose between bus, van, personal automobile, taxi, or walking.

Vehicle Occupancy Rates

Each transportation plan for special events must determine a vehicle occupancy rate. This rate will depend greatly on the type of special event. For example, Hunnicutt and Ashwood use 3.5 for football games and 2.5 for baseball games.[4,5] They have found that the vehicle occupancy rate tends to be directly proportional to the crowd size. This is an important factor because it means that no matter what magnitude the crowd is, the parking requirements remain relatively constant. Traffic Considerations for Special Events states that family oriented events have a higher vehicle occupancy rate than sporting events.[5] In addition, events that appear to senior citizens and youths will have a higher vehicle occupancy rate. Table 2.2, from Traffic Considerations for Special Events, presents examples of typical vehicle occupancy rates.[6]

Determining Arrival and Departure Times

Arrival and departure times must be known to determine the proper traffic operational system for special events. Many factors influence arrival and departure times, including: the game's score, desire to obtain a good seat if they are unreserved, the nature of the pre-event

TABLE 2.2 Typical Vehicle Occupancy Rates

Stadium	Persons/Vehicle by Event			
	Pro Football	Pro Baseball	Civil/ Religious	College Football
Oakland, Cal.	3.5	3.2		
San Diego, Cal.	2.5-3.1	2.8-3.0		
Anaheim, Cal.		3.41	3.55	3.11
Los Angeles, Cal.	2.6	2.6		
Atlanta, Ga.	2.7	3.0		
Denver, Col.	3.0	1.9		
Orange Bowl, Fla.	2.5	2.1		4.0
Cotton Bowl, Tex.	3.8			3.6

Source: Traffic Considerations for Special Events (Institute of Transportation Engineers Informational Report, 1976).

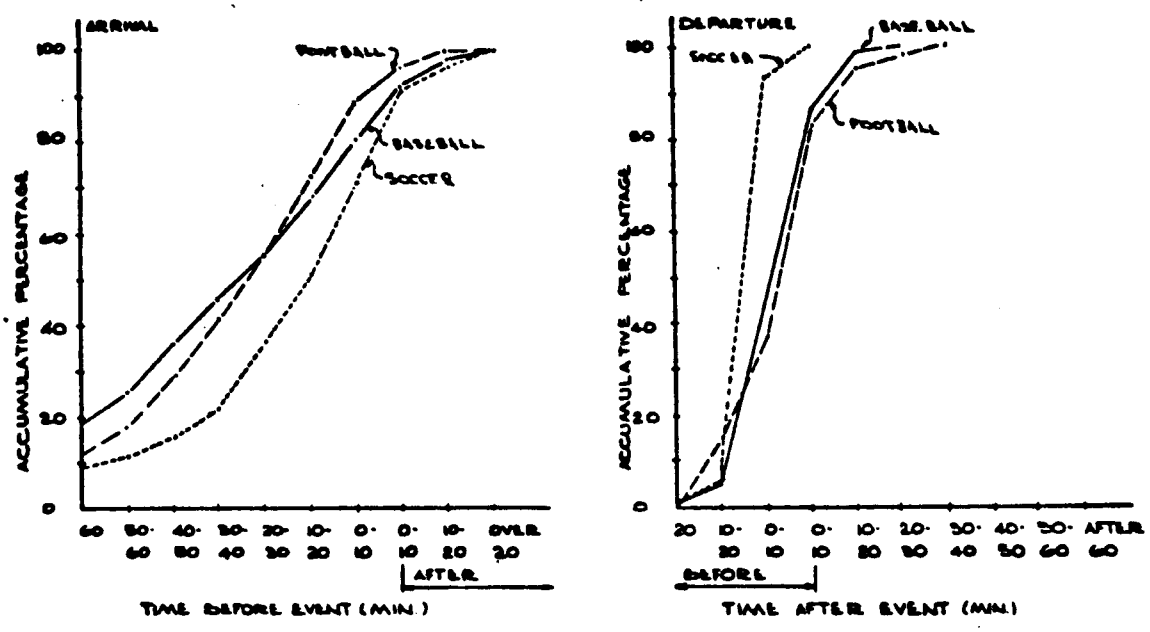
and post-event activities, type of event, characteristics of the stadium or site design, size of the crowd, critical transportation sections, parking garage circulation, and storage ramp capacity.[6] Figures 2.1, 2.2, and 2.3 are accumulative arrival and departure patterns for selective stadiums. For a special event such as a world's fair, arrivals and departures will occur throughout the day. The critical issue is how many patrons will choose to arrive at opening time and how many will choose to leave at closing time.

Parking Analysis

A parking analysis for a proposed or existing stadium is perhaps the most important aspect of a special event transportation plan. Hunnicutt states that "many consultants and planners rely on a variety of origin-destination or traffic methods to arrive at traffic and parking requirements."[4] However, his firm believes "that the best way to approach the problem is to give very close consideration to the parking generator, and to study its characteristics thoroughly. By this method, a much more accurate picture of traffic and parking can be obtained."[4] In many cases the major parking generator would be one major facility located adjacent to the stadium. Hunnicutt used this method in developing a transportation plan for the Seattle stadium.

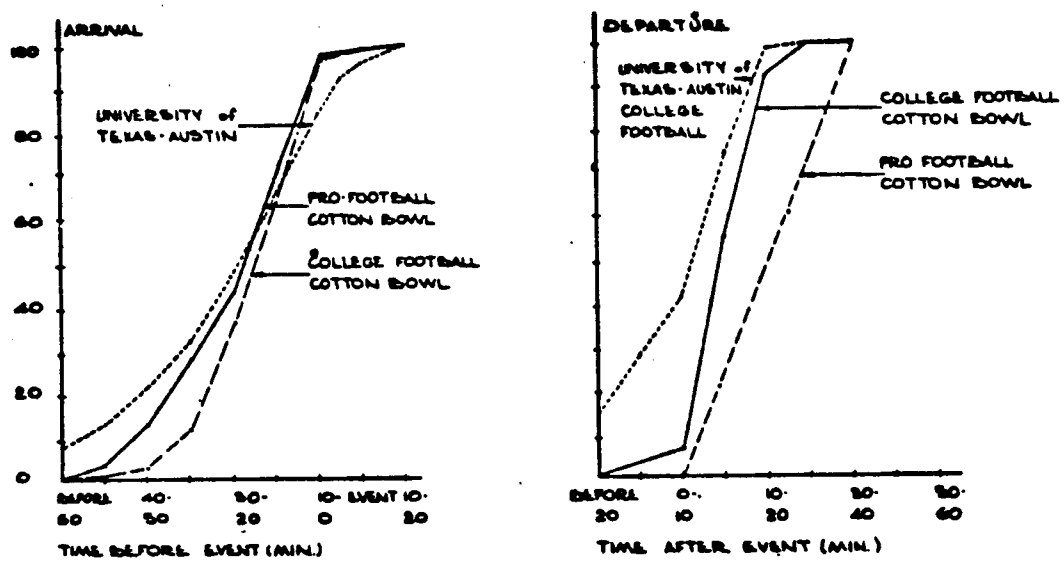
Parking need determinations of special events can be fulfilled after the previous five transportation plan steps have been completed. These steps will yield an estimate of the expected number of automobiles and their arrival times.

After obtaining this information for different design crowds, the next task is to determine reasonable walking distances so that parking



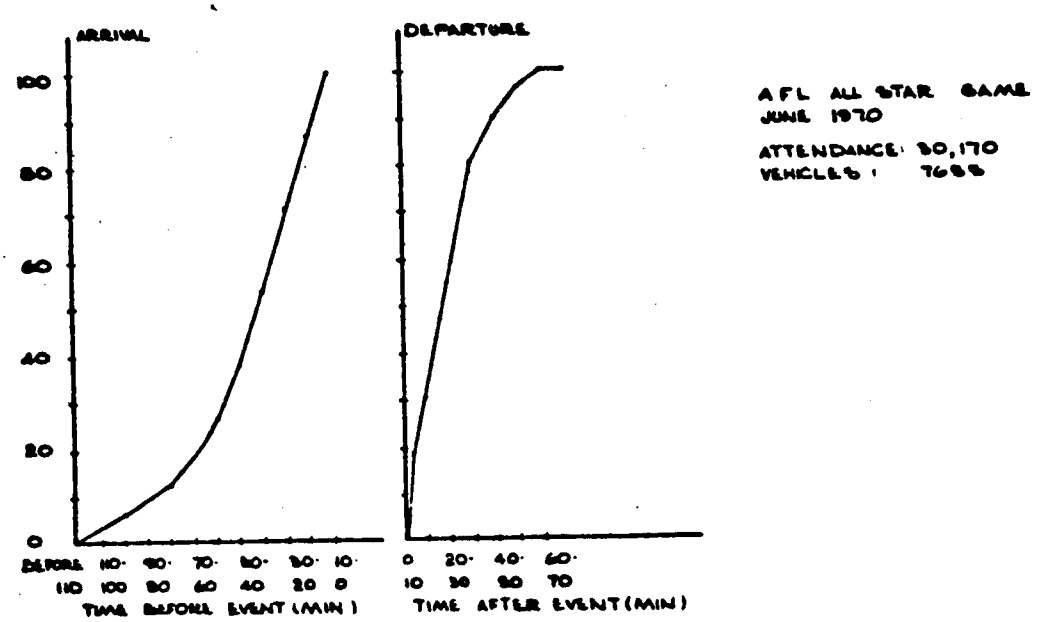
Source: Traffic Considerations for Special Events (Institute of Transportation Engineers Informational Report, 1976).

Figure 2.1. Accumulative Arrival and Departure Patterns, Atlanta Stadium



Source: Traffic Considerations for Special Events (Institute of Transportation Engineers Informational Report, 1976).

Figure 2.2. Accumulative Arrival and Departure Patterns, Cotton Bowl, Dallas, and the University of Texas, Austin (Memorial Stadium).



Source: Traffic Considerations for Special Events (Institute of Transportation Engineers Informational Report, 1976).

Figure 2.3. Accumulative Arrival and Departure Patterns, Houston Astrodome

facilities can be located and operated properly. A reasonable walking distance again depends on the size of crowd and the type of special event. Parking Principles recommends that a walking distance of 1,300 to 1,500 feet be used for a design crowd of 25,000.[3] For a design crowd of 45,000 they suggest that parkers can be expected to walk distances greater than 2,000 feet. Similarly, Hunnicutt estimates that for a design crowd of 25,000, a person will walk to the stadium a distance no greater than 2,500 feet, while 1,500 is a more realistic figure.[4] For football design crowds of 50,000, studies have shown that some individuals park a maximum of 3,000 feet away.[4] Ashwood uses a maximum value of 2,400 feet for a design crowd of 25,000 and 3,000 feet for a design crowd of 65,000.[5]

In Traffic Considerations for Special Events, the authors point out how critical it is to provide an adequate number of parking spaces in an adequate location.[6] For a major stadium that is not served well by public transportation, an inadequate supply of parking will lead to a reduction in attendance.[6] This can probably be overcome only when the team has an excellent season and is in contention for national honors. The authors also state that the frequency of a special event must also be considered. For example, fans of a college football team that plays only 5 to 7 home games per year might be willing to walk farther distances because it is an infrequent occurrence.

Traffic Operational Requirements for Special Events

Consideration must be given to traffic operational requirements for special events. Activities concerning the three major modes, local transit, automobile, and pedestrian must all be coordinated to have a

smooth flowing operation. Table 2.3, Transportation Enquiries, lists some of the questions the transportation planner must answer about each mode.[6]

After addressing these questions, the transportation planner must next form a transportation operational plan for the special event. Because it is an infrequent occurrence, the transportation planner should consider actions which will only be temporary. For example, some major arterials might work best one-way inbound before the event and one-way outbound after the event. In some cases, it might be appropriate to use temporary reversible lanes to accommodate the unbalanced traffic flow. With some special events, it might be necessary to install a special timing pattern for one signal or a sequence of signals. It might also be useful to utilize temporary signs to alert motorists to changes in the normal traffic system. In other cases it might be necessary to close some roadways and make them temporary pedestrian walkways. In other situations exclusive bus lanes may be developed. It is difficult to form specific guidelines for temporary actions, however, because each special event is unique.

Summary

Special event literature up to now has concentrated on sporting events such as baseball and football. There has been little research on other types of special events. Furthermore, the guidelines that have been developed are not always appropriate for events such as world's fairs and have a six-month duration, without a concentrated arrival and departure time. It also appears that more research is needed on the location of parking facilities in relation to the special event site.

TABLE 2.3. Transportation Enquiries

Transit	- how many transit trips? bus, regular system--what routes? bus, charters--from where? storage area? rapid transit--what routes? taxi--storage area? rail--shuttle system required? handicapped problems? (need close embarkation and debarkation) children (monitors need assembly area)
Auto	- how many auto trips? occupancy rates common to demographic patterns? parking spaces available (garages, on-street, lots, etc.) what origin patterns? (what freeways, arteries, local systems? etc.) what are prime corridors? what freeway ramps are to be used? what major streets in what patterns? remote parking areas?
Pedestrian	- what are pedestrian demands? walk trips? transit stations, bus debark and embark areas? ticket areas? "back to back" events (people storage adequate)? shelter in bad weather? ramps, elevators, escalators, moving belts--capacity and demand correlations?
Auxiliary Trips	- for the given activity, how many and what types of vehicles are common? are there special security problems?

Source: Traffic Considerations for Special Events (Institute of Transportation Engineers Informational Report, 1976).

Similarly, no research has been conducted on parking price and its sensitivity as it relates to walking distances.

Presently, there are two reasons why little data and research are available on transportation considerations for special events. First is the very nature of a special event; they occur so infrequently that many officials seem to be willing to accept the problems. Second, each special event is unique and has unique transportation problems. In many cases, such as with downtown sports stadiums, unusual transportation problems never arise; therefore, studies are never conducted. For example, a stadium housing a professional football team will attract maximum crowds only on week nights and Sundays. During these time periods the roadways usually have adequate capacity because traffic utilizing them for other purposes are minimum. Parking facilities are also usually more than adequate.

An example of some unique transportation problems was found at the 1980 Winter Olympic Games in Lake Placid, New York. A recent article by Charles W. Manning, Frederick S. Scholz, and Richard Albertin points out that many of these problems were created by cold weather, snow, and ice.[7] These adverse weather conditions, plus an inadequate number of access roads, inadequate housing, and a limited number of through streets within the olympic village made transportation a major problem. These problems were partly a result of an inadequate transportation plan. A thorough study of the transportation plan for Lake Placid should help eliminate similar problems in the future.

CHAPTER III

BACKGROUND; STUDY AND METHODOLOGY

I. BACKGROUND

Introduction

The 1982 World's Fair started back in 1975 as a dream of W. Stewart Evans, executive director of Downtown Knoxville Association. Evans was the initiator of the concept of bringing a World's Fair to Knoxville. He had the help of three United States presidents and the support of Knoxville's leadership.[8]

In 1976 the Knoxville International Energy Exposition, KIEE, contracted the architectural firm of McCarty Bullock Holsaple to design the World's Fair. The fair, which had the central theme "Energy Turns the World," evolved into a 72-acre site located in Knoxville's Lower Second Creek area. Figure 3.1 depicts the location of the fair site in relation to downtown Knoxville and the University of Tennessee. The fair site is bordered on the east side by a major arterial, Henley Street, on the west side by 11th Street and the University of Tennessee campus, on the south side by Neyland Drive, and on the north side by Southern Railway tracks. Cumberland Avenue divides the fair site into two major sections: the northern section located nearest to downtown Knoxville, and the southern section located nearest to the University of Tennessee. The two sections are connected at Cumberland Avenue by two pedestrian walkway bridges.

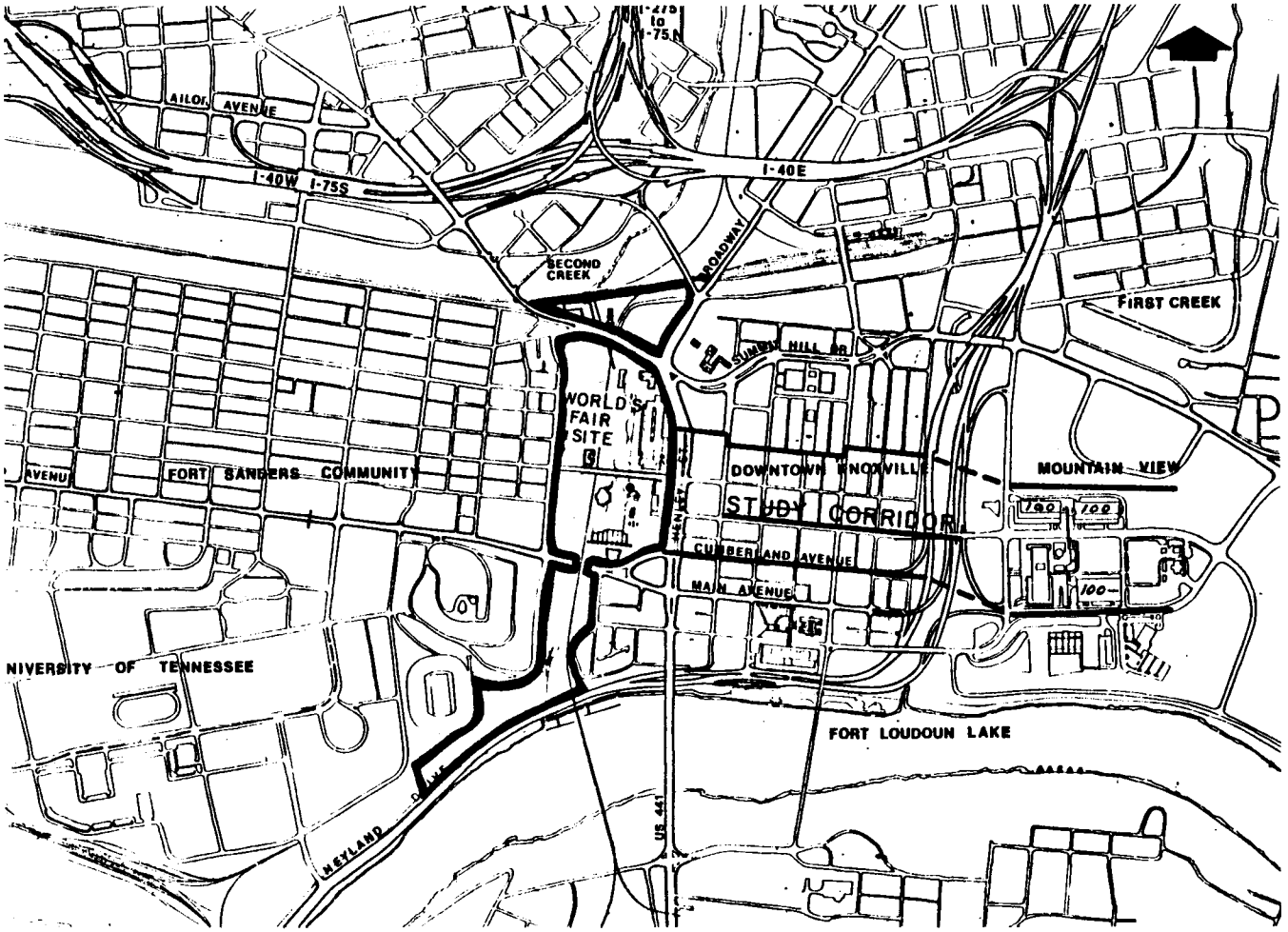


Figure 3.1. Location of the 1982 World's Fair and Study Corridor Including the Location of the Coliseum Parking Garages (identification number: 100)

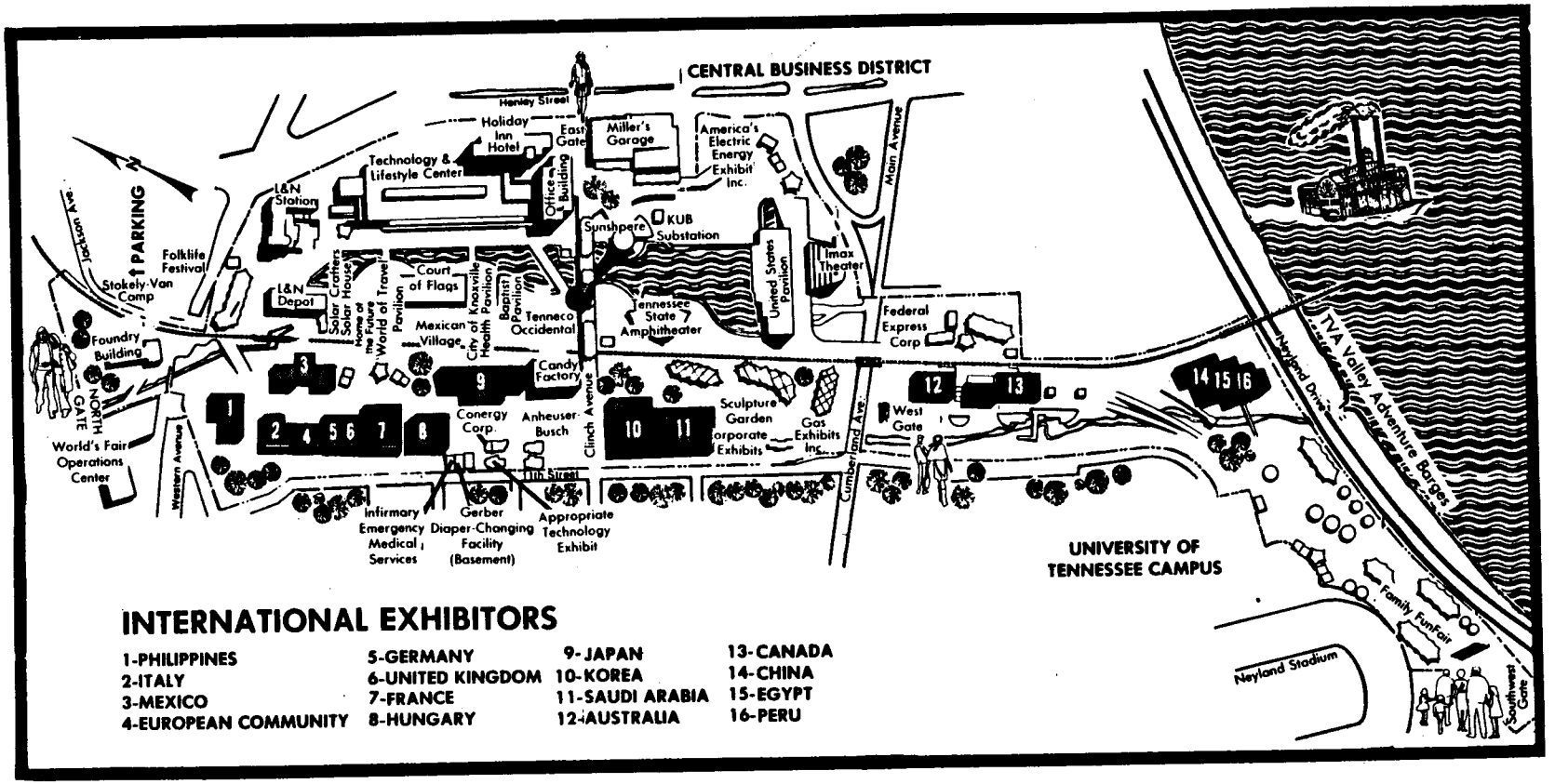
The 1982 World's Fair planned various types of attractions, including live performances, corporate exhibits, international exhibits, and restaurants. Figure 3.2 is a map of the fair site which highlights the location of different exhibits and points of interest. It was anticipated, before the fair closed on October 31, 1982, that it would attract 11 million visitors.[1]

Preparation

In preparing for the 1982 World's Fair, Knoxville and the Tennessee Department of Transportation undertook many improvements and modifications to the local transportation system. The improvements and modifications consist of four major areas: streets and highways, transit, pedestrian, and parking. Listed below are some of the many transportation improvements undertaken in anticipation of the fair:

1. Streets and highways. Improvements to the highways included the widening of Interstate 40/75 between the Interstate 75-Interstate 40/75 interchange and Papermill Road. Also the Interstate 40/75-Interstate 75 interchange was redesigned. Street improvements include the addition of an exit ramp to the Downtown Business Loop, major improvements to Henley Street, and numerous other improvements to roads near the fair site and along Interstate 40/75.

2. Transit. K-Trans service expanded transit operating hours to 5:30 a.m. to 12:30 p.m. Monday through Saturday and 8:30 a.m. to 12:00 p.m. on Sunday. Previously the operating hours were 5:30 a.m. to 7:15 p.m. Monday through Friday, 7 a.m. to 7 p.m. Saturday, and 8 a.m. to 4 p.m. Sunday. In addition, headways were reduced and some routes were realigned. For example, on the Kingston Pike route headways were



Source: Advertising Supplement to The Knoxville Journal and The Knoxville News-Sentinel, May 16-22, 1982, p. 4.

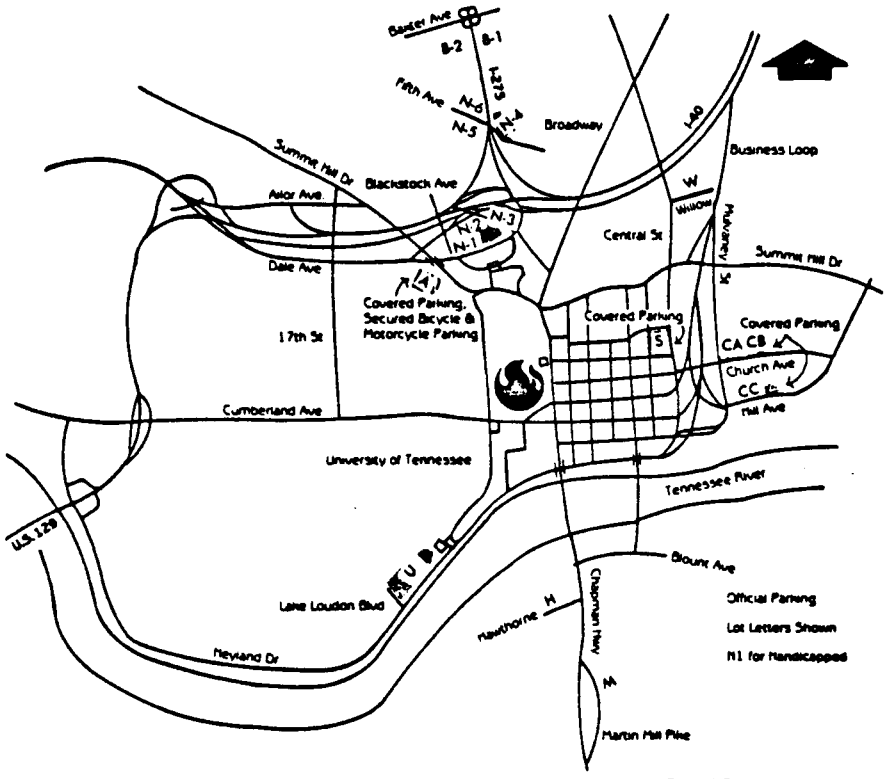
Figure 3.2. Points of Interest at the 1982 World's Fair

reduced from one-half hour to 15 or 20 minutes and service was extended to Downtown West. After the closing of the fair, it was planned to revert the operating hours back to the original schedule. K-Trans also received delivery of 40 new buses in anticipation of increased ridership.

3. Pedestrians. Extensive pedestrian traffic was anticipated around the fair site and pedestrian improvements were made to Henley Street, Cumberland Avenue, and other streets near the World's Fair site. These improvements included new pedestrian signals, sidewalks, and the placement of crossbars.

4. Parking. Parking in downtown Knoxville experienced some changes in short-term and long-term rates. When the fair opened, all day rates ranged from $2.50 to $20.00. Previously, all day rates normally did not exceed $3.00. In comparison to the changes in long-term parking rates, short-term rates did not increase as drastically, and in some cases did not increase at all. The number of parking facilities and their use were also altered in preparation for the World's Fair. Figure 3.3 locates all "Official World's Fair Parking Facilities." These parking facilities could be located by following an official trailblazer system on all regional highways, interstates, and arterials. In addition to "Official World's Fair Parking," many other unofficial parking facilities were developed. These unofficial lots can be found on the University of Tennessee campus, in the Fort Sanders area, and in downtown Knoxville.

The University of Tennessee made available a maximum of 3,000 parking spaces when school was not in session.[1] Downtown Knoxville



Lot Letter	Location		
A	The Parking Barn Blackstock Ave below Summit Hill Dr	M	Martin Mill Rd off Chapman Hwy
B	I-275 At Baxter Ave	N	Blackstock Ave between Dale & Fifth Aves
C	Coliseum Garages Church Ave. Mulvaney & Salvus, Hill Ave between Mulvaney & Salvus	S	State Street Garage State St between Clinch & Union Sts
H	Hawthorne St off Chapman Hwy	U	Lake Loudon Blvd between Neyland and Stadium Drs
		W	Willow St east of Central St

Source: Advertising Supplement to The Knoxville Journal and The Knoxville News-Sentinel, May 16-22, 1982, p. 22.

Figure 3.3. Official Parking Lots

had approximately 1,000 spaces available for World's Fair visitors on weekdays and between 4,000 and 5,000 on weekends.[1] Data were not available for the number of unofficial parking spaces in the Fort Sanders area. The KIEE estimated the total number of parking spaces for fair visitors to be 25,000.[9] Barton-Aschman estimated that there was a need for 14,100 parking spaces for fair visitors; therefore, the supply exceeded the demand by about 11,000 spaces.

Other important transportation changes took place in preparation for the World's Fair, including increasing law enforcement on streets and highways, developing park-and-ride lots, expanding taxi service, and developing shuttle and tour bus drop and pickup points. These changes were initiated for the purpose of improving traffic flow in Knoxville.

Fair Operation

The 1982 World's Fair began its six-month operation on Saturday, May 1, with an opening crowd of over 85,000. Negative publicity and warnings about parking, crowds, and traffic problems probably kept attendance well below the expected 100,000. Many magazine and newspaper articles questioned whether Knoxville's transportation system was capable of accommodating the expected 11 million visitors.

The parking and traffic problems, however, never materialized. On opening day few lots reached capacity and several "Official World's Fair" lots did not have a single automobile by 10:30 a.m.[10] One parking lot attendant downtown said that business was slow and he felt all the bad publicity about traffic and crowds had hurt it. The Tennessee Highway Patrol reported that all Interstates were flowing

smoothly with tour and shuttle bus operations functioning without flaws. Also, K-Trans reported that its park-and-ride lots were operating with no major problems.[10] During the remaining portion of the fair, traffic and parking problems were also at a minimum. Even when attendance exceeded 100,000, few problems developed.

Potential transportation problems were minimized by a strong tour and shuttle bus plan recommended by Barton-Aschman in their Transportation Plan. The recommendation emphasized the role of tour buses to handle the crowd and was based on the observation that approximately 85 million people lived within a single day's driving time of Knoxville.[1] In fact, the number of daily tour buses has far exceeded their projections. Also shuttle buses from park-and-ride lots, campgrounds, motel, and surrounding cities have been utilized more than expected. The number of daily tour buses (excluding the final week of the fair), which carry an average of approximately 40 people, have ranged from 118 to 701. This means that the number of people riding tour buses have ranged from 4,720 when the attendance was 51,453 to 28,040 when the attendance was 90,224. They projected that for a design crowd of 80,000, 15 percent or 12,000 would arrive by tour buses.

With expanded service, an increase in transit ridership has also helped minimize transportation problems. Table 3.1 presents K-Trans monthly revenue passenger totals for May through October of 1981, and May through October of 1982. The 1982 figures clearly indicate a dramatic increase in transit ridership during the World's Fair.

With this background, a specific study was conducted of parking spaces in the downtown area as discussed in the next section.

TABLE 3.1. K-Trans Revenue Passengers*

	1981	1982	Percent Increase
May	412,273	669,912	38.5
June	338,868	596,787	43.2
July	306,782	501,312	38.8
August	303,553	472,413	35.7
September	362,510	467,566	22.5
October	458,657	624,029	26.5

*Totals include express, regular routes, transfer, charter contract, KASH-Free Fare/Free Pass, The Lift, and special World's Fair shuttles.

Source: K-Trans form ATC-15 - Daily Operating Summary.

II. STUDY AND METHODOLOGY

Introduction

An event such as hosting the 1982 World's Fair adjacent to downtown Knoxville should be expected to alter the parking characteristics in the downtown area. The major considerations include: the location of the site in relation to the Central Business District, operation of the fair during weekdays, and the fair operating hours overlapping with normal downtown business hours. This study is designed to determine the extent and type of parking characteristic changes that will occur in the downtown area as a result of the World's Fair.

The downtown parking characteristics that were analyzed from the data include:

1. The number and location of local vehicles and external vehicles. A sampling of vehicle license plates was conducted to determine the number of vehicles from the local area and vehicles from outside the local area (external vehicles). Knowing the distribution of local and external vehicles by parking facility provides an insight into the shifting pattern of parking lot utilization. In turn this data could be analyzed by parking facility price and distance to the fair.

2. The peak accumulation of vehicles. The analysis determined the peak accumulation of vehicles parked in the study corridor. This information was collected for each parking facility and was compared to the peak accumulation before the fair opened.

3. The vehicle occupancy rate. Data were collected to determine an estimate of the vehicle occupancy rate for World's Fair visitors.

4. The arrival/departure patterns for World's Fair visitors and the average duration of World's Fair vehicles. Duration of occupancy and arrival/departure patterns were analyzed for a parking facility near the fair site. This analysis allowed insight into parking characteristics of World's Fair visitors.

The study considered only one corridor that extended 4,800 feet from the World's Fair site through the Central Business District. Because the parking supply extended well beyond the corridor, it was not possible to describe the pattern throughout the Central Business District, but the study corridor was felt to present typical conditions.

The Corridor

Knoxville's downtown area was the focus of the parking study, and it was determined that an east-west corridor three blocks wide beginning at the World's Fair site and ending at the Coliseum Parking Garages would provide a broad representation of the impact of the fair on parking utilization. Figure 3.1, page 25, identifies the corridor in relation to the fair site and the downtown area. The eastern part of the corridor is severed by the Downtown Business Loop which is a four-lane limited access facility. The Coliseum and its three parking garages provided over 2,200 spaces for the fair and is located on the eastern side of the Downtown Business Loop. The total number of individual spaces in the corridor was 4,434, or about 18 percent of the 25,000 estimated available for fair parking.

Inventory of Parking Facilities

Thirteen parking facilities were included in the study corridor. Three were parking garages, the remaining ten were at-grade lots. Two of the facilities, the State Street Garages with 818 spaces and the Coliseum Parking Garages with 2,600 spaces, were owned and operated by the City of Knoxville.[11] The remaining parking garage, which had a capacity of 375, was owned and operated by Miller's Department Store.[11] Figure 3.4 locates all of the parking facilities included in the study except the Coliseum Parking Garages which are depicted in Figure 3.1 (facilities 100), page 25. Each parking facility was given a unique identification number which was adapted, in part, from: Knoxville C.B.D. Parking Needs and Feasibility Study conducted by Kimley-Horn and Associates Inc. in 1977.[11] Table 3.2 presents the characteristics of each parking facility.

Data Collection Procedure

Parking lot utilization counts were conducted on nine Tuesdays over the period of April 6 to June 22. The specific survey dates were April 6, April 20, April 27, May 4, May 25, June 1, June 8, June 15, and June 22. The first three dates occurred before the opening day of the World's Fair and the remaining dates occurred while the World's Fair was in operation. Data were not collected on Tuesday, April 13, due to the Dogwood Arts Festival which is held downtown and was felt to have significant implications on parking characteristics. After May 4 many of the elementary and high schools were closed for summer vacation and the University of Tennessee had a reduction in enrollment, all of which were felt to have a significant impact on parking characteristics.

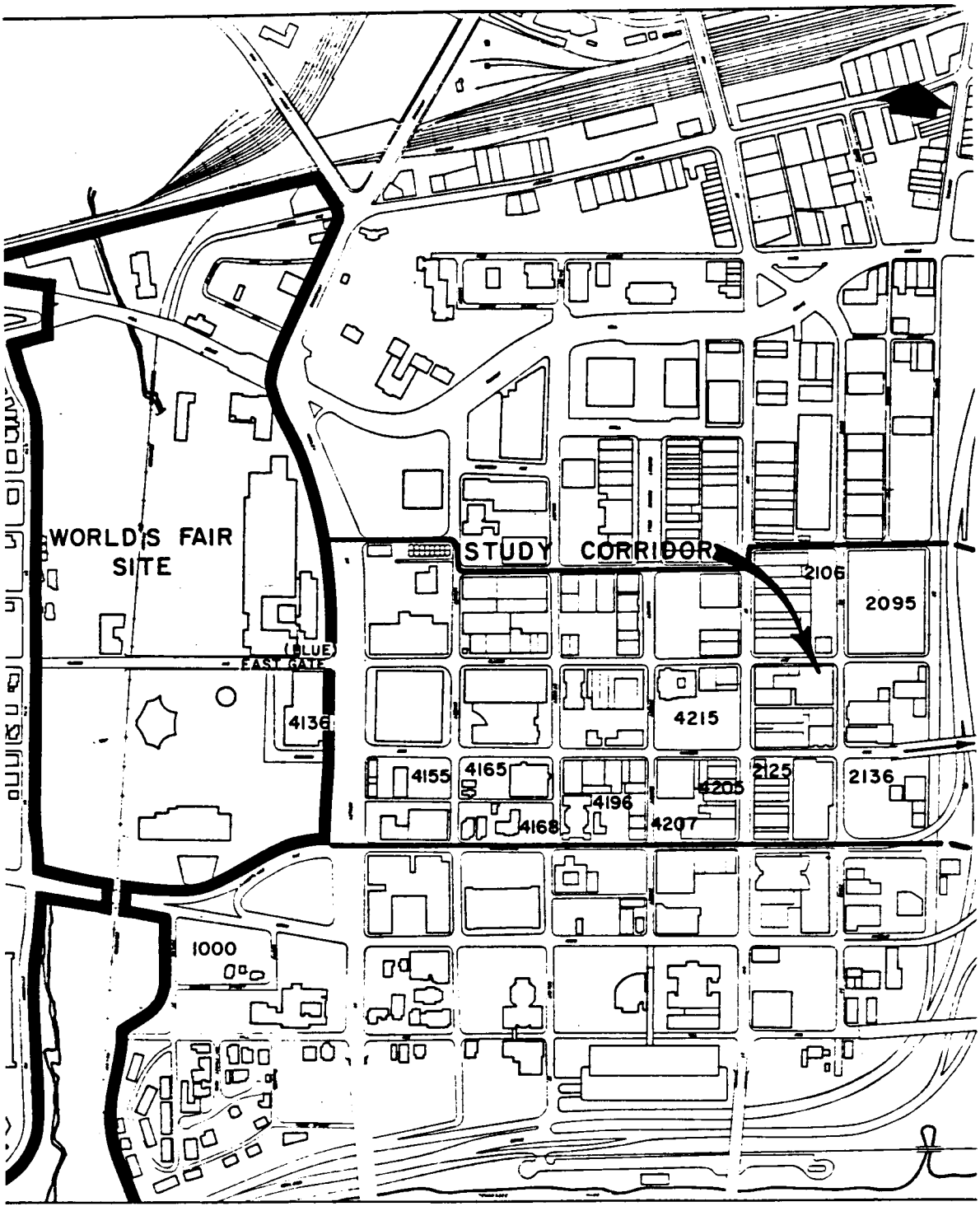


Figure 3.4. Parking Facilities in the Study Corridor, Excluding the Coliseum Parking Facilities and Including Facility 1000

TABLE 3.2. Inventory and Characteristics of Study Parking Facilities

Parking Facility	Capacity	Type of Facility: Off Street Employee	Type of Facility: Off Street Public Use	Attended/Unattended: Parking Attendants Before Fair	Attended/Unattended: Parking Attendants During Fair	Type of Vehicle Attended: (Majority) Commuter Facility[2]	Type of Vehicle Attended: (Majority) Short-Term Facility[3]	Type of Vehicle Attended: Mixture Commuter and Short Term[4]	Rates: Short-Term Rates Before Fair	Rates: Short-Term Rates During Fair	Rates: All Day Rates Before Fair	Rates: All Day Rates During Fair	Location: Approximate Walking Distance (feet) to East Gate of Fair	Location: Time (min) to East Gate of Fair
4136	375		x	x	x		x		20¢ per hour	50¢ per hour for 1st 3 hours	Accumulated from hourly rate	$20 1st 7 weeks, $12 remaining weeks	350	1.28
4155	26		x	x	x		x		60¢ 1st 1/2 hour, 60¢ each additional 1/2 hour	60¢ 1st 1/2 hour, 60¢ each additional 1/2 hour	$3.00	$10.00	775	2.87
4165	110,76, 103[1] Avg = 99		x	x	x		x		50¢ 1st 1/2 hour, 35¢ each additional 1/2 hour	50¢ 1st 1/2 hour, 50¢ each additional 1/2 hour	$3.00	$10.00	1075	4.38
4168	66		x		x	x			50¢ 1st 1/2 hour, 50¢ each additional 1/2 hour	60¢ 1st 1/2 hour, 60¢ each additional 1/2 hour	$2.00	$6.00	1450	5.13
4196	85		x	x	x	x			50¢ 1st 1/2 hour, 75¢ next 2 hours, next 2 hours=$1.50	60¢ 1st 1/2 hour, 60¢ each additional 1/2 hour	$2.00	$6.00	1850	7.43
4207	30		x		x	x			50¢ 1st 1/2 hour, 50¢ each additional 1/2 hour	50¢ 1st 1/2 hour, 50¢ each additional 1/2 hour	$3.00	$6.00	2050	7.60
4205	32		x		x		x		50¢ 1st 1/2 hour, 50¢ each additional 1/2 hour	50¢ 1st 1/2 hour, 50¢ each additional 1/2 hour	$3.00	$6.00	2350	8.10
4215	147		x	x	x			x	60¢ 1st 1/2 hour, 60¢ each additional 1/2 hour	60¢ 1st 1/2 hour, 60¢ each additional 1/2 hour	$3.00	$6.00	1875	7.47
2125	40		x	x	x	x			50¢ 1st 20 min., 50¢ each additional 20 min.	50¢ 1st 20 min., 50¢ each additional 20 min.	$2.50	$6.00	2175	8.67
2136	149		x	x	x	x			60¢ 1st 1/2 hour, 60¢ each additional 1/2 hour	60¢ 1st 1/2 hour, 60¢ each additional 1/2 hour	$2.00	$4.00	2375	9.93
2106	49		x	x	x	x			45¢ 1st 1/2 hour, 85¢ 1st hour, $1.05 1st 1-1/2 hour, $1.35 1st 2 hours	50¢ 1st 1/2 hour, 85¢ 1st hour, $1.20 1st 1-1/2 hour	$2.50	$2.50	2100	9.25
2095	818		x	x	x	x			45¢ 1st 1/2 hour, 35¢ each additional 1/2 hour	45¢ 1st 1/2 hour, 35¢ each additional 1/2 hour	Leased, others accumulated	$6.00	2150	9.87
100	2600		x	x	x	x			None	None	Leased $20/ month	$6.00 or $20/month[5]	4800[6] 7257	19.63[8]

x - indicates yes.

1. Before the fair the capacity was 110. The first week of the fair it decreased to 76 because of various vendors. The following weeks some of the vendors were displaced which increased the capacity to 103. Use 99 as the average.
2. Information from observations.
3. Information from observations.
4. Information from observations.
5. Includes shuttle bus ride.
6. Actual distance to East Gate.
7. Walking distance from drop-off of shuttle bus.
8. Includes waiting for shuttle bus, riding bus, and walking remaining distance.

The data were collected at four different time periods within the day. The survey times were 8 a.m. to 10 a.m., 11 a.m. to 1 p.m., 2 p.m. to 4 p.m., and 6 p.m. to 8 p.m. The 8 a.m. to 10 a.m. survey time was selected because it occurred before the 10 a.m. opening time of the World's Fair. The 6 p.m. to 8 p.m. survey time was selected because it occurred after business hours. The other two survey times were chosen to give indications of midday parking characteristics.

Certain assumptions were made during the survey process and are listed below:

1. Vehicles that had a Tennessee license plate beginning with the numbers 3 for Knox County, 8 for Blount County, 10 for Anderson County, 31 for Sevier County, 79 for Union County, and 41 for Loudon County were considered to be from the local area. In addition, these vehicles were assumed to be parked downtown for reasons other than activities at the World's Fair. (The exact reason a vehicle was parked in the corridor could not be determined in this study.)

2. Any vehicle with a Tennessee license plate that could not be associated with a county was assumed to be local and thus not parked downtown because of the World's Fair.

3. The remaining vehicles were assumed to be from outside the local area (external vehicles) and parked downtown due to the World's Fair.

4. The percent increase in external vehicles was assumed to be as a result of the World's Fair.

For this study two types of information were recorded for each parking facility: the total number of vehicles and the license plate

classification of local and external vehicles. On the first date, April 20, all license plates were recorded in each parking facility except the garages, Miller's, State Street, and the Coliseum. This proved to be very time consuming; therefore, for the remaining weeks, a sampling technique was used.

In the parking garages, vehicle license plates were sampled from each floor in order to eliminate the bias attributed to early or late arriving vehicles. For example, it was felt that Knoxville commuters would arrive early so their vehicles would occupy the lower levels of the parking garages. World's Fair visitors would arrive somewhat later, so their vehicles would occupy the upper levels of the parking garages.

For the parking garages the same spaces were surveyed for each time period. If a vehicle was backed into a space, it was not included in the sample. This procedure allowed the sample size to be somewhat dependent on the total occupancy of each garage. Table 3.3 gives the percentage of total occupancy sampled for the parking garages at 2 p.m. to 4 p.m., the peak accumulation period. From this table it can be seen that the percent sampled remained relatively constant for each date.

For the remaining parking facilities the sampling technique differed because only vehicles with visible license plates were included. Table 3.4 presents the average percent sampled, for each parking facility, stratified by time periods. As noted, the percent of license plates sampled ranged from 40.8 to 97.9. The low value of 40.8 percent was associated with lot 4205, which because of the layout did not permit vehicle license plates to be easily read. With the exception of this

TABLE 3.3. Percent Parked Vehicles Sampled at 2 p.m. to 4 p.m. for the Parking Garages

Date	Miller's Garage 4136	State Street Garage 2095	Coliseum 100
4/ 6	40.4	29.6	-[1]
4/20	40.8	23.2	29.6
4/27	46.2	25.1	29.3
5/ 4	45.5	23.2	28.9
5/25	51.7	27.8	23.0
6/ 1	43.9	26.1	25.0
6/ 8	43.4	26.9	28.0
6/15	42.7	27.8	27.2
6/22	46.3	30.0	28.6
Mean	44.5	26.6	27.5
S.D.	3.24	2.34	2.17

1. Data were not collected on this date because of time limitations.

TABLE 3.4. Average Percent Sampled (for nine dates) of Total Occupancy by Time Observation

Lot	8 a.m.	11 a.m.	2 p.m.	6 p.m.	Average
4155	97.6	98.0	98.3	97.5	97.9
4165	87.9	80.6	80.2	84.5	83.3
4168	98.5	96.8	95.2	97.0	96.9
4196	90.4	82.4	88.2	85.4	86.6
4215	96.0	82.2	90.0	88.7	89.2
4207	97.2	92.3	94.5	77.3	90.3
4205	43.5	37.8	39.2	42.8	40.8
2125	65.6	81.5	70.5	82.6	75.1
2136	89.3	86.4	77.7	92.5	86.5
2106	72.7	72.9	74.1	88.8	77.1

lot, the other facilities produced a sample in excess of 75 percent of total occupancy.

Arrival Rates, Turnover Rates, and Vehicle Occupancy Rates

The data for arrival rate, turnover rates, and vehicle occupancy rates were collected on August 11, 1982, in lot 1000 (see Figure 3.4). The arrival rate data were collected at 15-minute intervals between 8 a.m. and 11:30 a.m. The turnover data were collected between 8 a.m. and 11:30 a.m. and at 1:30 p.m., 3:30 p.m., 4:30 p.m., 6:30 p.m., 7:30 p.m., and 8:30 p.m. The vehicle occupancy rate data were collected between 8 a.m. and 11:30 a.m.

The parking facility, number 1000, utilized to collect this data was located between South Street and Poplar Street off Cumberland Avenue. It was approximately one block from the West Gate of the World's Fair and had a capacity of 250 and was occupied exclusively by World's Fair parkers. The rates were $9.00 for all day parking and $5.00 after 5 p.m. Vans and automobiles were allowed; however, recreational vehicles were not.

Because of the large capacity, only a sample of the total spaces was observed for turnover rates. The sample size was 63 spaces or 25.2 percent of the total capacity. An effort was made to obtain a representative sample by sampling from each section of the facility.

III. SUMMARY

In anticipation of 11 million fair visitors, the City of Knoxville and the Tennessee Department of Transportation provided transportation improvements in four major areas: streets and highways,

transit, pedestrians, and parking. These improvements helped eliminate many of the potential transportation problems that could be associated with a special event such as a world's fair. In retrospect, transportation problems were also minimized by a large number of tour and shuttle buses and increases in transit ridership.

The parking characteristics which were analyzed for the corridor were: (a) the number and location of local and external vehicles; (b) the peak accumulation of vehicles; (c) the vehicle occupancy rate; and (d) the arrival/departure patterns for World's Fair visitors and the average duration of World's Fair vehicles. The corridor utilized for this analysis extended 4,800 feet from the World's Fair site to the Coliseum Parking Garages and included 13 study facilities. Data on arrival rates, turnover rates, and vehicle occupancy rates were collected at a parking facility outside the study corridor. This facility was located approximately one block from the World's Fair site and was occupied entirely by external vehicles.

CHAPTER IV

ANALYSIS

Introduction

During the construction of the 1982 World's Fair, many Knoxvillians feared extensive traffic and parking problems in the downtown area. However, these problems never materialized. In the Transportation Plan for the 1982 World's Fair, Barton-Aschman estimated that, for a design crowd of 80,000 persons, 53,800 would arrive by automobile. With an estimated vehicle occupancy rate of 3.5, over 15,400 vehicles would arrive daily, and 14,100 could be expected to be parked of the maximum accumulation. With this procedure they estimated that 14,100 parking spaces would be required for the World's Fair.[1] A survey performed by the Knoxville International Energy Exposition, KIEE, determined that there were over 25,000 parking spaces available on weekdays for World's Fair parkers.[9] This included the parking spaces on the University of Tennessee campus, in the downtown area, in the Fort Sanders area, official World's Fair parking, as well as informal parking spaces.

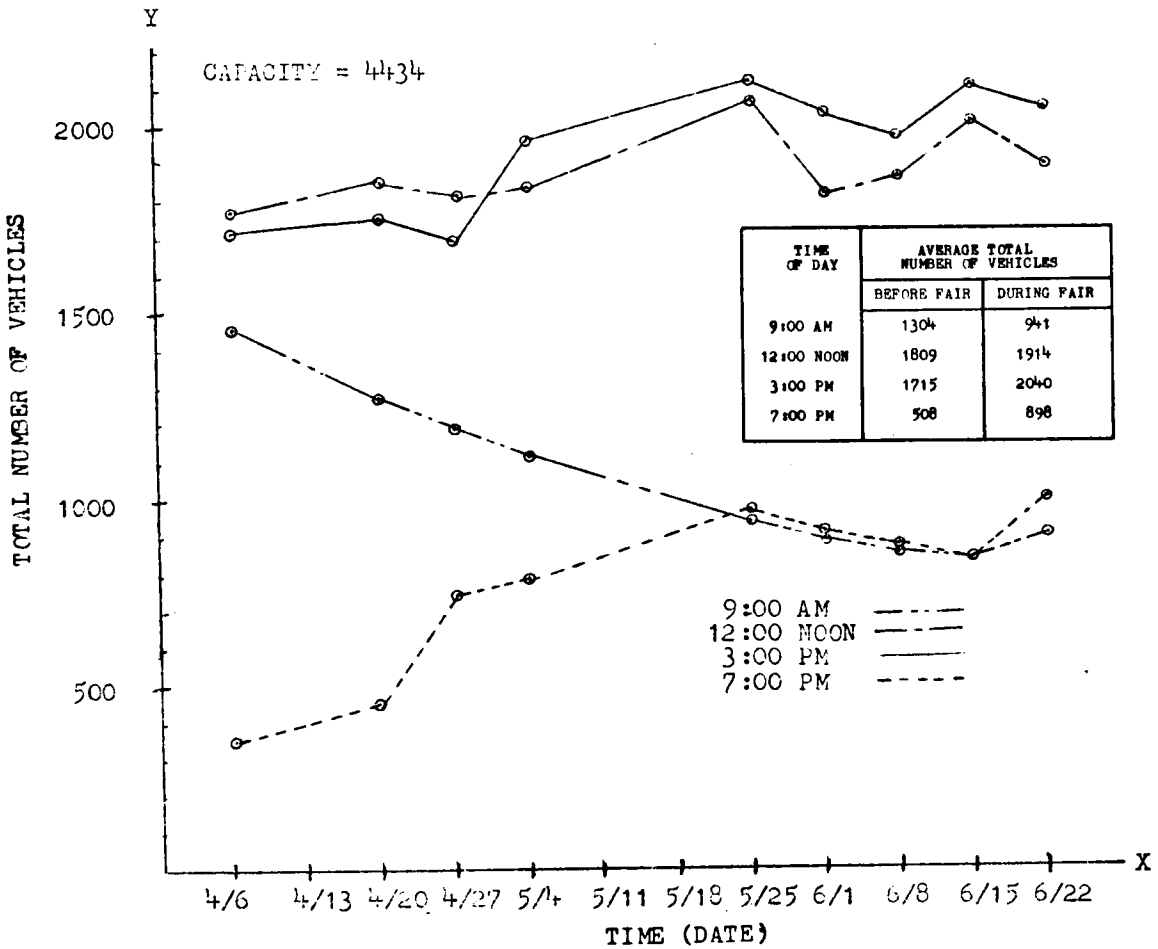
Parking problems were also minimized by a large number of tour buses. In the Transportation Plan for the 1982 World's Fair, Barton-Aschman estimated, for a design crowd of 80,000 persons, 12,000 would arrive by tour buses.[1] In retrospect this estimate has proven to be low. In the month of May an average of approximately 400 tour buses per day carried about 16,000 visitors to the World's Fair. On Saturday,

May 8, more than 700 tour buses carrying approximately 31,000 visitors arrived at the World's Fair gate.[12] This accounted for approximately 36 percent of the day's turnstile attendance of 85,709, where Barton-Aschman had estimated that tour buses would be responsible for only 15 percent of the total daily attendance.[1] Unfortunately, there is no method of predicting the daily number of tour buses and passengers that will arrive at the World's Fair. David R. Miller, director of transportation services for KIEE, said this about the tour buses, "Accurately predicting . . . the number of tour and charter buses bringing passengers to the fair is impossible, because KIEE transportation officials often don't know the buses are coming until ten days before the buses arrive." He also added, "KIEE will accept reservations from bus operators until three days before a bus's arrival date."[13]

Even with a surplus of parking facilities for World's Fair patrons, there were some significant changes in parking characteristics in the study corridor.

Aggregate Trends of Parking Facilities in the Corridor

Parking data for the study corridor were collected for three separate dates before the fair opened: April 6, April 20, and April 27. During the fair, data were collected on six dates: May 4, May 25, June 1, June 8, June 15, and June 22. Figure 4.1 depicts the total number of vehicles parked in the corridor on the nine separate dates. The data are stratified by time periods with 9 a.m. representing 8 a.m. to 10 a.m., 12 noon representing 11 a.m. to 1 p.m., 3 p.m. representing 2 p.m. to 4 p.m., and 7 p.m. representing 6 p.m. to 8 p.m. These designations will be adopted for the remainder of the study.



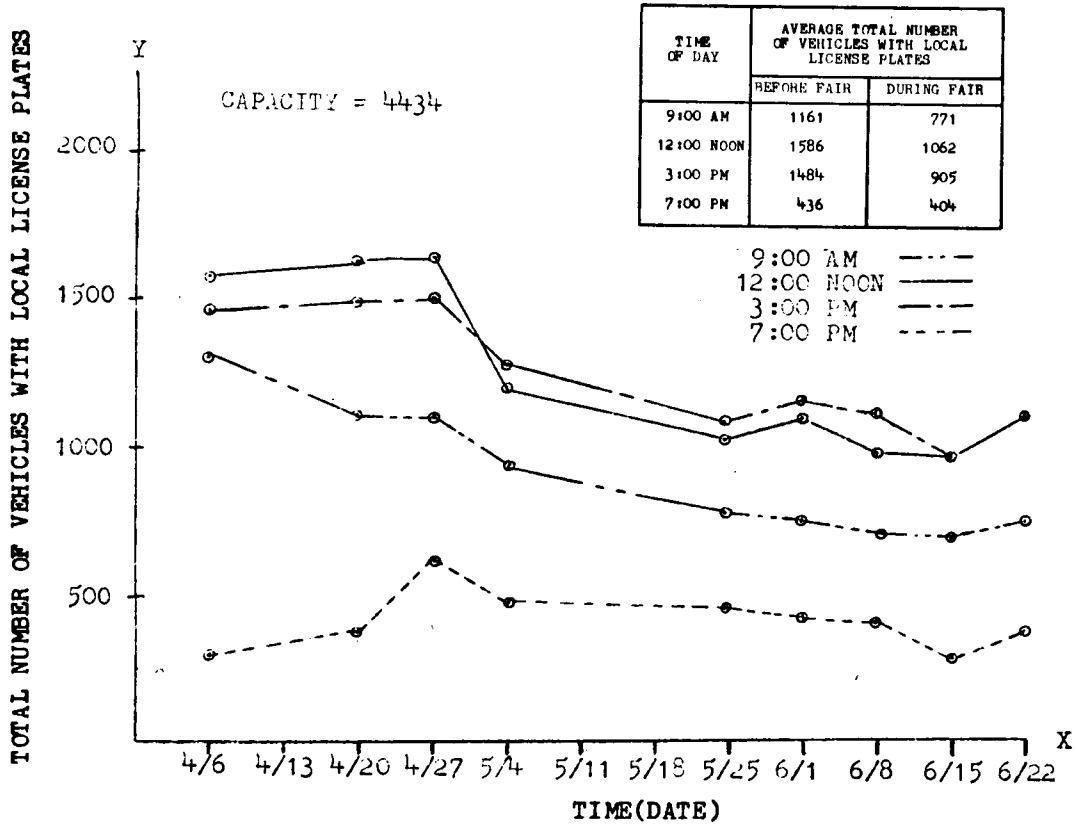
TIME OF DAY	AVERAGE TOTAL NUMBER OF VEHICLES	
	BEFORE FAIR	DURING FAIR
9:00 AM	1304	941
12:00 NOON	1809	1914
3:00 PM	1715	2040
7:00 PM	508	898

Figure 4.1. Total Number of Vehicles vs. Time

The overall trend indicates an increase in parking after the fair opened. It is interesting to note that for the 9 a.m. time period there is a steady decline in the total number of parked vehicles from April 6 until June 15. This decline began even before May 1, the opening day of the World's Fair. If 9 a.m. parkers are assumed to be commuters, this suggests that Knoxville commuters sought alternate locations and were concerned that parking prices would be raised in anticipation of opening day. However, the 9 a.m. increase in total vehicles recorded from June 15 to June 22 is unexplained. Also, the increase in total parked vehicles at 7 p.m. on April 20 to April 27 is unusual and can best be explained by a World's Fair preview that occurred on the evening of April 27. Figure 4.1 also reports average total number of vehicles for each time period before and during the fair. In the period in which the fair was in operation, the total number of vehicles increased, except for the 9 a.m. time observation.

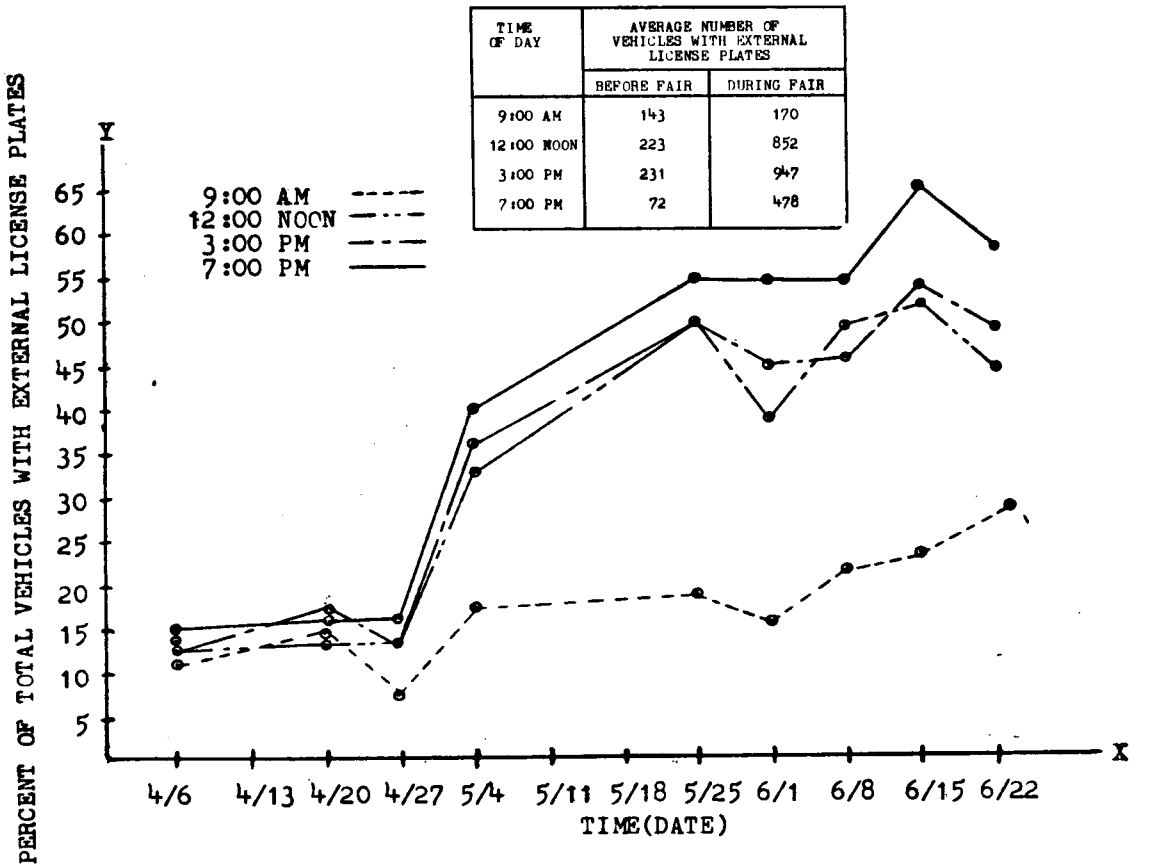
Figure 4.2 denotes the total number of local vehicles based on the license plates. At each time period there was a noticeable decrease in local vehicles between April 27 to May 4. The implication is that some local vehicles were displaced in anticipation of opening day of the fair. Figure 4.2 also contains information which identifies the average total number of local vehicles in the corridor before and during the fair. From this table it can be seen that, for each time period, a decrease in vehicles occurred.

As the total number of vehicles with local license plates declined, the total number of vehicles with external license plates increased. Figure 4.3 identifies the percent of total vehicles with



TIME OF DAY	AVERAGE TOTAL NUMBER OF VEHICLES WITH LOCAL LICENSE PLATES	
	BEFORE FAIR	DURING FAIR
9:00 AM	1161	771
12:00 NOON	1586	1062
3:00 PM	1484	905
7:00 PM	436	404

Figure 4.2. Total Number of Vehicles with Local License Plates vs. Time



TIME OF DAY	AVERAGE NUMBER OF VEHICLES WITH EXTERNAL LICENSE PLATES	
	BEFORE FAIR	DURING FAIR
9:00 AM	143	170
12:00 NOON	223	852
3:00 PM	231	947
7:00 PM	72	478

Figure 4.3. Percent of Total Vehicles with External License Plates vs. Time

external license plates on the nine separate dates. Note that for 9 a.m., 12 noon, and 3 p.m. the percent of vehicles with external license plates increased from 10 to 15 percent on April 27 to 30 to 40 percent on May 1 and 45 to 55 percent on May 25. The 9 a.m. time period also shows a general increase in percent of total vehicles with external plates, but the trend is less pronounced than at the other time periods. Figure 4.3 also includes information on the average total number of vehicles with external license plates before and during the fair. The most noticeable increase in external vehicles occurs at 7 p.m.

For the study corridor the peak accumulation of vehicles shifted from 12 noon to 3 p.m. as illustrated in Figure 4.4. Before the fair an average of 89 percent of the 4,434 total spaces were occupied at 12 noon, and decreased to 81 percent at 3 p.m. During the fair an average of 84 percent of the total spaces were utilized at 12 noon, and it increased to 91 percent at 3 p.m. This shift indicates that a special event, such as the World's Fair which is open ten hours per day and is located adjacent to the downtown area, will alter Central Business District peak parking accumulations.

It should also be noted from Figure 4.4 that for 9 a.m. the average percent accumulation decreased from 54 percent to 29 percent. This decrease implies that many Knoxville commuters that previously parked their vehicles in the corridor selected new locations as a result of the fair. Conversely, there was a substantial increase in the average percent accumulation of parked vehicles in the corridor at 7 p.m. This increase, 32 percent, is undoubtedly because the fair remained open until 10 p.m.

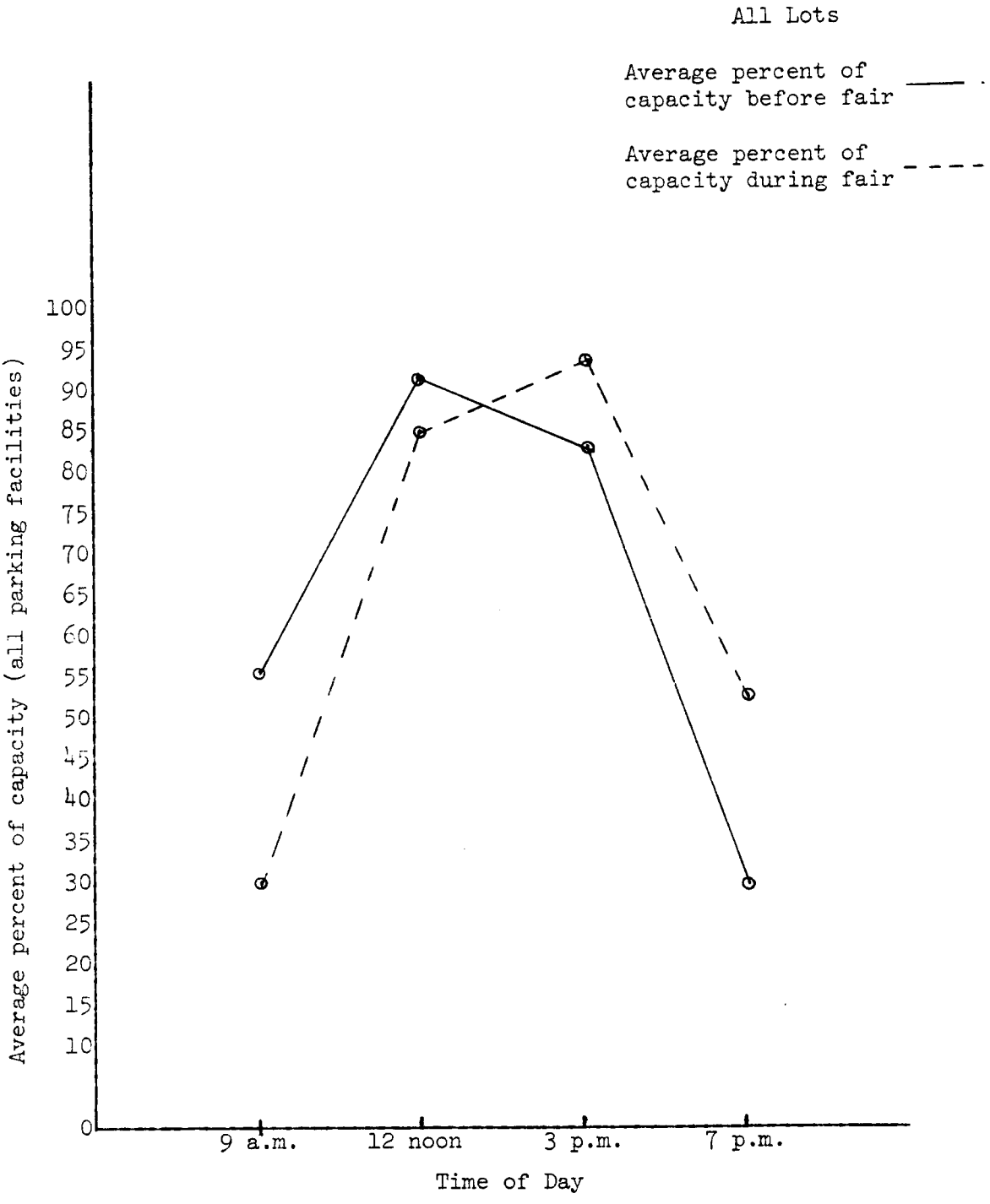


Figure 4.4. Average Percent of Capacity (All Parking Facilities) versus Time of Day

Appendix Figures A.1 through 4.7 identify the peak accumulation of vehicles for each parking facility surveyed in the study corridor. From these figures it can be seen that peak accumulation varies extensively between specific parking facilities. To a large extent, these variations can be explained by the percent of the parking facility being occupied by long-term World's Fair parkers. For example, Figure A.3 indicates the peak accumulation for facility 4165 shifts from 12 noon to 3 p.m. This facility was utilized extensively by World's Fair visitors. On the other hand, Figure A.10 shows that the peak accumulation for facility 2136 is 12 noon both before and during the fair, which indicates it was utilized mostly by commuters.

The before/after parking characteristics of the study corridor can be summarized below:

1. The total number of vehicles parked in the corridor for each of the survey days increased at 12 noon, 3 p.m., and 7 p.m. as a result of the World's Fair. The trend was recognized as early as two weeks before the opening day.

2. The total number of vehicles parked in the corridor decreased at 9 a.m. as Knoxville commuters sought other locations.

3. While the number of total parked vehicles increased, the number of vehicles with local license plates decreased for each time period. This indicates local parkers were being displaced by vehicles with external license plates that were apparently parked in the study corridor because of the World's Fair. See Figure 4.5 which depicts this displacement.

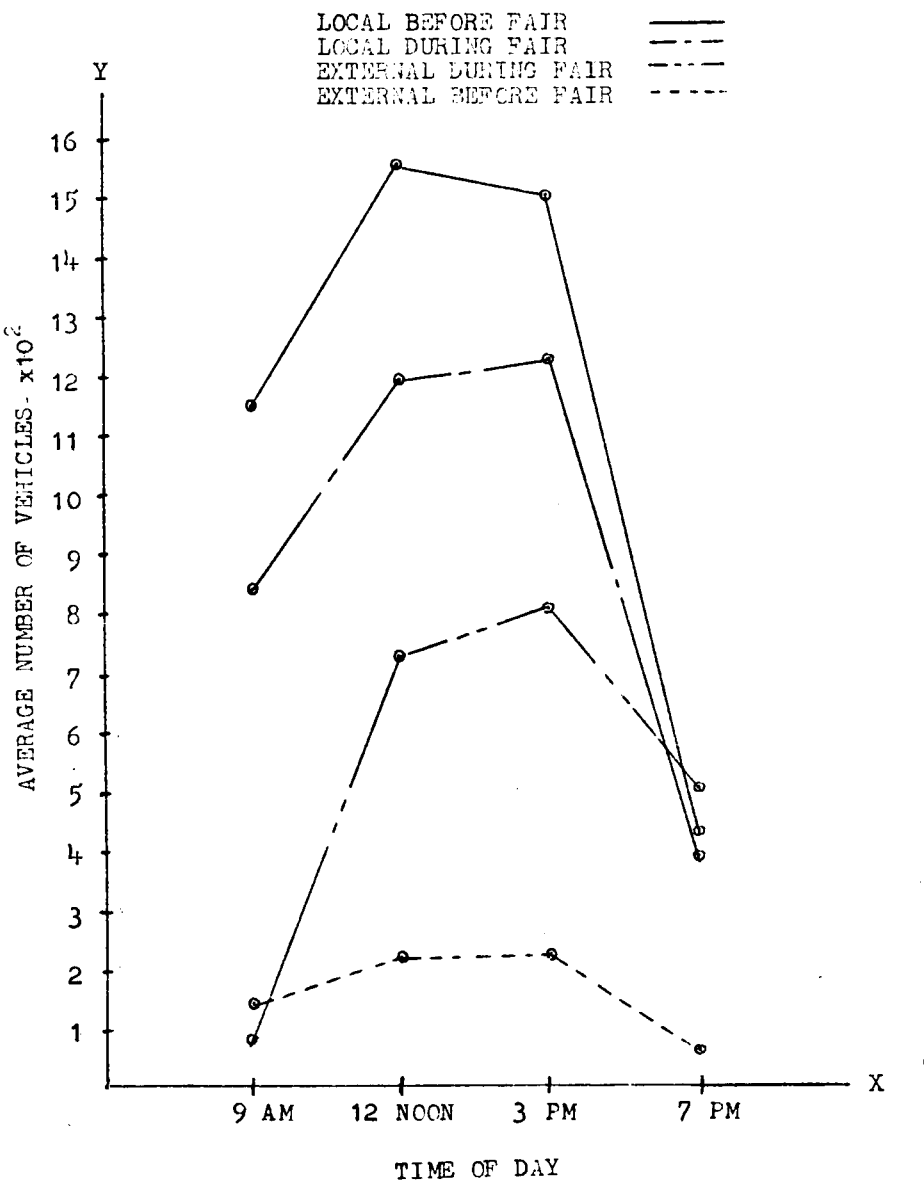


Figure 4.5. Average Total Number of Vehicles with External and Local License Plates Before and During Fair (by Time of Day)

4. The peak accumulation of vehicles in the corridor shifted from 12 noon to 3 p.m.

Impact of World's Fair on Corridor Before Opening Day

The study corridor had probably sustained changes in parking characteristics even before the World's Fair opened on May 1. It can be seen in Figure 4.3 that the percent of vehicles with external license plates ranged from approximately 10 percent to 15 percent almost four weeks before the fair opened. Even a greater percent of vehicles with external license plates were present in the corridor on April 20, ten days before opening day of the fair.

Data were collected in 1980 by Transpo Associates, a local consulting firm, on total number of vehicles for seven of the parking facilities in the study corridor. This data, which were collected between 9 a.m. and 10 a.m. on five separate dates, were compared to the data collected for the 12 noon period (see Table 4.1) and reveals that, depending on the parking facility, there is a -3.3 to 27.7 percent increase in total number of vehicles over the 1980 figures. The average percent increase for seven lots was 10.3, but it was not possible to determine if any of the increase was due to a totally seasonal difference, a time variation, natural growth, or pre-fair construction activities.

Correlation of Attendance with Total Vehicles and External Vehicles

Fair attendance during the survey period ranged from 40,000 on Sunday, May 2, to a high of 99,306 on Saturday, May 15. It should be noted that total daily attendance included all employees and some double

TABLE 4.1. Comparison of Data in 1981 to Data One Month Before World's Fair Opened

Lot	Capacity	(9:00-10:00) 1980 Average Number Vehicles (5 dates)	(11:00-1:00) 1982 Average Number Vehicles Before Fair (3 dates)	Percent Increase
4155	26	22.6	24.7	8.5
4168	66	53.2	59.0	9.8
4196	85	72.4	88.7	18.4
4207	30	23.2	28.3	18.0
4205	32	25.8	35.7	27.7
2125	40	34.6	39.0	11.3
2136	149	131.6	127.3	-3.3
			Average percent increase =	10.3

counting of individuals as they leave and reenter the fair site. For these reasons attendance figures are somewhat inflated when compared to individuals actually on the site. Attendance for the six dates on which parking data were collected ranged from 48,690 to 96,844.

Figure 4.6 presents a plot of attendance and external vehicles parked in the corridor at 3 p.m. This time period was selected because it represented the peak parking accumulation in the corridor. This graph indicates a general relationship does exist between the two variables.

Trends of Individual Parking Facilities

The impact of the World's Fair varied substantially between individual parking facility. This variation depended on the parking facilities' location, its short-term and long-term rates, and its accessibility to the fair. Appendix Figures A.8 through A.20 provide detailed data for each facility on total vehicles, average total vehicles with local license plates, and average total vehicles with external license plates. This data illustrate the wide variation of impact the World's Fair had on each parking facility. For example, Figure A.15 indicates that facility 4155 realized a substantial increase during the fair in total vehicle occupancy at 7 p.m. Conversely, Figure A.20 illustrates that facility 4207 had an almost insignificant increase in total vehicles at 7 p.m.

Table 4.2 presents the impact of fair visitors on each parking facility by providing the percent increase of external license plates at 3 p.m. It can be seen from this table that facility 4155, see Figure 3.4, page 36, for the location, had the largest percent increase of

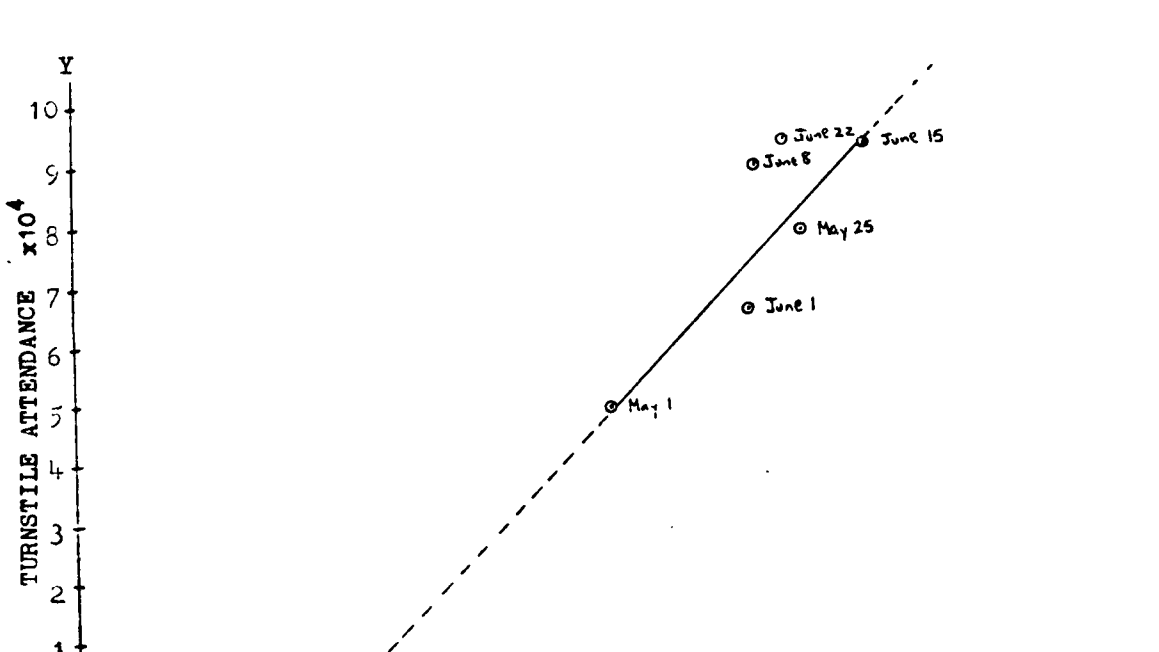


Figure 4.6. Turnstile Attendance vs. Percent of Vehicles in Corridor with External License Plates

TABLE 4.2. Percent of Vehicles with External License Plates at 3 p.m.

Parking Facility	Percent Vehicles with External License Plates		
	Average Before Fair	Average During Fair	Average Percent Increase
4136	23.8	48.4	50.8
4155	9.5	83.2	88.6
4165	15.6	55.4	71.8
4168	13.2	70.8	81.4
4196	15.8	44.4	64.4
4215	10.9	44.1	75.3
4207	18.2	33.8	46.1
4205	16.6	60.2	72.4
2125	9.5	31.5	70.0
2136	8.0	40.8	80.4
2106	13.1	22.5	41.8
2095	13.6	35.7	61.9
100	5.9	31.6	81.3

vehicles with external license plates. Interestingly, this lot was located just 775 feet from the East Gate with an all day rate of ten dollars. The parking facility that had the least amount of change with external parkers was lot 2106 which was located 2,100 feet from the East Gate with an all day rate of only $2.50. As expected, this facility had many early arriving commuters.

Vehicles Displaced

The parking facilities in the corridor realized an overall displacement of local vehicles. Table 4.3 provides an estimate of the average number of vehicles with local license plates that were displaced for each parking facility during the World's Fair. This table shows that at 9 a.m. an average of 300 local vehicles were displaced, at 12 noon 392 were displaced, at 3 p.m. 303 were displaced, and at 7 p.m. 38 were displaced. The following assumptions were used in this analysis:

1. All vehicles in the corridor at 9 a.m. are commuters. Most World's Fair visitors will arrive after 9 a.m.

2. All commuter vehicles in the corridor will remain after 3 p.m.

3. Local vehicles which are not commuters are labeled "short-term vehicles" and are there for shop or personal business.

Using these assumptions, an average of 300 commuter vehicles were displaced. At 12 noon, assuming all 300 commuter vehicles were still in place, an average of 92 "short-term vehicles" were displaced. At 3 p.m. an average of only 3 "short-term vehicles" were displaced. This analysis is not applicable to the 7 p.m. period because most commuters have departed from work by then.

TABLE 4.3. Average Number of Vehicles with Local License Plates Displaced During Operation of the Fair by Time of Day

Parking Facility	Capacity	Time Period			
		9 a.m.	12 Noon	3 p.m.	7 p.m.
4136	375	17	95	47	3
4155	26	7	17	18	4
4165	99[1]	22	59	30	14
4168	66	28	37	33	20
4196	85	24	33	19	1
4215	147	43	44	71	18
4207	30	9	3	3	2
4205	32	3	26	14	4
2125	40	14	12	7	15
2136	149	31	24	18	11
2106	49	21	10	2	-6
2095	818	75	72	68	17
100	2600	6	-40	-27	-46
Totals	4516	300	392	303	38

1. Average capacity (see footnote 1, Table 3.2).

This procedure can also be applied to individual parking facilities. In the Miller's Parking Garage, lot 4136 in Figure 3.4, page 36, there was an average of 17 commuter vehicles displaced. At 12 noon an average of 95 vehicles were displaced which indicated that 82 percent of the total vehicles displaced were "short-term." With the Coliseum Parking Garages, facility 100 in Figure 3.1, page 25, the table indicates that the number of local vehicles increased. It appears the Coliseum Parking Garages became more attractive for long-term downtown parkers because of its inexpensive monthly rate of $20.00.

Percent of Vehicles with External Plates in Relation to Parking Facility Location and Rates

When planning for the parking facilities of a special event, the planner needs to determine patron sensitivity to location and price. In this study an attempt was made to correlate these two components with parking facility use. The dependent variable (Y) utilized was the average percent of vehicles in each parking facility with external license plates. The independent variables were X_1, the average travel time from the parking facility to the East Gate, and X_2, the all day rates for each facility. With the exception of the Coliseum Parking Garages, the average travel time was estimated to be the walking distance from the parking facility to the East Gate. For the Coliseum facility, where a shuttle bus system was used, the travel time included waiting for the shuttle bus, riding the shuttle bus, and walking the remaining distance to the East Gate. Table 4.4 presents, for each parking facility, the corresponding travel time to the East Gate, and the all day parking rate.

TABLE 4.4. Travel Time from Each Parking Facility to the East Gate and Facility Rates

Parking Facility	Travel Time (Minutes)[1]	Rates/Day ($)
4136	1.28	12-20
4155	2.87	10
4165	4.38	10
4168	5.13	6
4196	7.43	6
4215	7.47	6
4207	7.60	6
4205	8.10	6
2125	8.67	6
2106	9.25	6
2095	9.87	2.50
2136	9.93	6
100	19.63	4

1. From parking attendant booth of each facility to East Gate.

Figures 4.7, 4.8, 4.9, and 4.10 represent regression analyses summaries conducted for the time periods 9 a.m., 12 noon, 3 p.m., and 7 p.m., respectively. For the survey times 9 a.m., 12 noon, and 3 p.m. three separate regression analyses were performed as listed below:

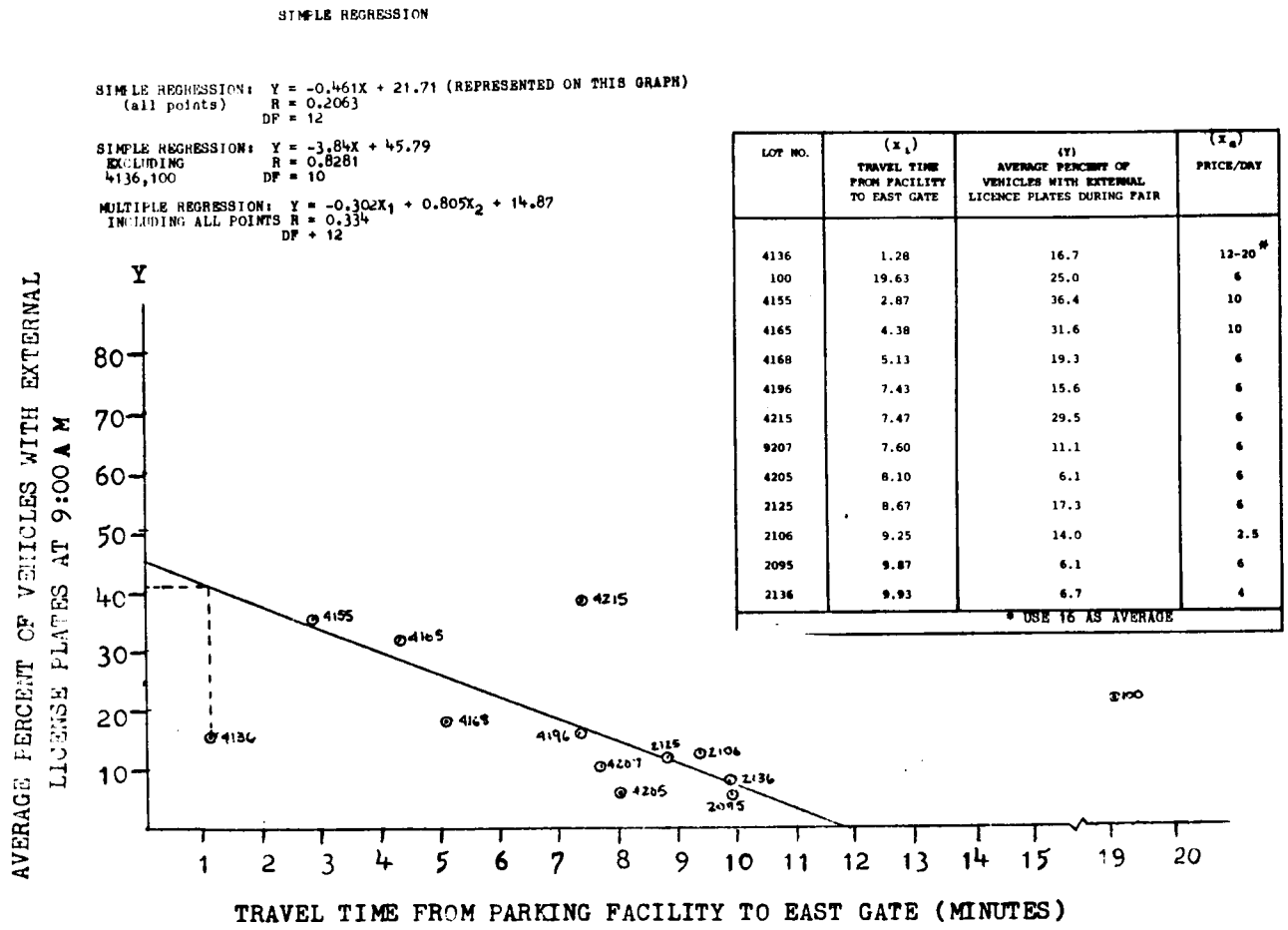
1. Simple regression analysis using all parking facilities.

2. Simple regression analysis excluding the Miller's and Coliseum Parking Garages (lots 4136 and 100, respectively).

3. Multiple regression analysis utilizing all parking facilities. For the survey time, 7 p.m., only simple regression analysis was performed (excluding lots 4136 and 100) because it was felt that multiple regression analysis results would be atypical due to pricing changes reflecting special evening rates. See Figure 4.10.

Simple Regression Analysis Using All Parking Facilities: This analysis was performed, using travel time as the independent variable and percent of vehicles with external license plates as the dependent variable, and yielded multiple correlation coefficients ranging from 0.2063 to 0.5919 with 12 degrees of freedom. See Figures 4.7-4.9. When plotting the two variables, it can be seen that two outlying points consistently exist, lots 4136 and 100.

Simple Regression Analysis Excluding the Miller's and Coliseum Parking Garages: This analysis was performed with the same two variables for each survey time and yielded multiple correlation coefficients ranging from 0.8281 for 9 a.m. to 0.7249 for 7 p.m., with 10 degrees of freedom in each case. See Figures 4.7-4.9. The suggestion is that, excluding the two outlying points, a better fit does exist between the two variables. In addition, the negative sign of the X_1 coefficient



LOT NO.	(x_1) TRAVEL TIME FROM FACILITY TO EAST GATE	(Y) AVERAGE PERCENT OF VEHICLES WITH EXTERNAL LICENCE PLATES DURING FAIR	(x_2) PRICE/DAY
4136	1.28	16.7	13-20*
100	19.63	25.0	6
4155	2.87	36.4	10
4165	4.38	31.6	10
4168	5.13	19.3	6
4196	7.43	15.6	6
4215	7.47	29.5	6
9207	7.60	11.1	6
4205	8.10	6.1	6
2125	8.67	17.3	6
2106	9.25	14.0	2.5
2095	9.87	6.1	6
2136	9.93	6.7	4

* USE 16 AS AVERAGE

Figure 4.7. Travel Time from Facility to East Gate vs. Average Percent of Vehicles with External License Plates During Fair (at 9 a.m.)

SIMPLE REGRESSION: (all points) $Y = -2.17X + 61.22$ (REPRESENTED ON THIS GRAPH)
$R = 0.5061$
$DF = 12$

SIMPLE REGRESSION: EXCLUDING 4136,100 $Y = -6.61X + 93.95$
$R = 0.7433$
$DF = 10$

MULTIPLE REGRESSION: INCLUDING ALL POINTS $Y = -1.96X_1 + 0.47X_2 + 56.28$
$R = 0.5104$
$DF = 12$

LOT NO.	(X$_1$) TRAVEL TIME FROM PARKING FACILITY TO EAST GATE	(Y) AVERAGE PERCENT OF VEHICLES WITH EXTERNAL PLATES DURING FAIR	(X$_2$) PRICE/DAY
4136	1.28	44.5	12-20*
100	19.63	30.8	6
4155	2.87	80.1	10
4165	4.38	52.5	10
4168	5.13	72.3	6
4196	7.43	40.4	6
4215	7.47	42.1	6
4207	7.60	28.9	6
4205	8.10	69.0	6
2125	8.67	21.6	6
2106	9.25	21.1	2.5
2095	9.87	35.5	6
2136	9.93	36.4	4

*USE 16 AS AVERAGE

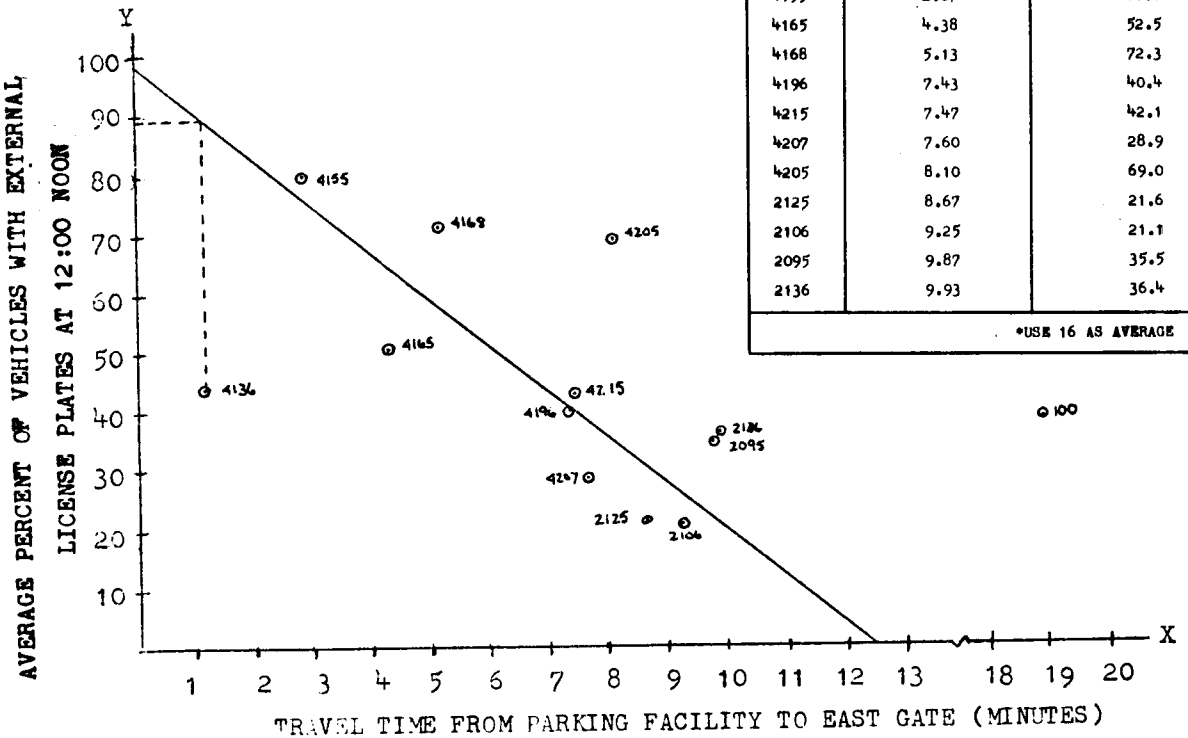
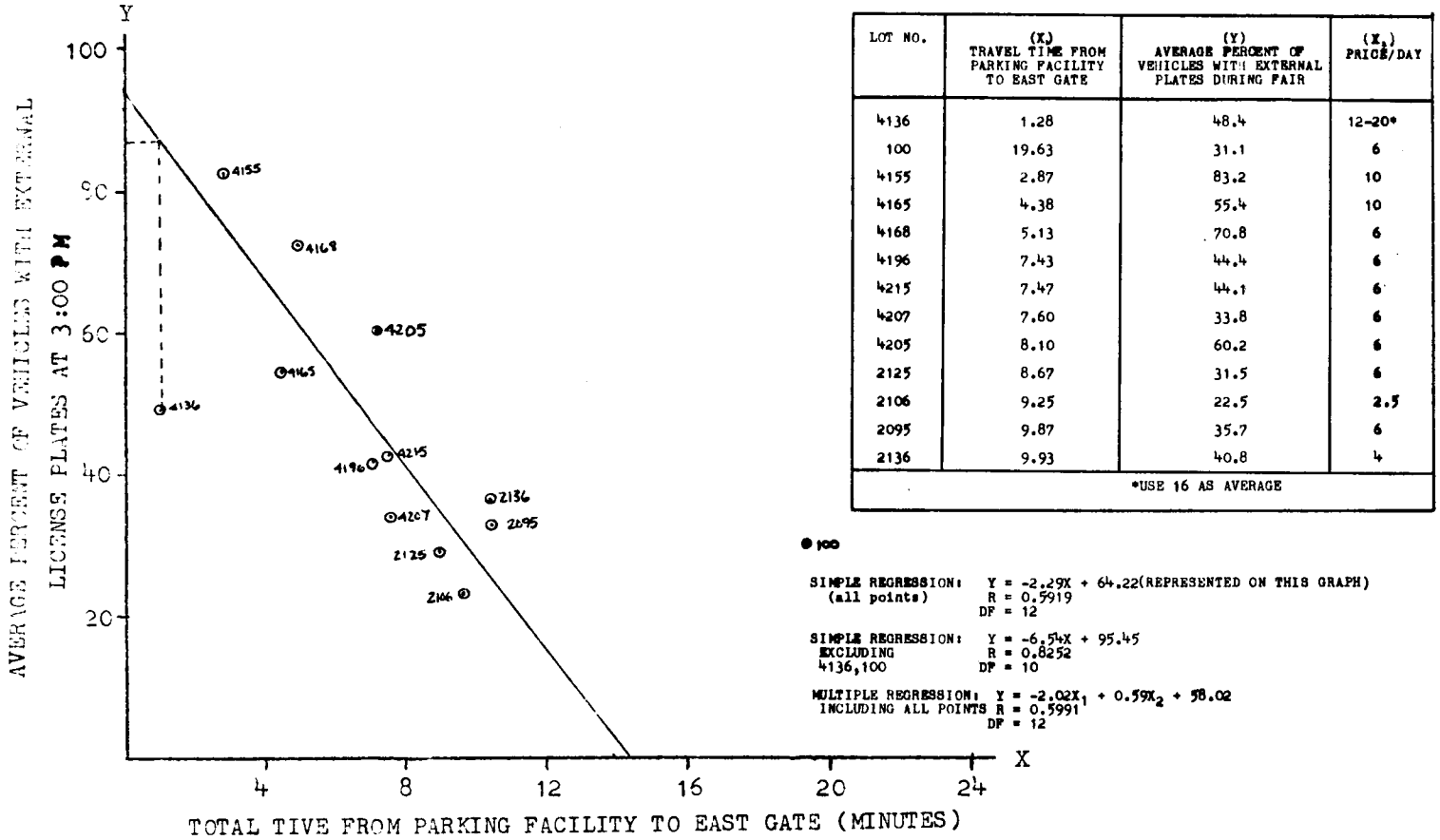


Figure 4.6. Travel Time from Facility to East Gate vs. Average Percent of Vehicles with External License Plates During Fair (at 12 noon)



LOT NO.	(X₁) TRAVEL TIME FROM PARKING FACILITY TO EAST GATE	(Y) AVERAGE PERCENT OF VEHICLES WITH EXTERNAL PLATES DURING FAIR	(X₂) PRICE/DAY
4136	1.28	48.4	12-20*
100	19.63	31.1	6
4155	2.87	83.2	10
4165	4.38	55.4	10
4168	5.13	70.8	6
4196	7.43	44.4	6
4215	7.47	44.1	6
4207	7.60	33.8	6
4205	8.10	60.2	6
2125	8.67	31.5	6
2106	9.25	22.5	2.5
2095	9.87	35.7	6
2136	9.93	40.8	4
*USE 16 AS AVERAGE			

● 100

SIMPLE REGRESSION: (all points) $Y = -2.29X + 64.22$ (REPRESENTED ON THIS GRAPH)
$R = 0.5919$
$DF = 12$

SIMPLE REGRESSION: EXCLUDING 4136,100 $Y = -6.54X + 95.45$
$R = 0.8252$
$DF = 10$

MULTIPLE REGRESSION: INCLUDING ALL POINTS $Y = -2.02X_1 + 0.59X_2 + 58.02$
$R = 0.5991$
$DF = 12$

Figure 4.9. Travel Time from Facility to East Gate vs. Average Percent of Vehicles with External License Plates During Fair (at 3 p.m.)

LOT NO.	(X) TRAVEL TIME FROM PARKING FACILITY TO EAST GATE	(Y) AVERAGE PERCENT OF VEHICLES WITH EXTERNAL PLATES DURING FAIR
4136	1.28	44.8
100	19.63	61.6
4155	2.87	76.8
4165	4.38	59.2
4168	5.13	74.6
4196	7.43	63.0
4215	7.47	54.6
4207	7.60	57.8
4205	8.10	48.3
2125	8.67	60.4
2106	9.25	34.3
2095	9.87	59.1
2136	9.93	59.4

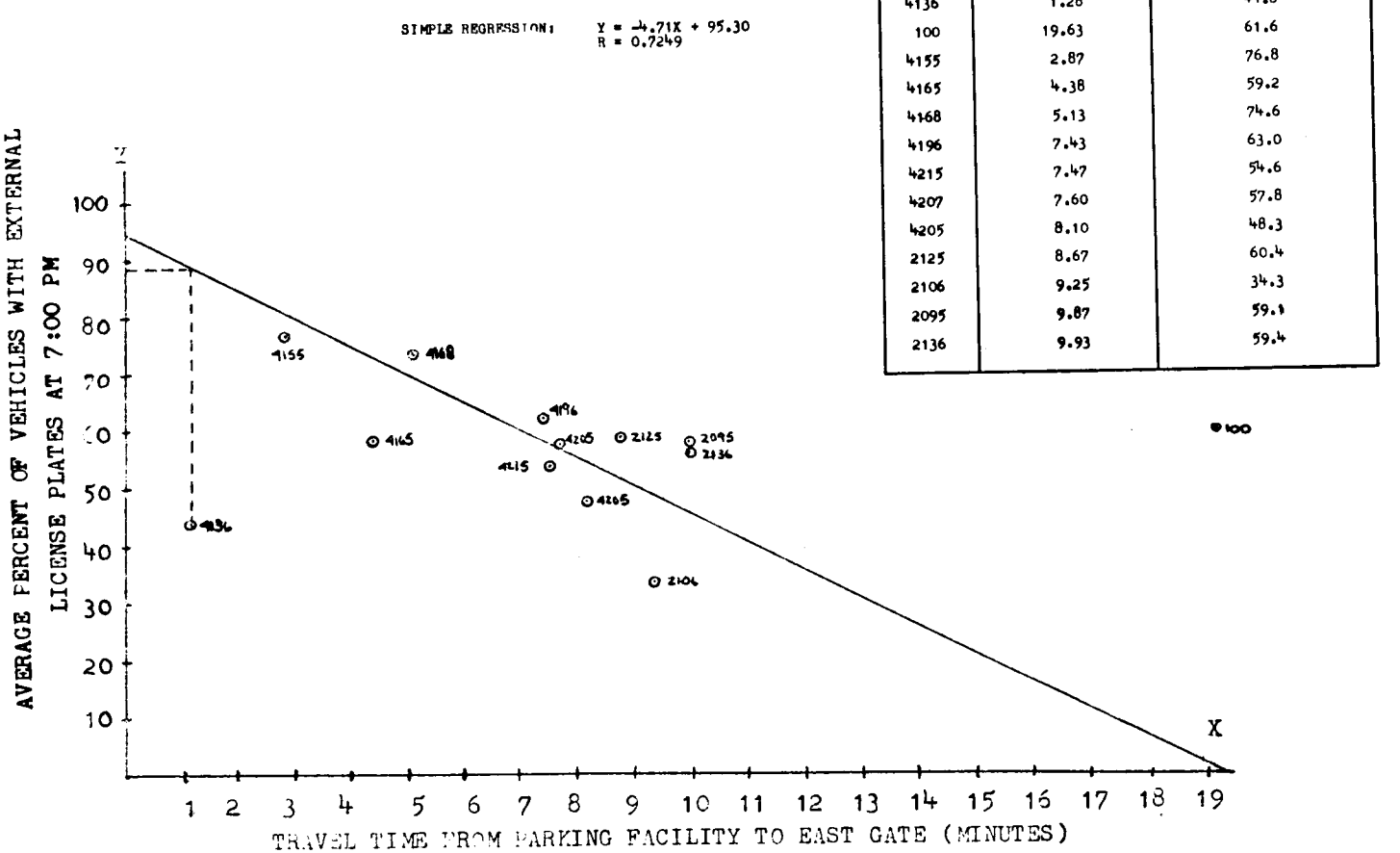


Figure 4.10. Travel Time from Facility to East Gate vs. Average Percent of Vehicles with External License Plates During Fair (at 7 p.m.)

suggests that travel time is a more significant variable than price. With further analysis it is clear the outlying points, or facilities, are not typical of others in the corridor. For example, the Miller's Parking Garage (4136) had an average all day rate which exceeded the others by $13.50 to $16.00. The Coliseum Parking Garages (100) had an average travel time of 19.63 minutes which was almost 10 minutes greater than the other facilities.

Excluding the Miller's Parking Garage, the facilities in the corridor have all day rates ranging from $2.50 to $10.00. The implication is that, if Miller's all day rates were compatible to other parking facilities, its average percent of external vehicles would increase for each time period. For example, with the 9 a.m. survey time, an adjustment in price could be expected to result in an increase in utilization. See Figure 4.7. For the remaining time periods, the percent of external vehicles would increase to approximately 90 if their rates were consistent with other facilities. This is a good example of how pricing can be used to discourage special event parkers.

Multiple Regression Analysis Utilizing All Parking Facilities: For further examination of price sensitivity, a multiple regression analysis was performed between the average percent of vehicles in each parking facility with external license plates, the average travel time, and the all day rates. In Figures 4.7 through 4.9, it can be seen that the multiple correlation coefficients range from 0.334 to 0.5991 with 12 degrees of freedom. From these figures it can also be seen that the sign is negative for the X_1 coefficient. This suggests that World's Fair visitors are less sensitive to price than travel time from the

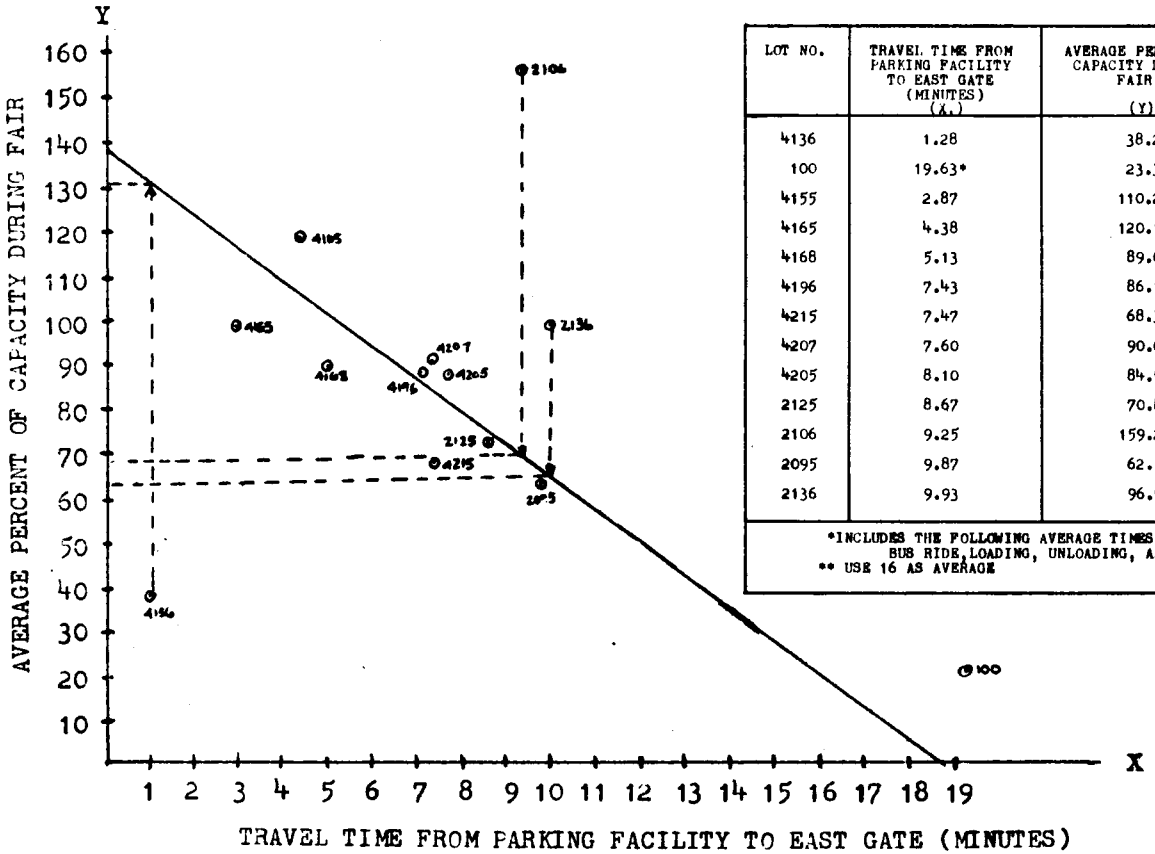
parking facility to the fair site. Price sensitivity appears to be a factor only when the all day rates exceed ten dollars.

Relationship Between Travel Time from Each Parking Facility to the Fair Site and Average Percent of Capacity

This analysis suggests that there is a correlation between travel time from the parking facility to the East Gate and the average percent of capacity of each lot during the fair. Figure 4.11, which depicts a graph of these two variables at 12 noon, indicates that there are four outlyers (points separated from the regression line), 4136, 2106, 2136, and 100. Facility 4136, the Miller's Parking Garage, again is an atypical lot because its average all day rate was $16.00. Likewise, facility 2106 was atypical because its all day rate was $2.50 and facility 2136 because its all day rate was $4.00. Facility 100, the Coliseum Parking Garages, again was atypical because of the exceptionally long travel time to the fair site. The other parking facilities, which had all day rates ranging from $6.00 to $10.00, are plotted and apparently suggest that a linear relationship does exist. Figure 4.10 implies that facility 4136's potential percent of capacity would be almost 130 at 12 noon if its all day rates were consistent with other lots (i.e., in Figure 4.12, point 4136 would intersect the linear line at almost 130 percent). Similarly, facility 2106's percent of capacity would be only 70 and 2136's would be 65 if the all day rates were compatible.

Vehicle Occupancy Rates

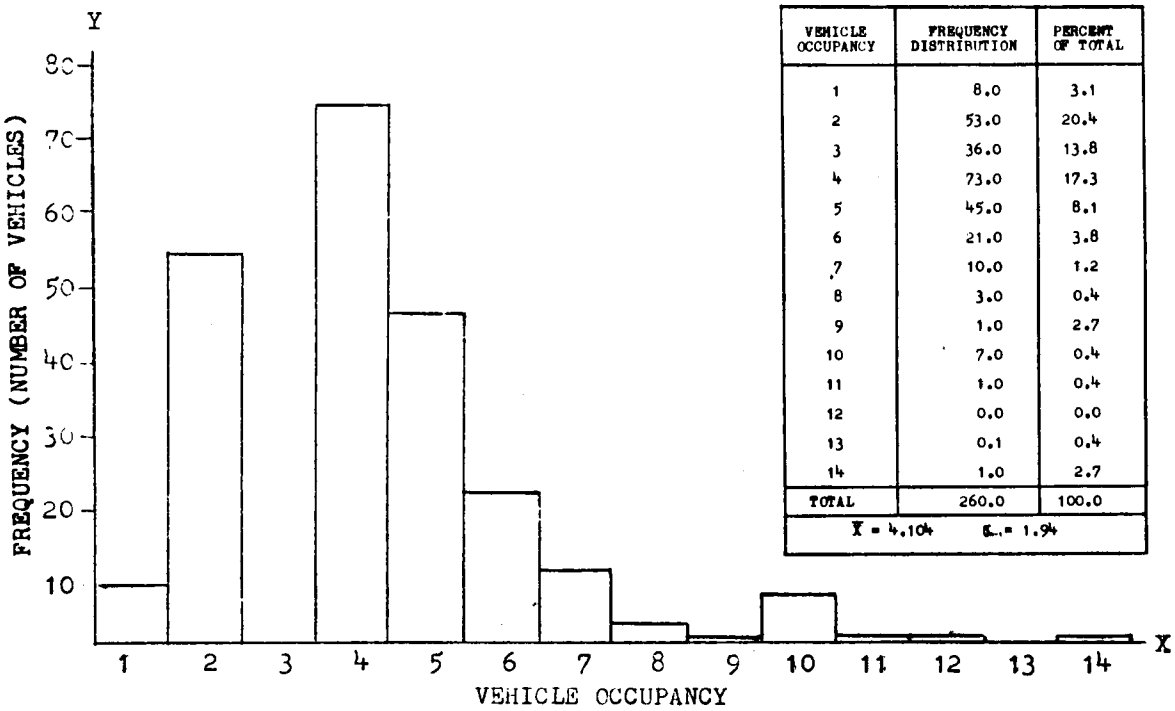
Lot 100, a parking facility located adjacent to the World's Fair site, was selected to obtain detailed vehicle occupancy data for three



LOT NO.	TRAVEL TIME FROM PARKING FACILITY TO EAST GATE (MINUTES) (X_i)	AVERAGE PERCENT OF CAPACITY DURING FAIR (Y)	PRICE/DAY (X_2)
4136	1.28	38.2	12-20**
100	19.63*	23.3	6
4155	2.87	110.2	10
4165	4.38	120.1	10
4168	5.13	89.6	6
4196	7.43	86.1	6
4215	7.47	68.3	6
4207	7.60	90.6	6
4205	8.10	84.9	6
2125	8.67	70.8	6
2106	9.25	159.2	2.5
2095	9.87	62.5	6
2136	9.93	96.9	4

*INCLUDES THE FOLLOWING AVERAGE TIMES: (WAIT, BUS RIDE, LOADING, UNLOADING, AND WALK)
** USE 16 AS AVERAGE

Figure 4.11. Travel Time from Parking Facility to East Gate (minutes) vs. Average Percent of Capacity During Fair (12 noon)



VEHICLE OCCUPANCY	FREQUENCY DISTRIBUTION	PERCENT OF TOTAL
1	8.0	3.1
2	53.0	20.4
3	36.0	13.8
4	73.0	17.3
5	45.0	8.1
6	21.0	3.8
7	10.0	1.2
8	3.0	0.4
9	1.0	2.7
10	7.0	0.4
11	1.0	0.4
12	0.0	0.0
13	0.1	0.4
14	1.0	2.7
TOTAL	260.0	100.0
$\bar{X}$ = 4.104	σ_x = 1.94	

Figure 4.12. Histogram of Vehicle Occupancy

and one-half hours. The sample, which included 260 vehicles, see Figure 4.12, yielded a mean vehicle occupancy rate of 4.1 and a mode of 4. The Transportation Plan for the 1982 World's Fair estimated the design vehicle occupancy rate would be 3.5, which is almost 15 percent less.[1] Using the design estimate of 53,800 persons arriving daily by automobile, Barton-Aschman determined that the daily parking demand would be based on approximately 13,100 vehicles excluding employees (53,800/3.5 x 85% vehicles accumulated at one time). However, if the mean occupancy rate were 4.1, the estimated parking demand would be 11,150 (53,800/4.1 x 85%). The difference in daily parking demand, which is almost 2,000 spaces, could be a critical factor in developing a special event transportation plan.

Arrival Rates

Arrival rates could be critical in a special event transportation plan if they are highly concentrated. Data were collected on arrival rates for the World's Fair parking facility and are presented in Table 4.5. As noted by Table 4.5, the most frequent arrival time is between 9:15 a.m. and 9:30 a.m. with 59.6 percent of the facility being occupied by 10 a.m., the opening time of the World's Fair. By 11:30 a.m., 87.2 percent of the total spaces were occupied. This data also indicate that for a special event, such as the World's Fair, some patrons will arrive as early as two hours before opening time.

Turnover Rates

Data were also collected to determine the number of hours a typical World's Fair vehicle will occupy a parking space. This data are

TABLE 4.5. Arrival Rate Frequency Distribution

Time	Lot Capacity = 250 Number Vehicles	Cumulative Number Vehicles	Cumulative Percent of Capacity
8:00- 8:15	7	7	2.8
8:15- 8:30	13	20	8.0
8:30- 8:45	14	34	13.6
8:45- 9:00	24	58	23.2
9:00- 9:15	21	79	31.6
9:15- 9:30	26	105	42.0
9:30- 9:45	24	129	51.6
9:45-10:00	20	149	59.6
10:00-10:15	12	161	64.4
10:15-10:30	9	170	68.0
10:30-10:45	12	182	72.8
10:45-11:00	13	195	78.0
11:00-11:15	17	212	84.8
11:15-11:30	6	218	87.2
	218		

Note: The most popular arrival hour is 8:45-9:45 when 95 vehicles arrived.

presented in Table 4.6 which is a frequency distribution of occupancy length. The most frequent occupancy length was 12 hours, the mean was 9.56 hours, and the range was 3 to 12 hours. Because of the data collection methodology, these occupancy lengths are only estimates based on the following assumptions:

1. The vehicles arrived at 9:45 a.m. (which is the most frequent arrival time).

2. The vehicle departure time was estimated based on the absence or presence of the vehicle at each data collection time period (see Table 4.6, footnote).

Summary

From the analysis, it was clear that the parking characteristics in the corridor changed as a result of the 1982 World's Fair. The following summarizes these changes in the corridor:

1. An aggregate increase in total vehicles.

2. An aggregate increase in external vehicles.

3. An aggregate decrease in local vehicles.

4. Vehicles of World's Fair visitors in the corridor were more prevalent, and replaced some local vehicles, closer to the fair site.

5. Visitors of the World's Fair were more sensitive to walking time than parking rates.

6. Approximately 75 percent of the local vehicles displaced were commuters.

The analysis also indicates that the vehicle occupancy rate for a family oriented event such as the World's Fair might be over 4.00 rather than the often used 3.5 value. It also indicates that World's Fair

TABLE 4.6. Frequency Distribution of Occupancy Length

Data Collection Time Periods	Occupancy Length*	Frequency Distribution	Percent of Total
8:30-11:30 (continuous)	3		
11:30	3	2	3.0
1:30	5	7	10.6
3:30	6	7	10.6
4:30	7	4	6.1
5:30	8	2	3.0
6:30	9	5	7.6
7:30	10	5	7.6
8:30	11	9	13.6
9:30	12	25	37.9
		66	100.00
	mode = 12 hours	x = 631	
	mean = 9.56 hours		
	range = 3 hours to 12 hours		

*The most frequent arrival time is 8:45 a.m. to 9:45 a.m.

For occupancy length, it was assumed that each vehicle arrived at 9:45 a.m.

If the vehicle were present at 11:30 a.m. but not 1:30 p.m., it was assumed to depart at 12:45 p.m.

If the vehicle were present at 1:30 p.m. but not 3:30 p.m., it was assumed to depart at 2:45 p.m.

If the vehicle were present at 3:30 p.m. but not 4:30 p.m., it was assumed to depart at 3:45 p.m.

If the vehicle were present at 4:30 p.m. but not 5:30 p.m., it was assumed to depart at 4:45 p.m.

If the vehicle were present at 5:30 p.m. but not 6:30 p.m., it was assumed to depart at 5:45 p.m.

If the vehicle were present at 6:30 p.m. but not 7:30 p.m., it was assumed to depart at 6:45 p.m.

If the vehicle were present at 7:30 p.m. but not 8:30 p.m., it was assumed to depart at 7:45 p.m.

If the vehicle were present at 8:30 p.m. but not 9:30 p.m., it was assumed to depart at 8:45 p.m.

If the vehicle were present at 9:30 p.m., it was assumed to depart at 9:45 p.m.

visitors began arriving two hours before opening time, and the most frequent arrival period was between 8:45 a.m. and 9:45 a.m. Finally, turnover rates in the exclusive World's Fair parking facility were minimum. Most World's Fair patrons remained for twelve hours.

CHAPTER V

CONCLUSION

An analysis of downtown parking characteristics in Knoxville indicated the 1982 World's Fair had substantial impact on parking patterns. As expected, the presence of a major special event such as a World's Fair drawing approximately 28,000 to 101,000 visitors daily, located adjacent to a downtown area, in a medium size community, will significantly increase parking demands. Based on a study of parking characteristics for a corridor, extending from the fair site 4,800 feet radially through the downtown area, the average daily number of total vehicles parked increased from about 1,708 to 2,118. This represents a 19.4 percent increase for the 4,434 public spaces located in the corridor. In addition, peak accumulation increased from approximately 89 percent of capacity to 93 percent.

In response to the influx of parkers attracted to the fair, two significant changes occurred. First, parking prices were increased. Before the fair opened, the average all day rate, excluding monthly leased prices, for parking spaces in the corridor was $2.45. The average all day rate increased to $7.00 during the fair. Secondly, the supply of parking spaces increased in response to opportunity; but because of already developed land, this was not a critical factor in the study corridor. Barton-Aschman, transportation consultant to the fair, estimated that there was a need for 14,100 overall parking spaces to

accommodate World's Fair visitors.[1] During the fair the number of available parking spaces was estimated to be approximately 25,000.[9]

For the study corridor it was observed that the characteristics of the parkers changed as local individuals parking downtown for work, shop, and personal business vacated spaces in favor of vehicles from outside the local area which were assumed to be fair visitors. During the midday hours, before the fair, the average percent of vehicles with external license plates was 12.8. During the World's Fair, the average percent of vehicles with external license plates increased to 45.2.

The replacement of local vehicles with external vehicles was more pronounced in parking facilities located closer to the fair site. The analysis showed a direct correlation between the percent of external vehicles in each parking facility and the walking travel time from the parking facility to the fair site. The analysis also indicated that World's Fair visitors parking in the corridor were more sensitive to walking distance than parking rates.

The peak accumulation of vehicles parked in the corridor shifted from 12 noon before the fair to 3 p.m. during the fair. In addition, the analysis indicated that the daily number of parked external vehicles seemed to parallel daily World's Fair attendance.

The data collected at a sample parking facility utilized exclusively by World's Fair visitors indicated that the daily turnover rate was minimum. For example, almost 38 percent of the vehicles were parked for 12 or more hours, with a mean time of 9.6 hours. The data also indicated that the parking facility was at 87.2 percent of capacity at 11:30 a.m. By 10 a.m., the official opening time of the fair, 59.6

percent of the spaces were utilized. Interestingly, some World's Fair visitors arrived at this facility as early as 8 a.m. Finally, the data showed that the mean vehicle occupancy rate was 4.1 persons per vehicle. The most frequent number of persons per vehicle was four, and the range was one to fourteen persons per vehicle.

This study also provided observations concerning functioning of a transportation system during a special event such as a World's Fair. These observations were not quantified but could be of assistance to the planning of transportation facilities for special events. The following is a list of these observations:

1. The number of tour buses was underestimated by Barton-Aschman. For a design crowd of 80,000, they estimated that 12,000 would arrive by tour bus. Data indicated that the number of individuals riding tour buses ranged from approximately 4,720 to 28,040. These tour buses were provided with excellent terminals for loading and unloading which minimized dwell time. The number of tour buses decreased in magnitude in the summer months when schools were not in session. During these months more families are on vacation and this encourages travel by personal vehicle.

2. A family oriented special event such as the 1982 World's Fair will attract a large number of recreational vehicles and campers. These types of vehicles were prevalent at most parking facilities in the study corridor. In addition, vans were observed to be unusually popular at the exclusive World's Fair parking facility. Again this reflects the family orientation of the event. These types of vehicles could be reflective of the relatively high (4.1) vehicle occupancy rate.

3. The number of expected available parking spaces for the World's Fair estimated by Barton-Aschman was less than the actual number provided because many entrepreneurs developed private parking facilities.

4. World's Fair visitors tend to locate the site first, and then will concentrate on locating parking facilities close to the site. For this reason outlying parking facilities will be utilized less than those close to the site. Also, visitors did not seem to be overly sensitive to price.

5. Comments with parking lot managers indicated that World's Fair visitors preferred facilities with attendants because they can provide security for their automobiles.

It is difficult to develop transportation plans for special events because of the absence of previous studies on special events, and because of the uniqueness of each special event. The following guidelines were developed based on experience with the 1982 World's Fair. However, some of these guidelines can be applied to special events that do not fit the description of a world's fair.

Guidelines-- Based on General Observations

1. Tour and shuttle buses should be encouraged. However, it would be useful to know in advance the number of buses that will visit the fair daily. Questionnaires sent to tour and shuttle bus owners might be helpful. Also, early reservations of buses should be encouraged so that delay time can be minimized.

2. Well designed bus terminals should eliminate problems with loading and unloading. Staggering the arrival times of buses is desirable.

3. Maximum effort should be made to inform special event visitors of parking options. Use of outlying park-and-ride lots and shuttle buses should be encouraged. Maps at information centers should be provided.

4. Parking facilities need to be designed for recreational vehicles, vans, and campers. These vehicles will probably be more prevalent for a family oriented event.

5. There should be close coordination between the special event operated parking facilities and parking facilities operated by private entrepreneurs. This should help eliminate the problem of over-construction of parking facilities.

6. To achieve maximum utilization, parking facilities should be priced based on travel time and walking distance from the facility to the special event site.

7. Parking rates should reflect a small vehicle turnover rate. Most special event parking spaces will collect revenue from one vehicle per day.

8. Some visitors of special events such as the World's Fair will arrive as early as two hours before opening time.

9. Parking attendants can be utilized to yield maximum use of parking space.

10. The utilization of local transit by downtown workers, visitors, and fair employees should be encouraged by providing information and schedules at key locations such as banks, visitor centers, and motels.

11. The peak accumulation of vehicles in the downtown area for a special event such as the World's Fair will occur between 2 p.m. and 4 p.m. When scheduling other special events in the downtown area, this factor should be considered.

Limits on time, money, and manpower prevented this study from analyzing other transportation characteristics associated with the 1982 World's Fair. The following studies would supplement future special event transportation plans and are recommended as possible research topics.

1. External vehicle origination analysis which could assist in predicting total visitors expected at the special event.

2. A complete public transportation analysis to determine the effects of a special event on transit ridership.

3. A study to determine the mode split for a special event such as the World's Fair.

4. Further research to determine if a correlation does exist between daily attendance of the special event and the number of external vehicles parked for the special event.

5. Further research to determine an estimate of the vehicle occupancy rate for a family oriented event such as the World's Fair.

6. More research on price sensitivity, walking time sensitivity from the parking facility to the special event site, and walking distance sensitivity from the parking facility to the special event site.

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LIST OF REFERENCES

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APPENDIX

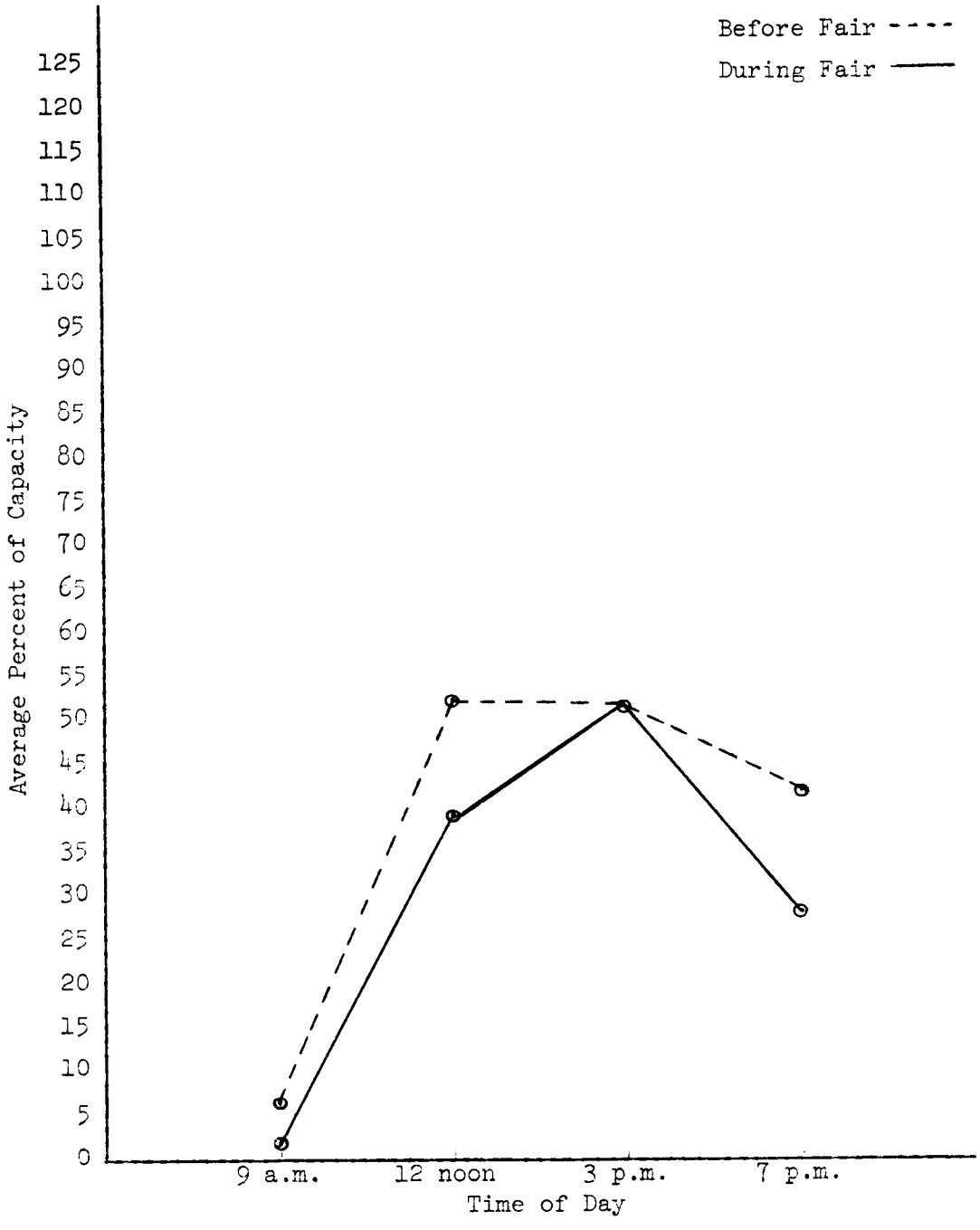


Figure A.1. Average Percent of Capacity Versus Time of Day for Facility 4136

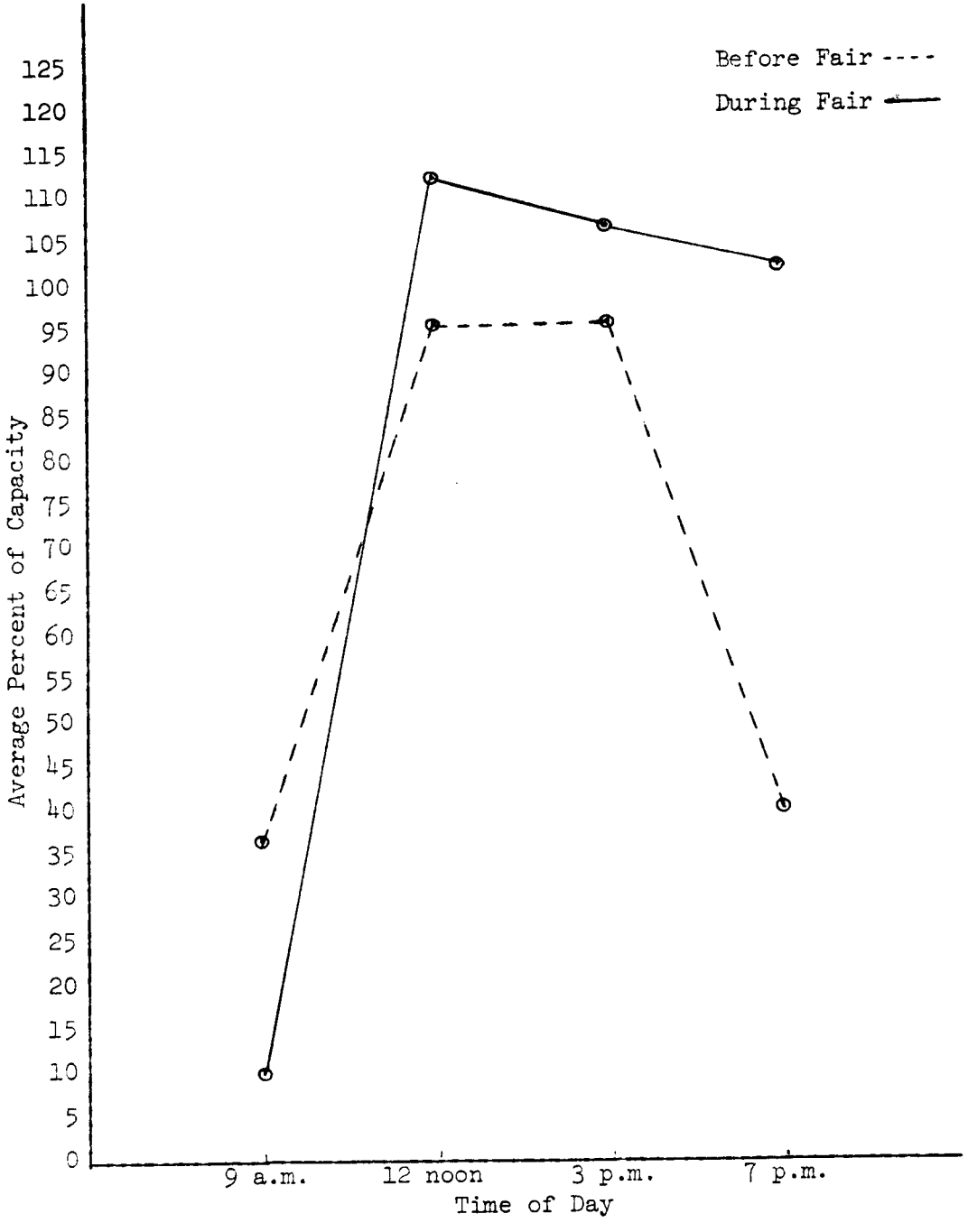


Figure A.2. Average Percent of Capacity Versus Time of Day for Facility 4155

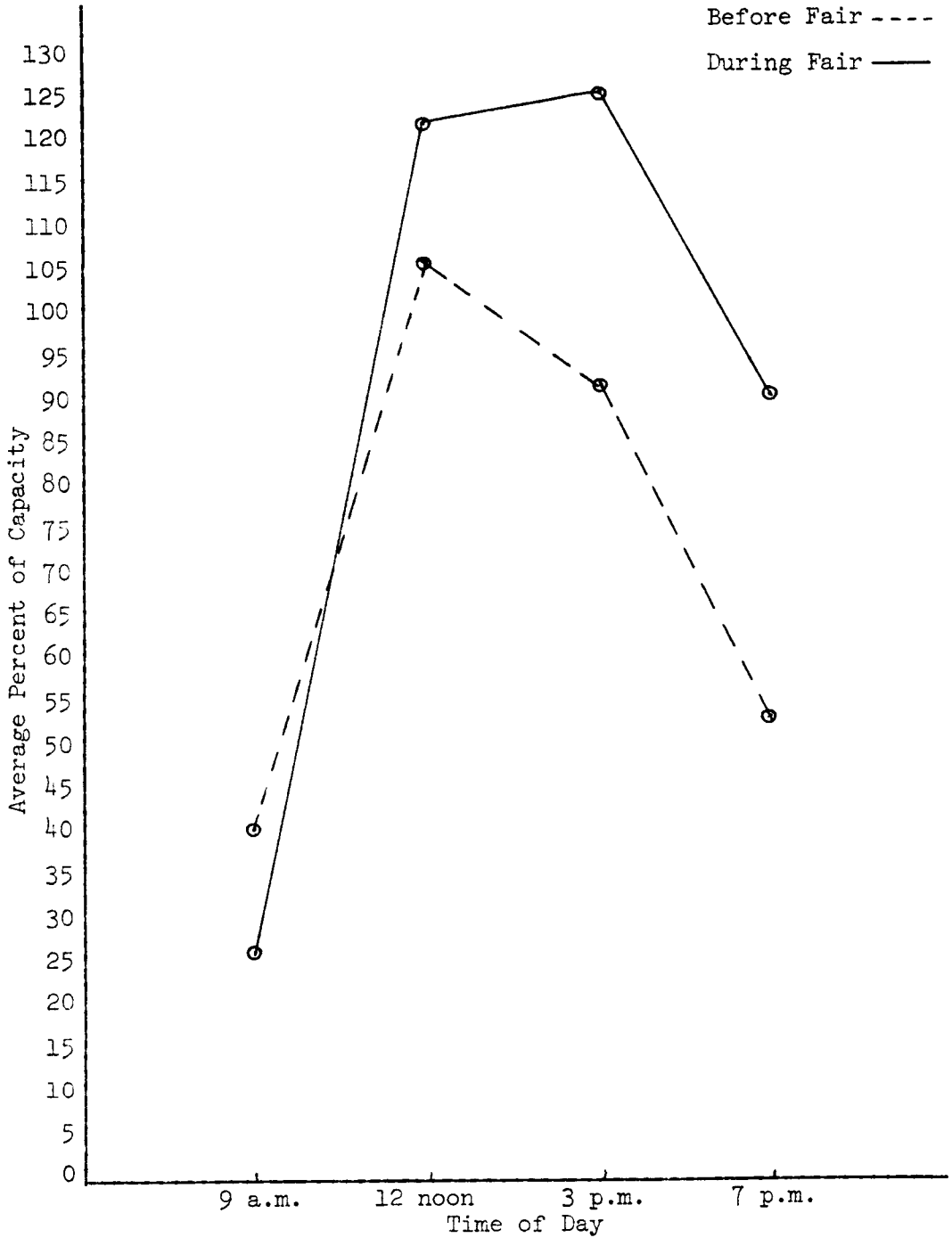


Figure A.3. Average Percent of Capacity Versus Time of Day for Facility 4165

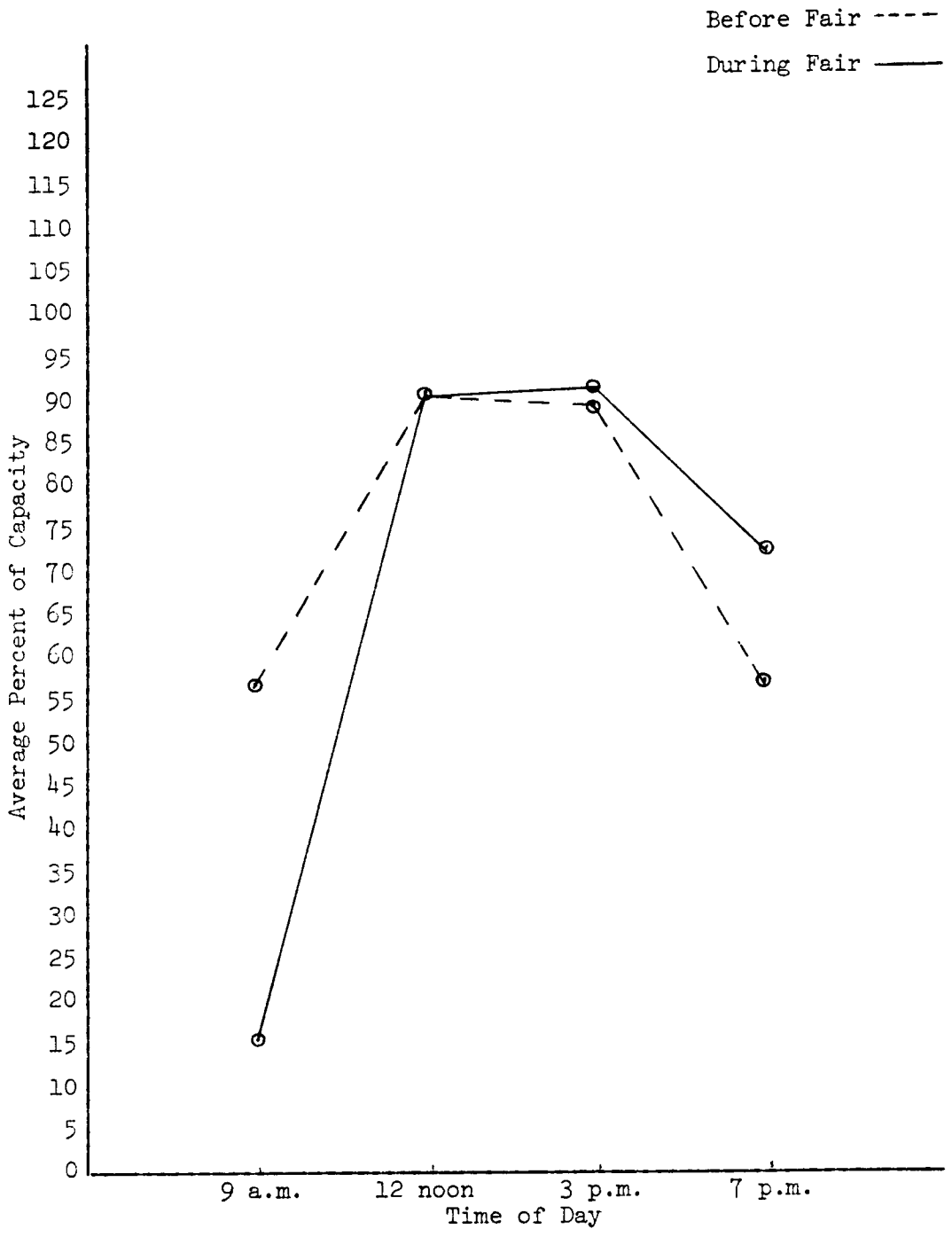


Figure A.4. Average Percent of Capacity Versus Time of Day for Facility 4168

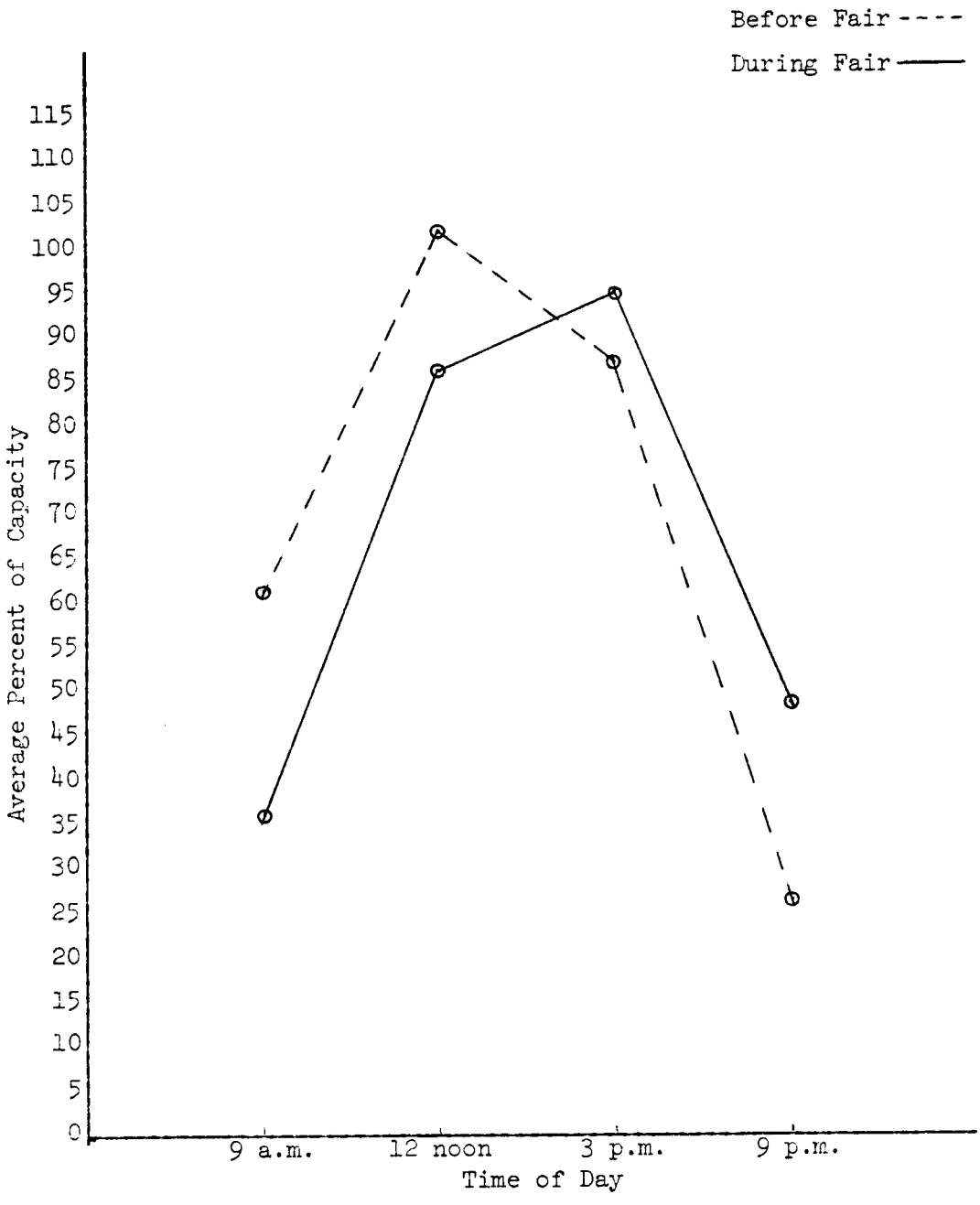


Figure A.5. Average Percent of Capacity Versus Time of Day for Facility 4196

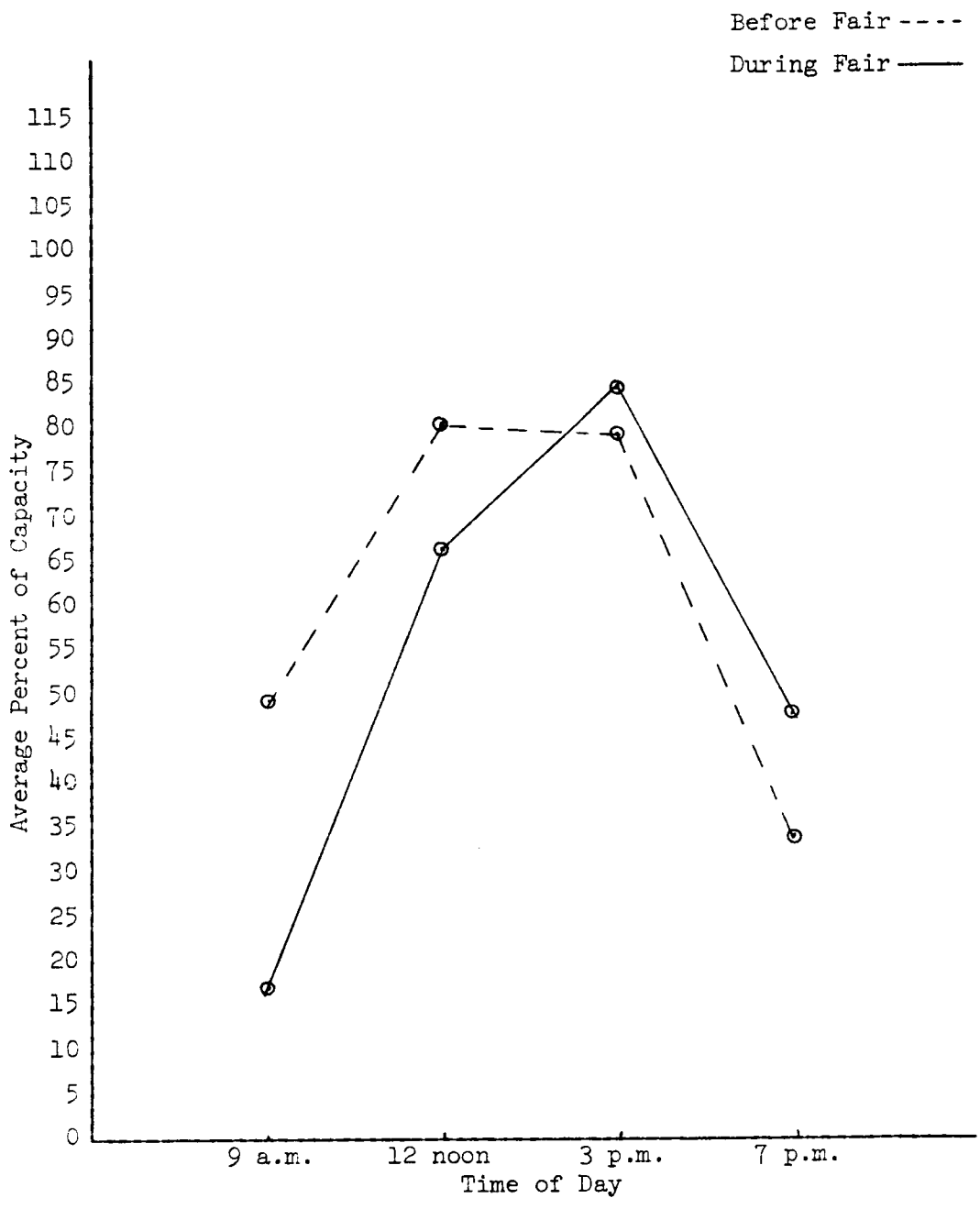


Figure A.6. Average Percent of Capacity Versus Time of Day for Facility 4215

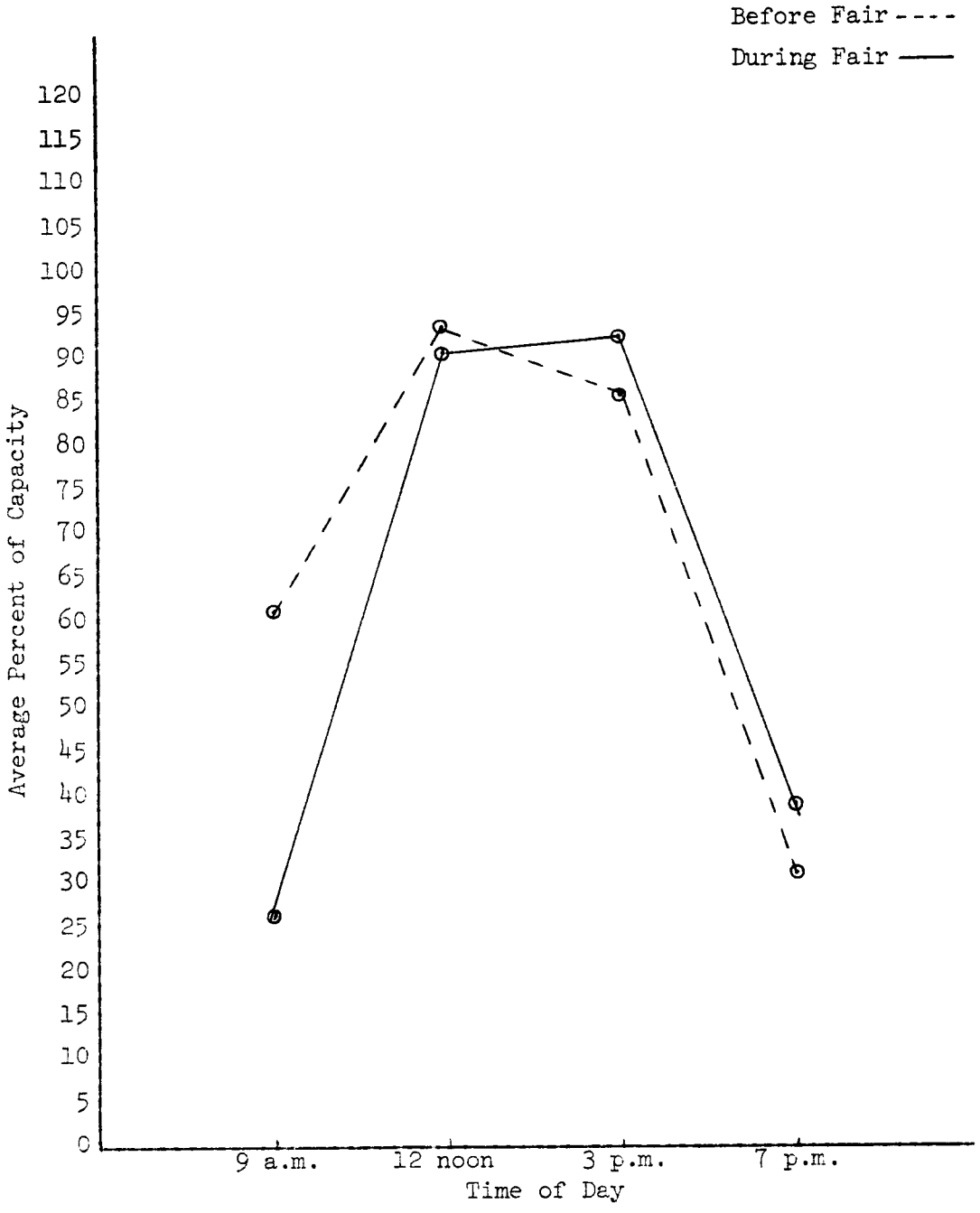


Figure A.7. Average Percent of Capacity Versus Time of Day for Facility 4207

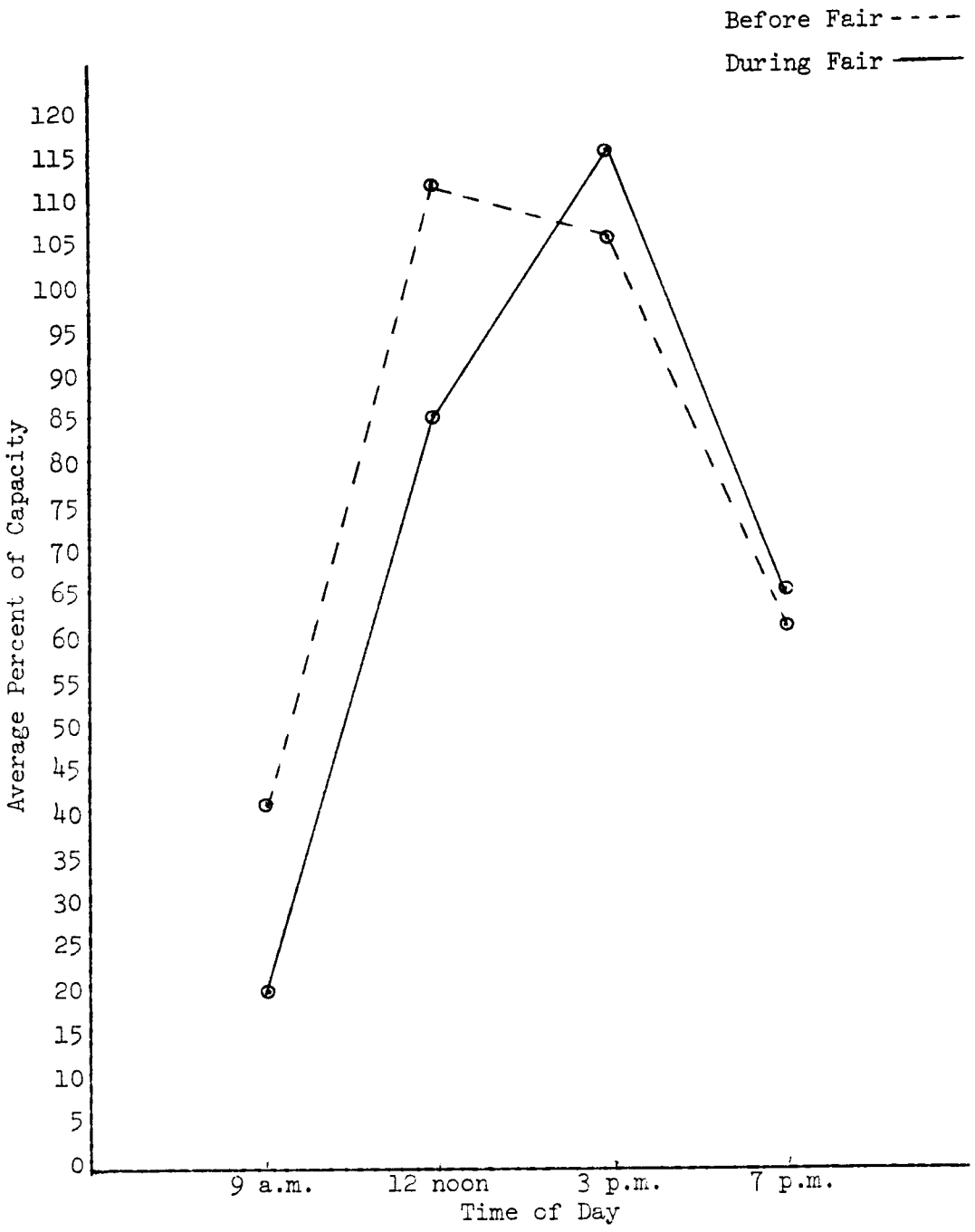


Figure A.8. Average Percent of Capacity Versus Time of Day for Facility 4205

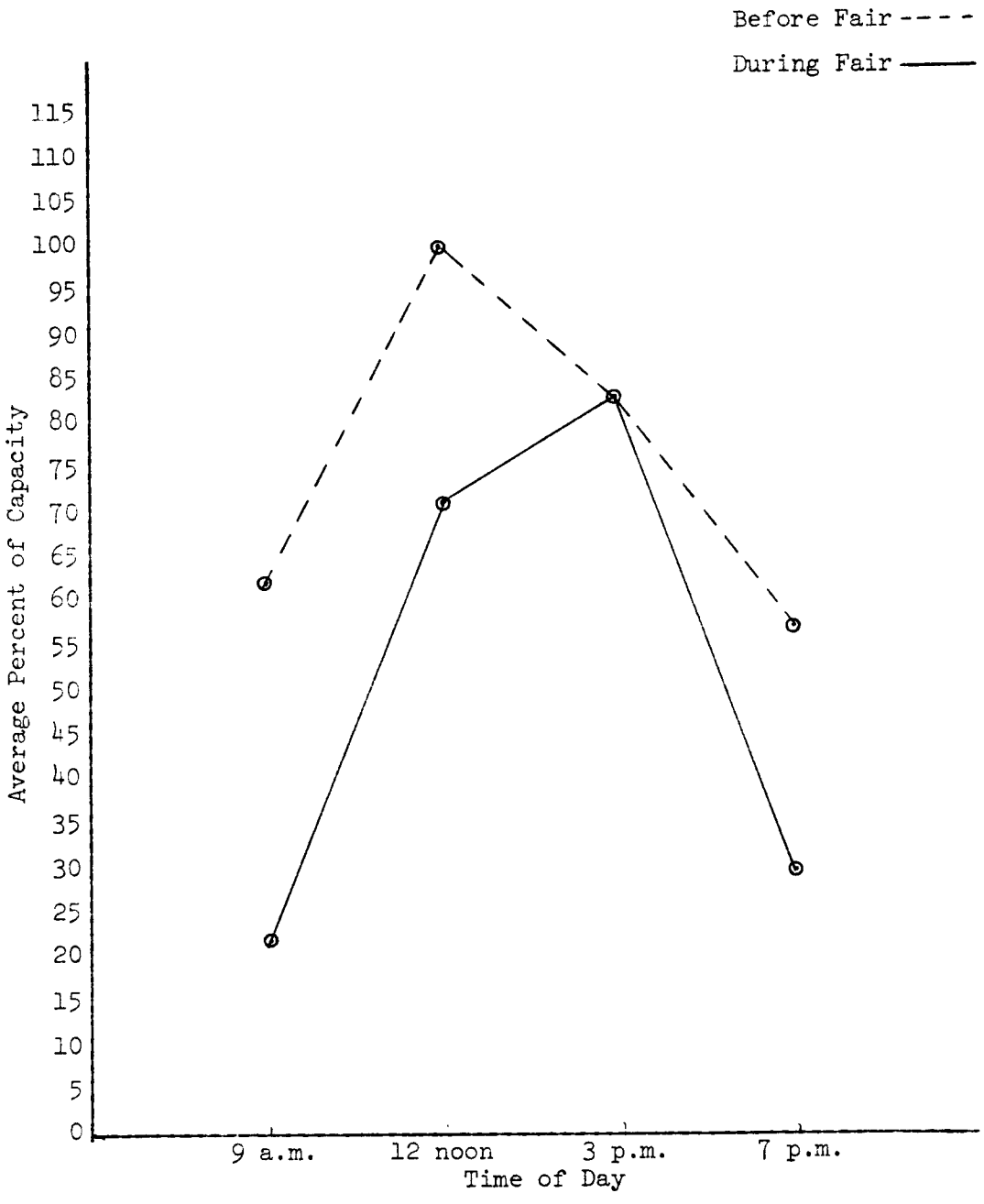


Figure A.9. Average Percent of Capacity Versus Time of Day for Facility 2125

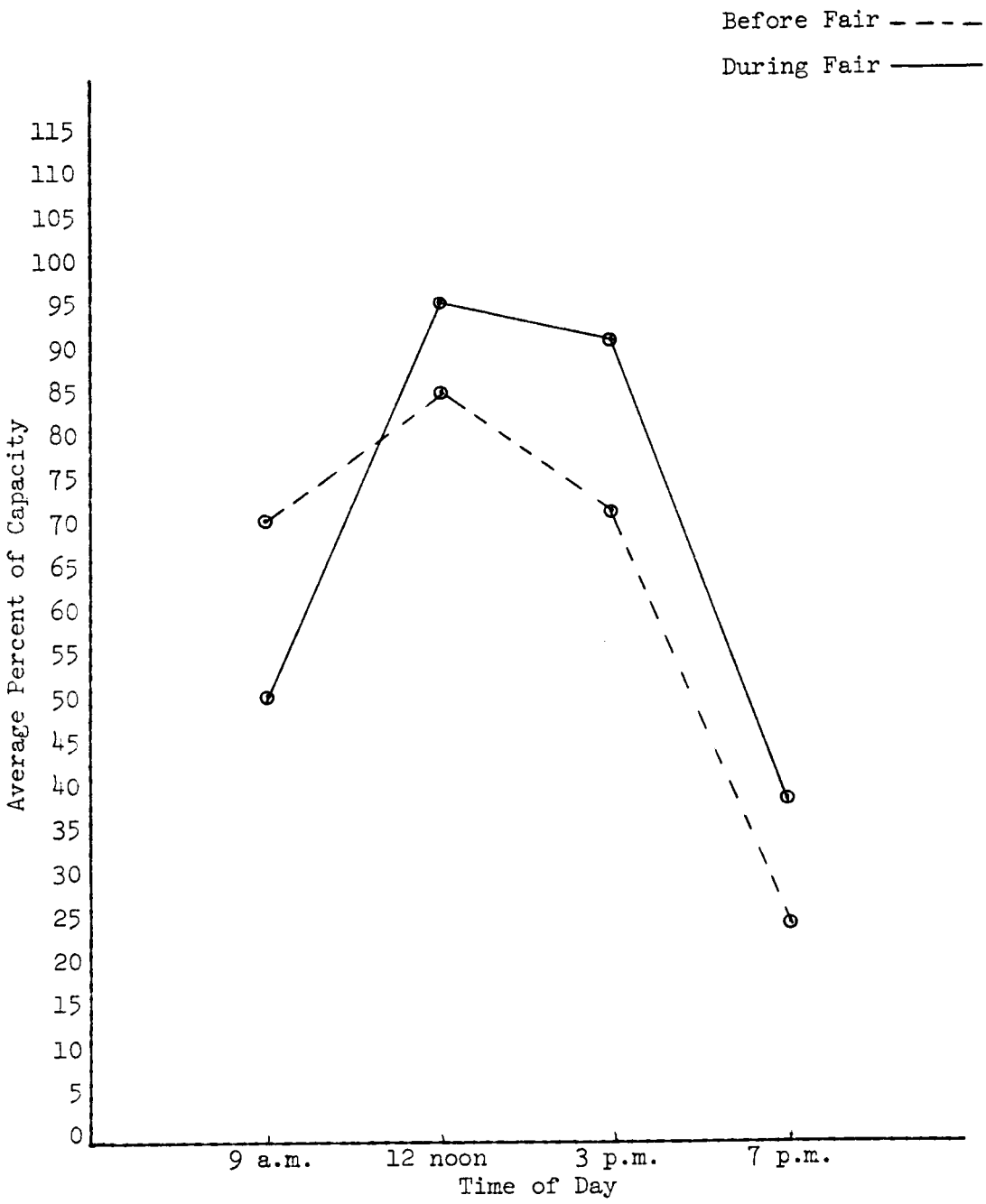


Figure A.10. Average Percent of Capacity Versus Time of Day for Facility 2136

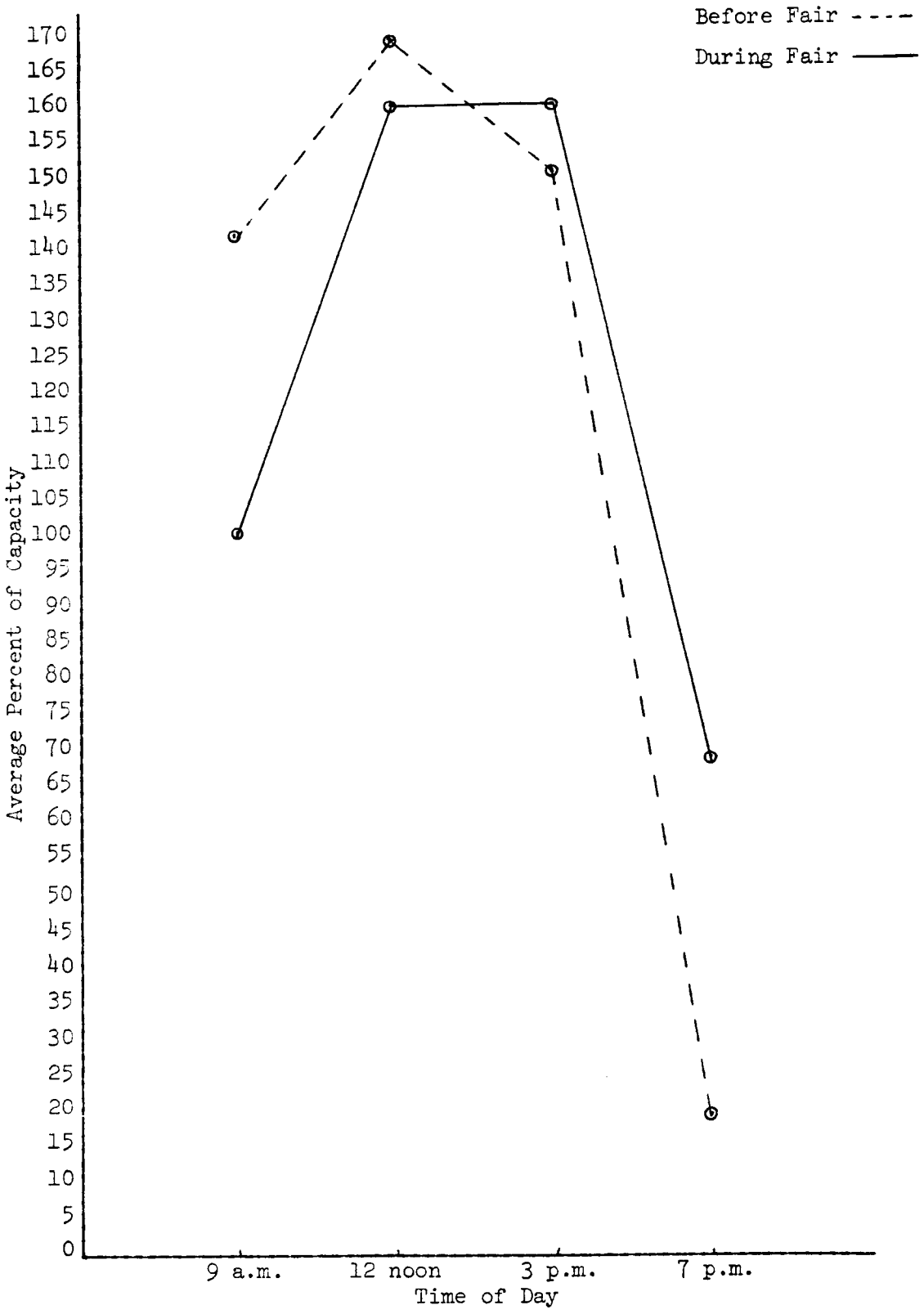


Figure A.11. Average Percent of Capacity Versus Time of Day for Facility 2106

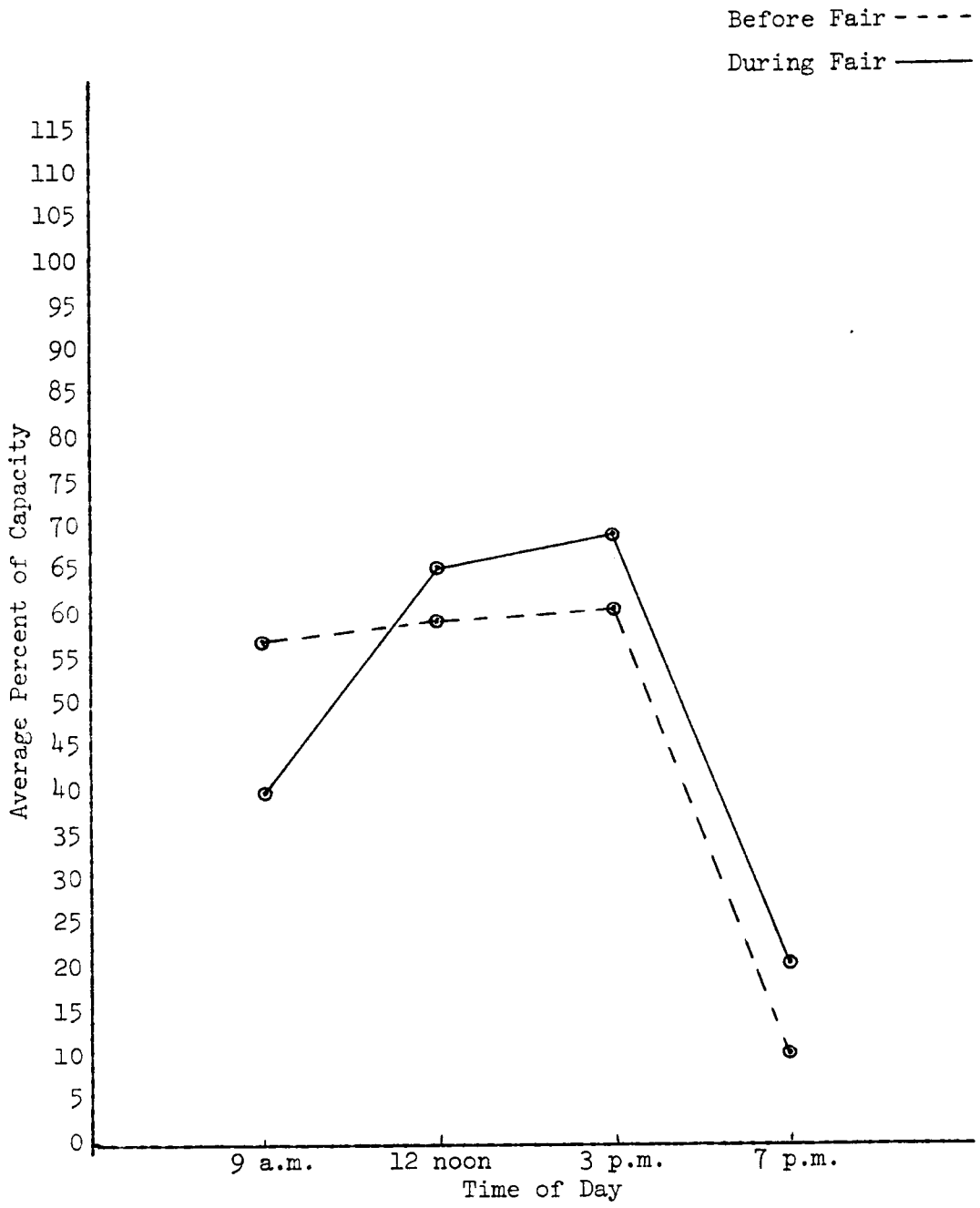


Figure A.12. Average Percent of Capacity Versus Time of Day for Facility 2095

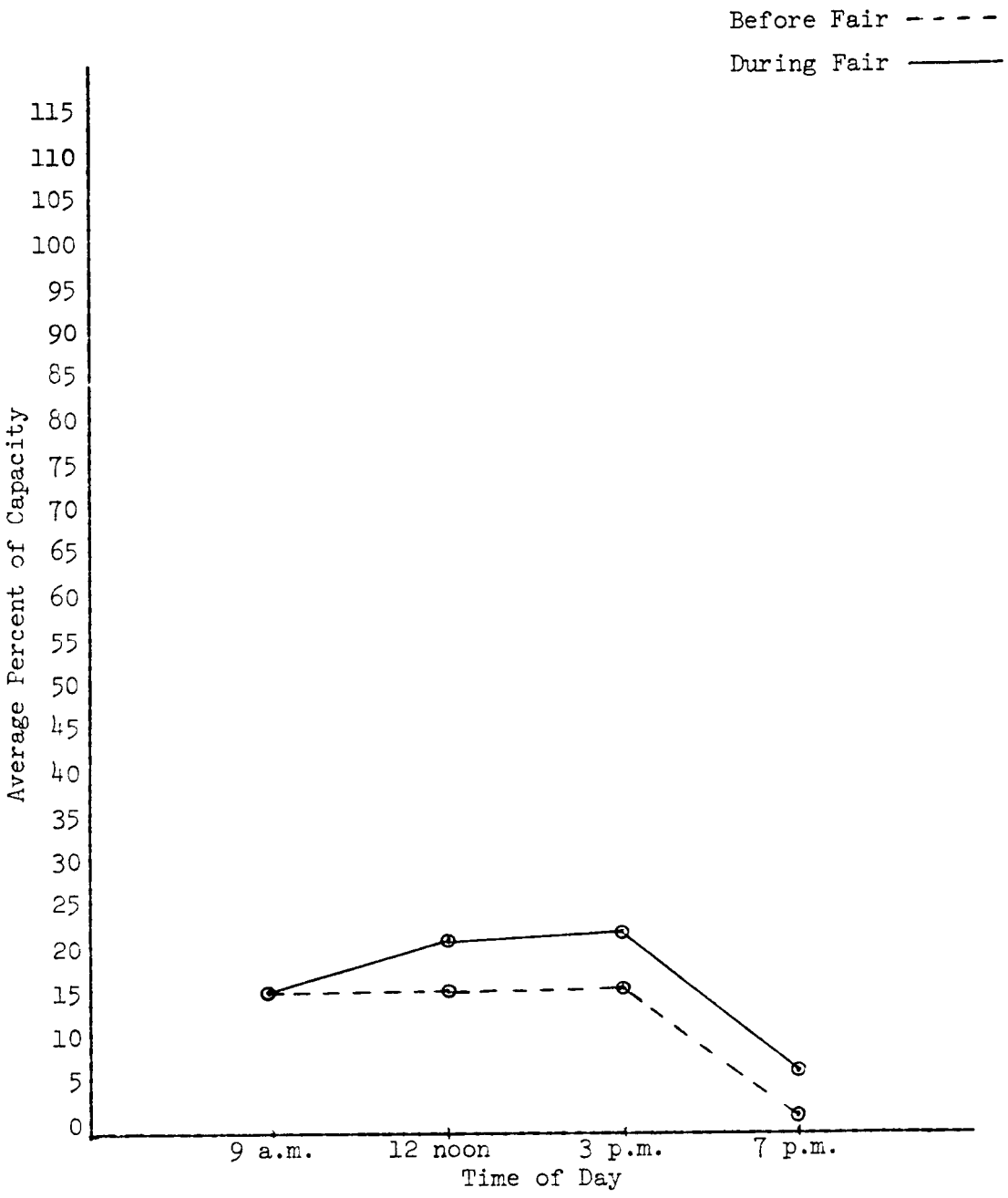


Figure A.13. Average Percent of Capacity Versus Time of Day for Facility 100

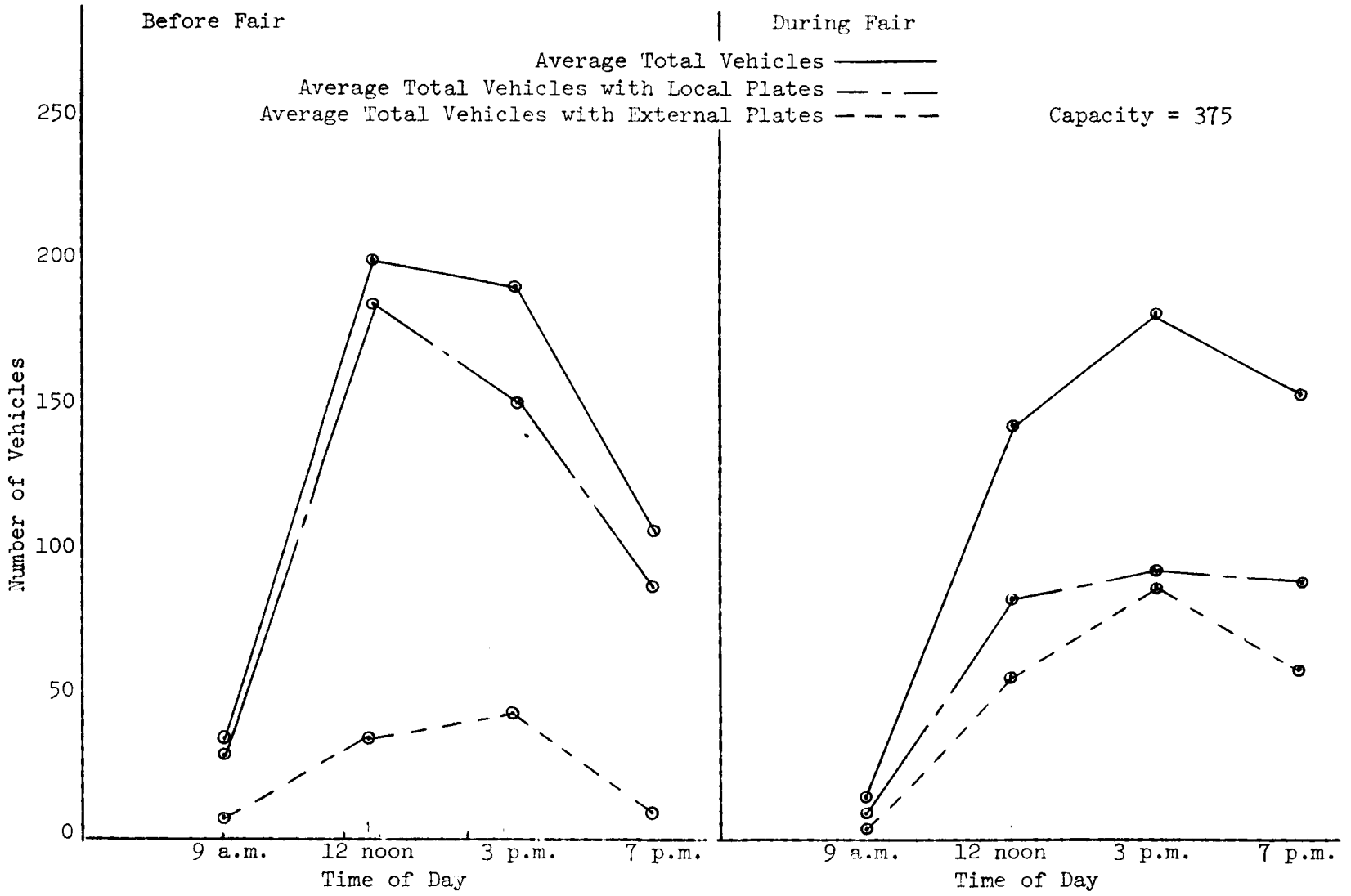


Figure A.14. Before/During Vehicle Characteristics Data for Facility 4136

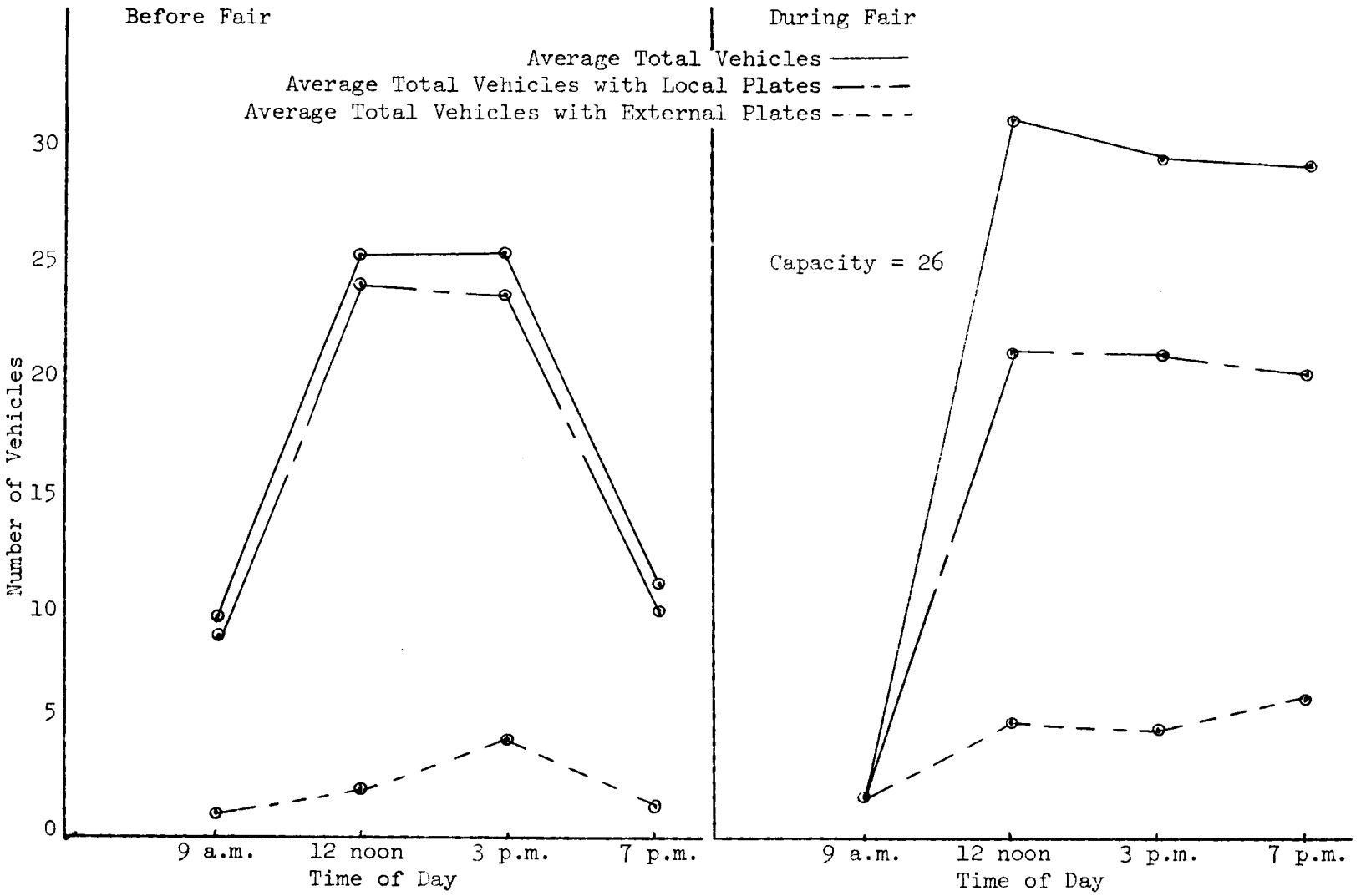


Figure A.15. Before/During Vehicle Characteristics Data for Facility 4155

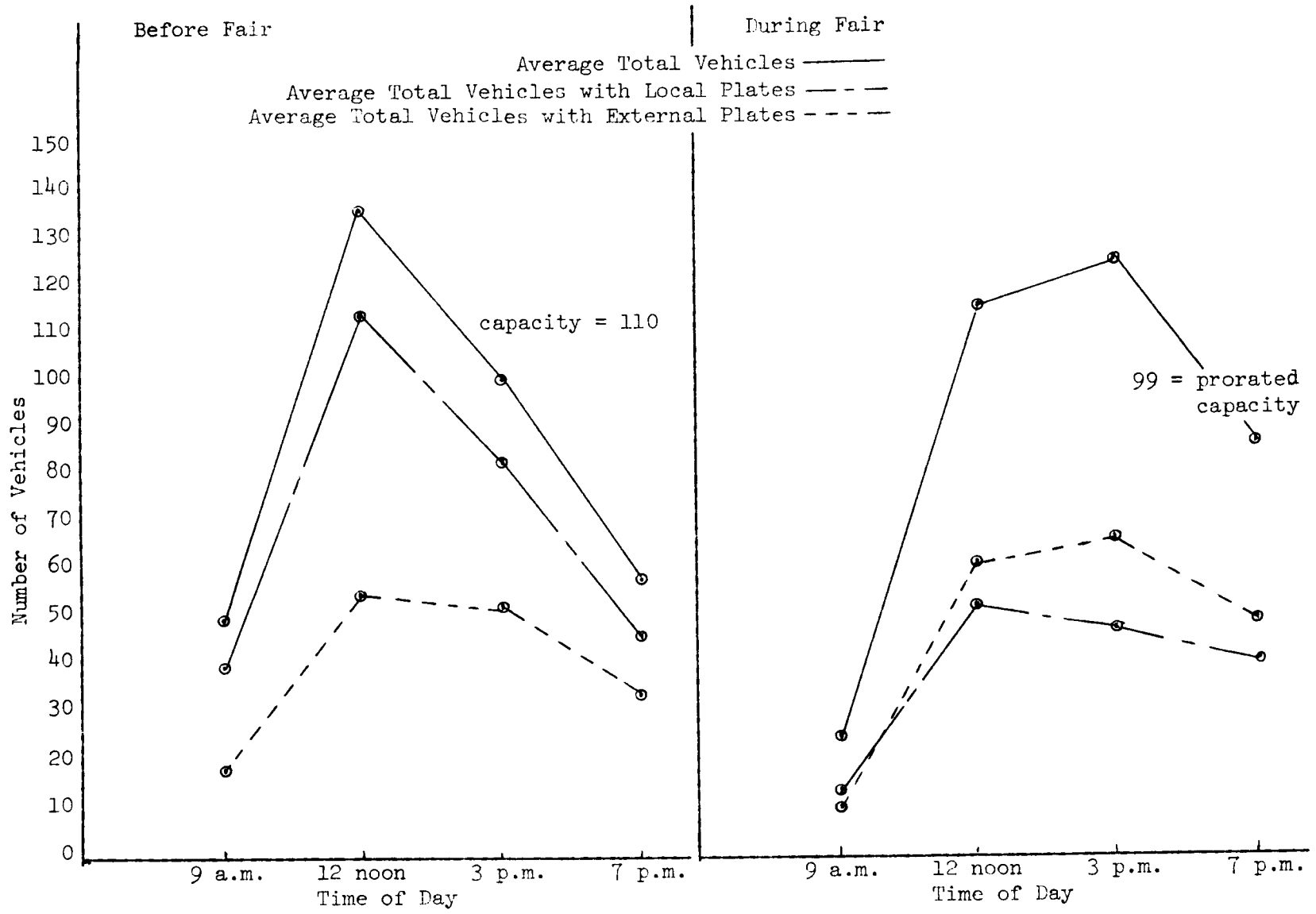


Figure A.16. Before/During Vehicle Characteristics Data for Facility 4165

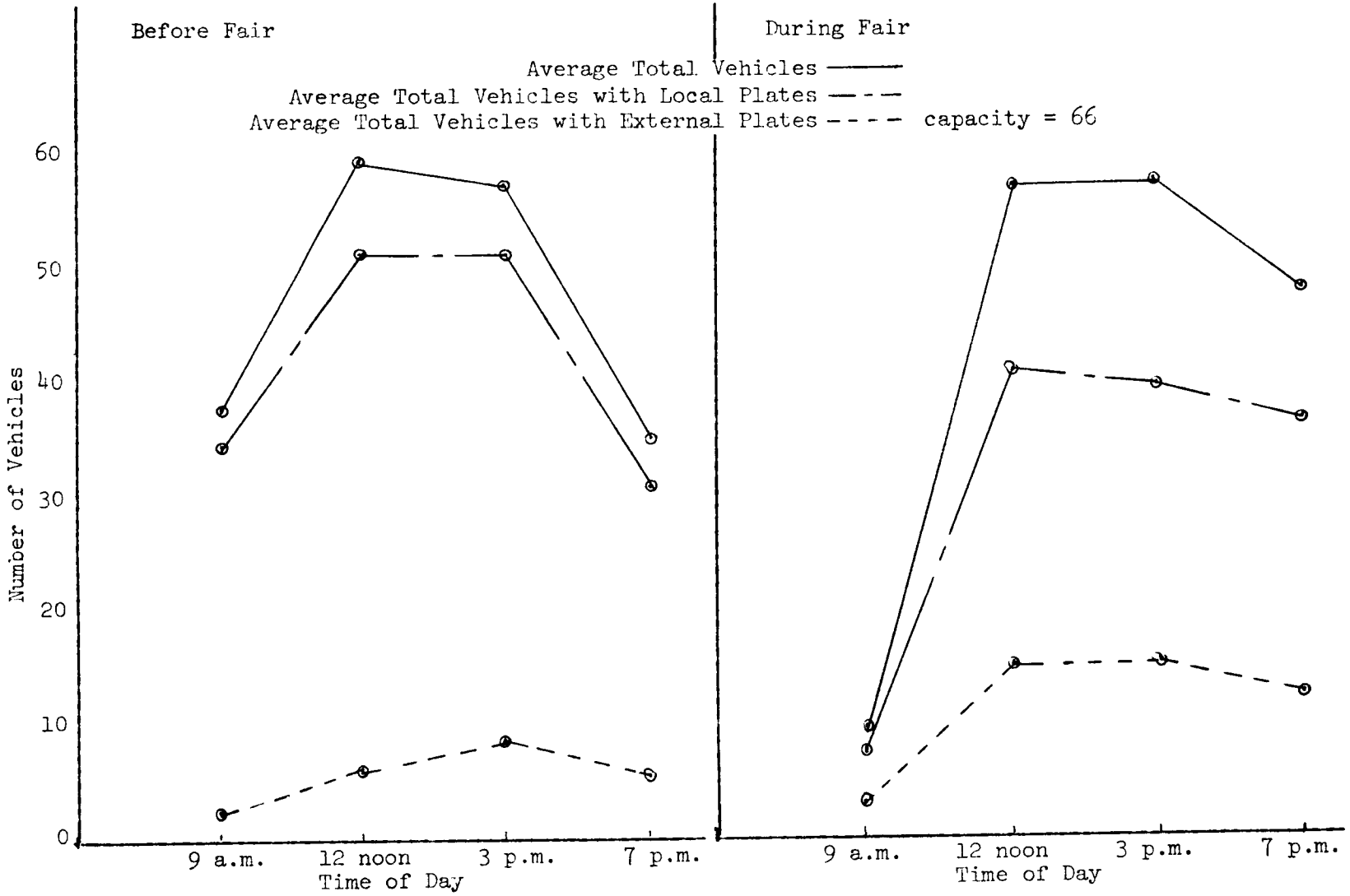


Figure A.17. Before/During Vehicle Characteristics Data for Facility 4168

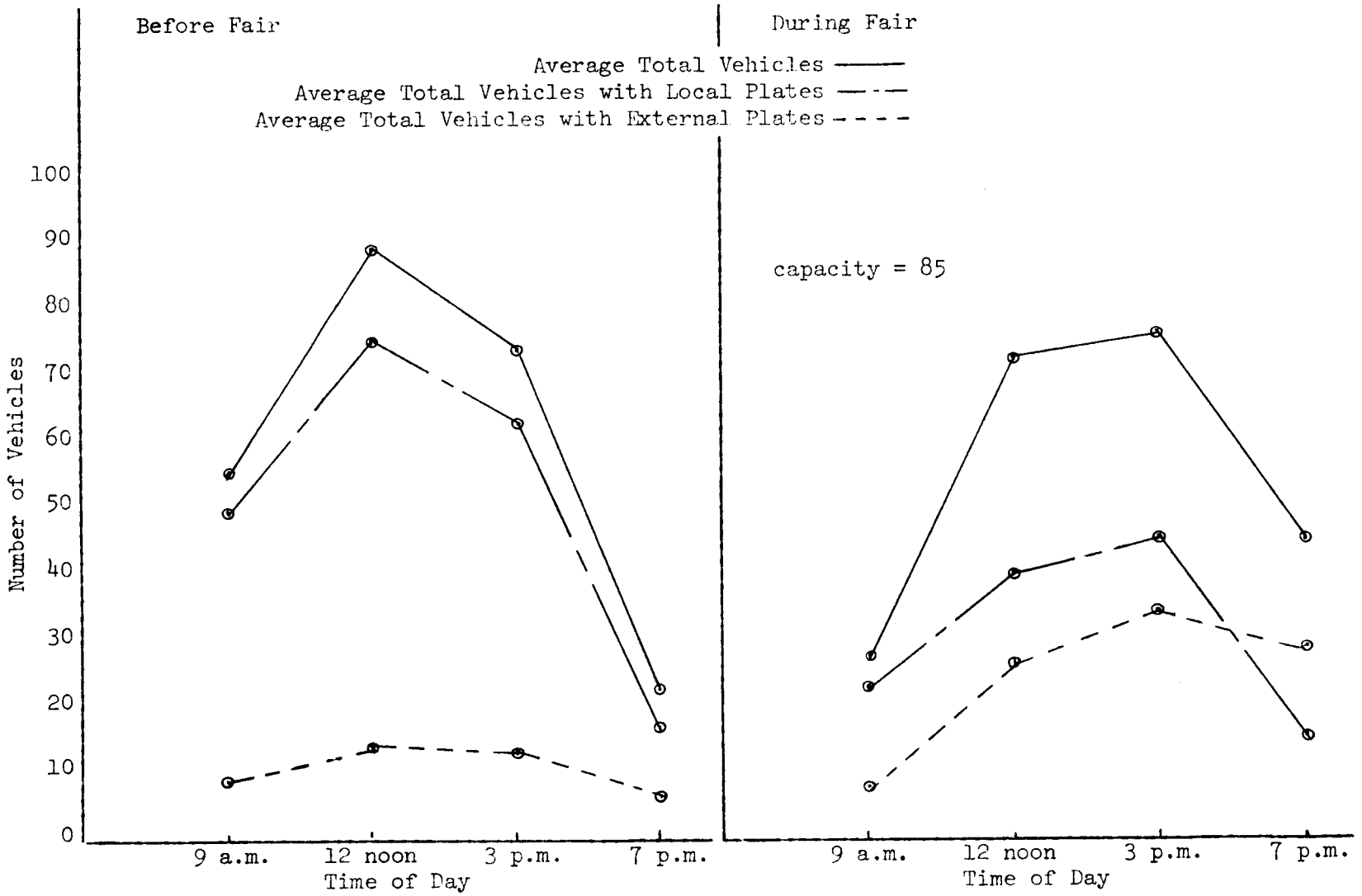


Figure A.18. Before/During Vehicle Characteristics Data for Facility 4196

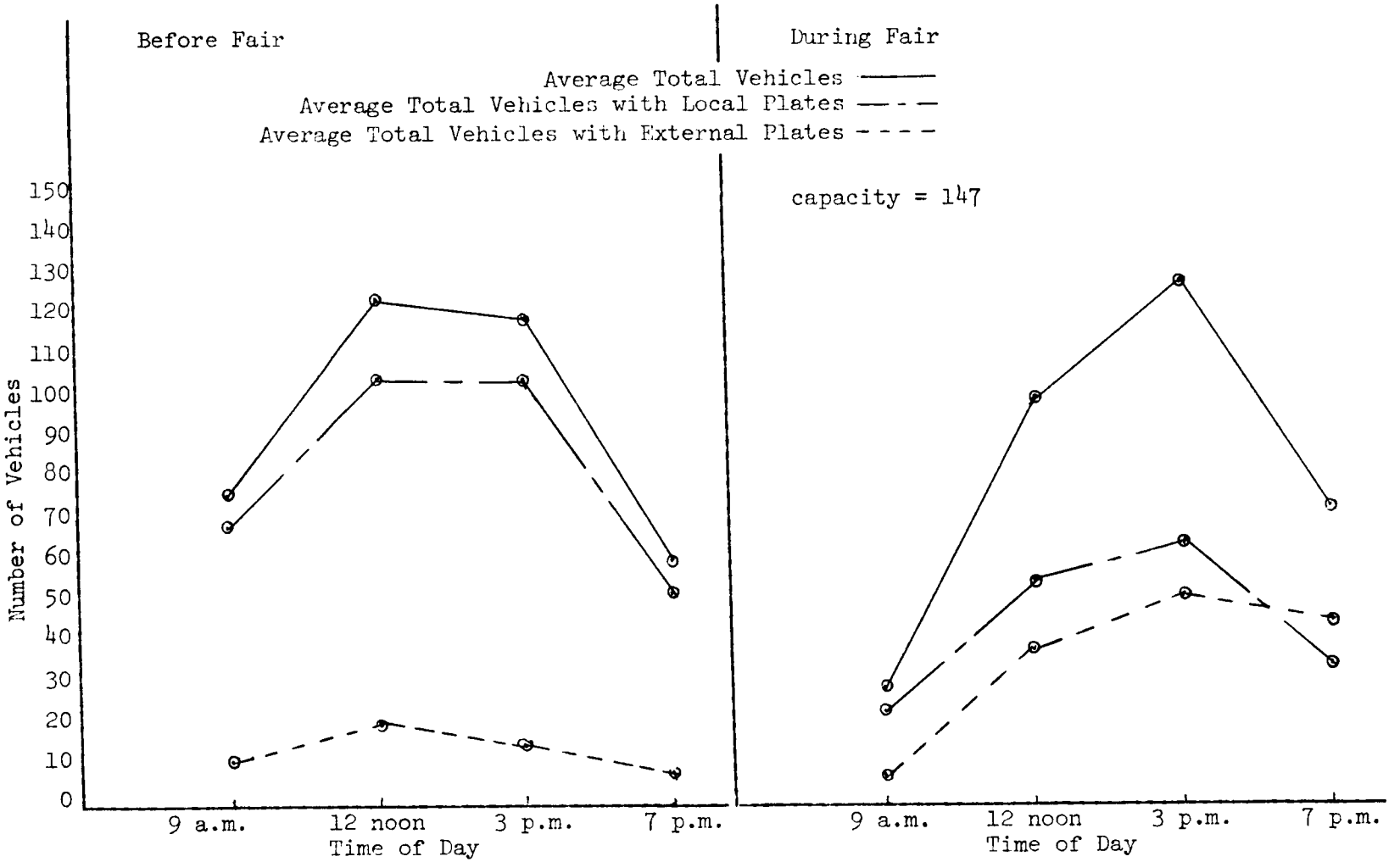


Figure A.19. Before/During Vehicle Characteristics Data for Facility 4215

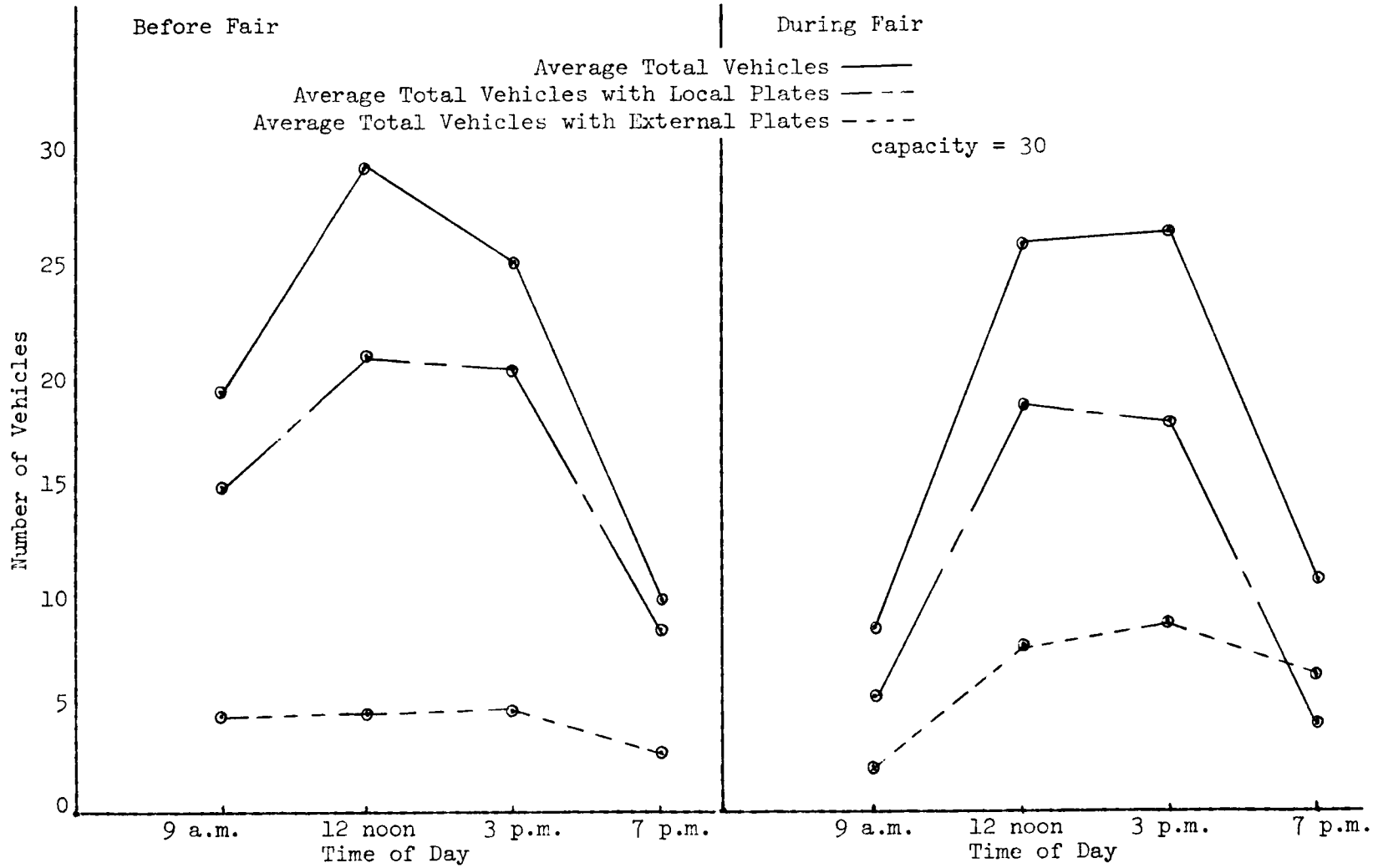


Figure A.20. Before/During Vehicle Characteristics Data for Facility 4207

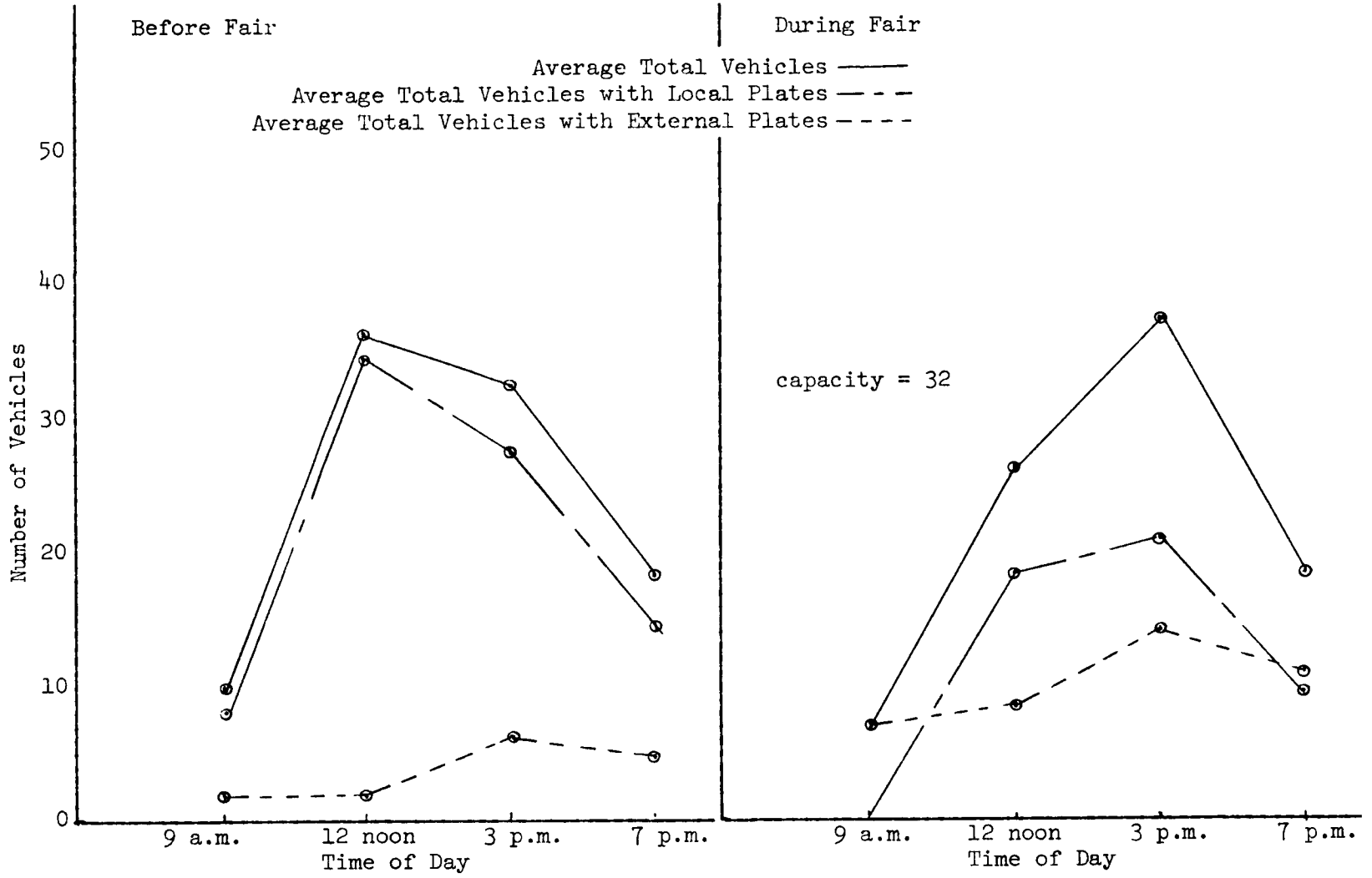


Figure A.21. Before/During Vehicle Characteristics Data for Facility 4205

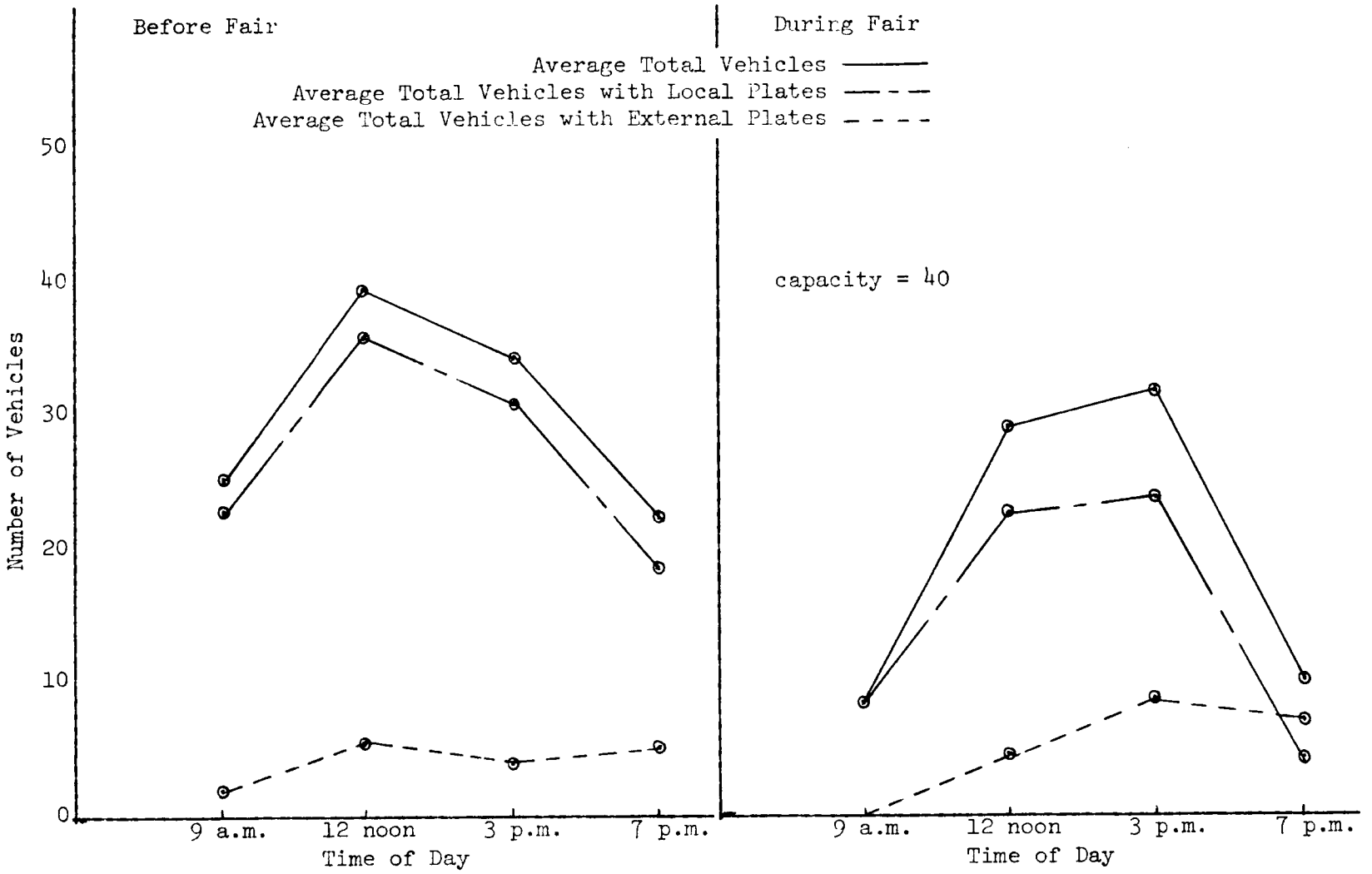


Figure A.22. Before/During Vehicle Characteristics Data for Facility 2125

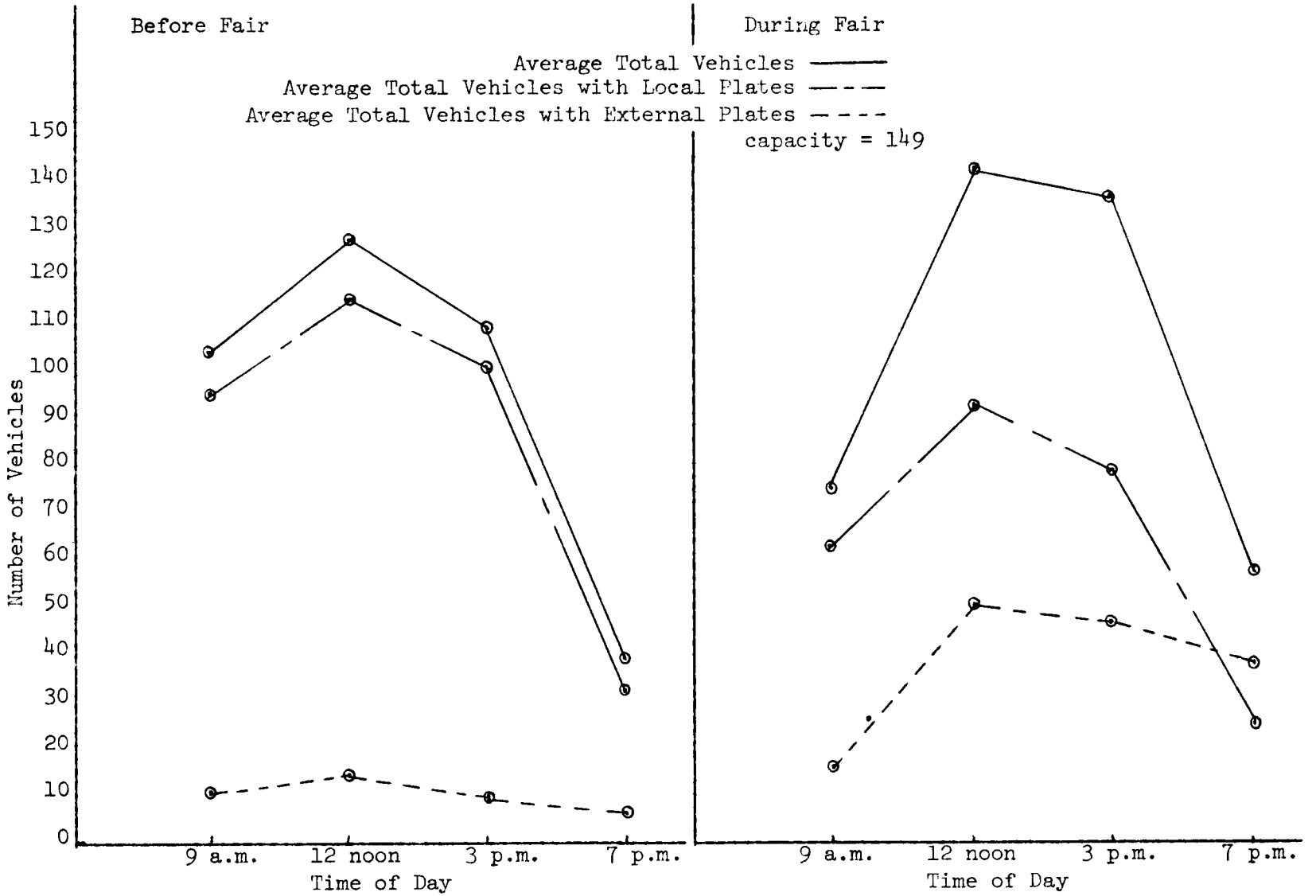


Figure A.23. Before/During Vehicle Characteristics Data for Facility 2136

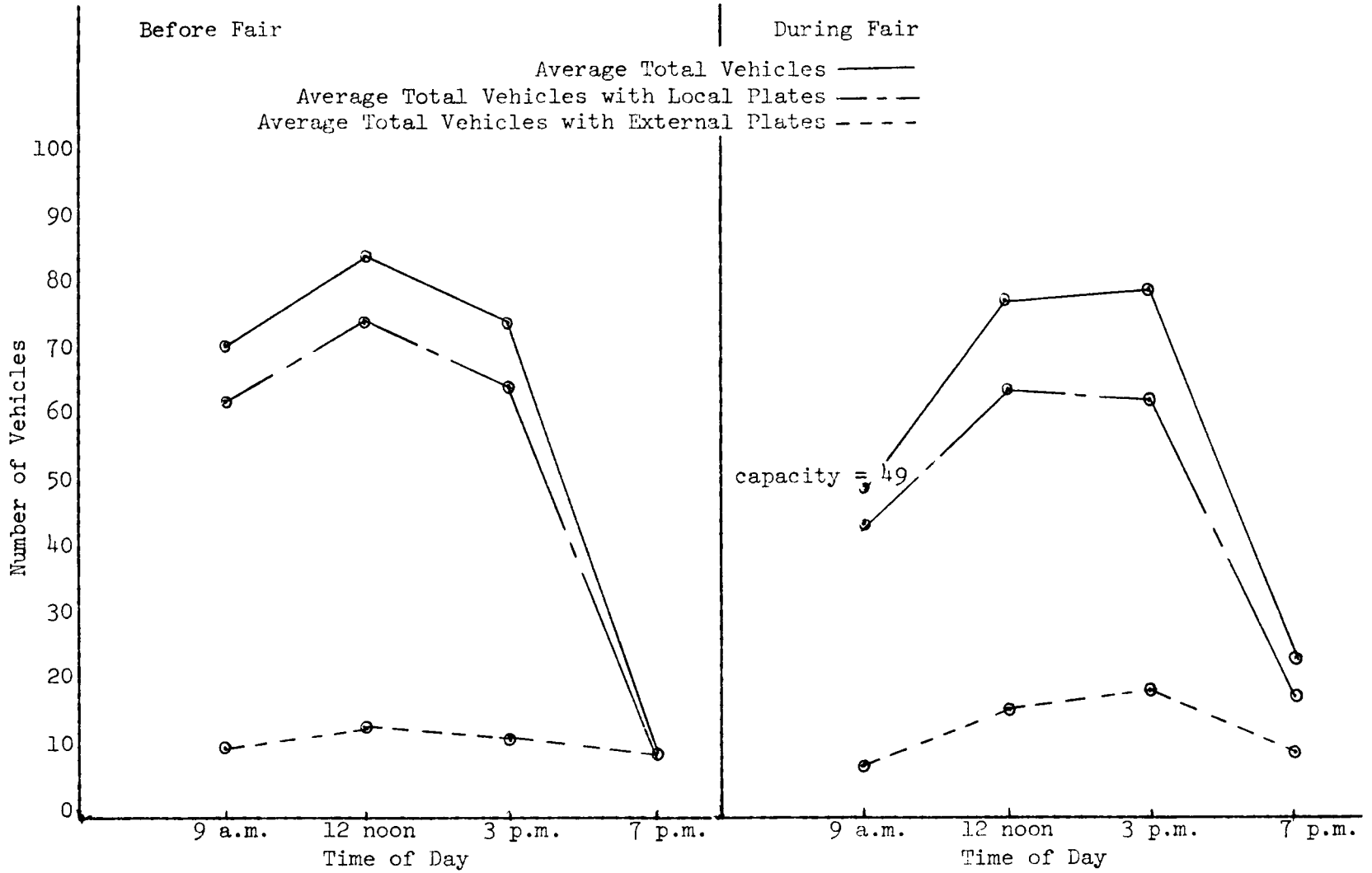


Figure A.24. Before/During Vehicle Characteristics Data for Facility 2106

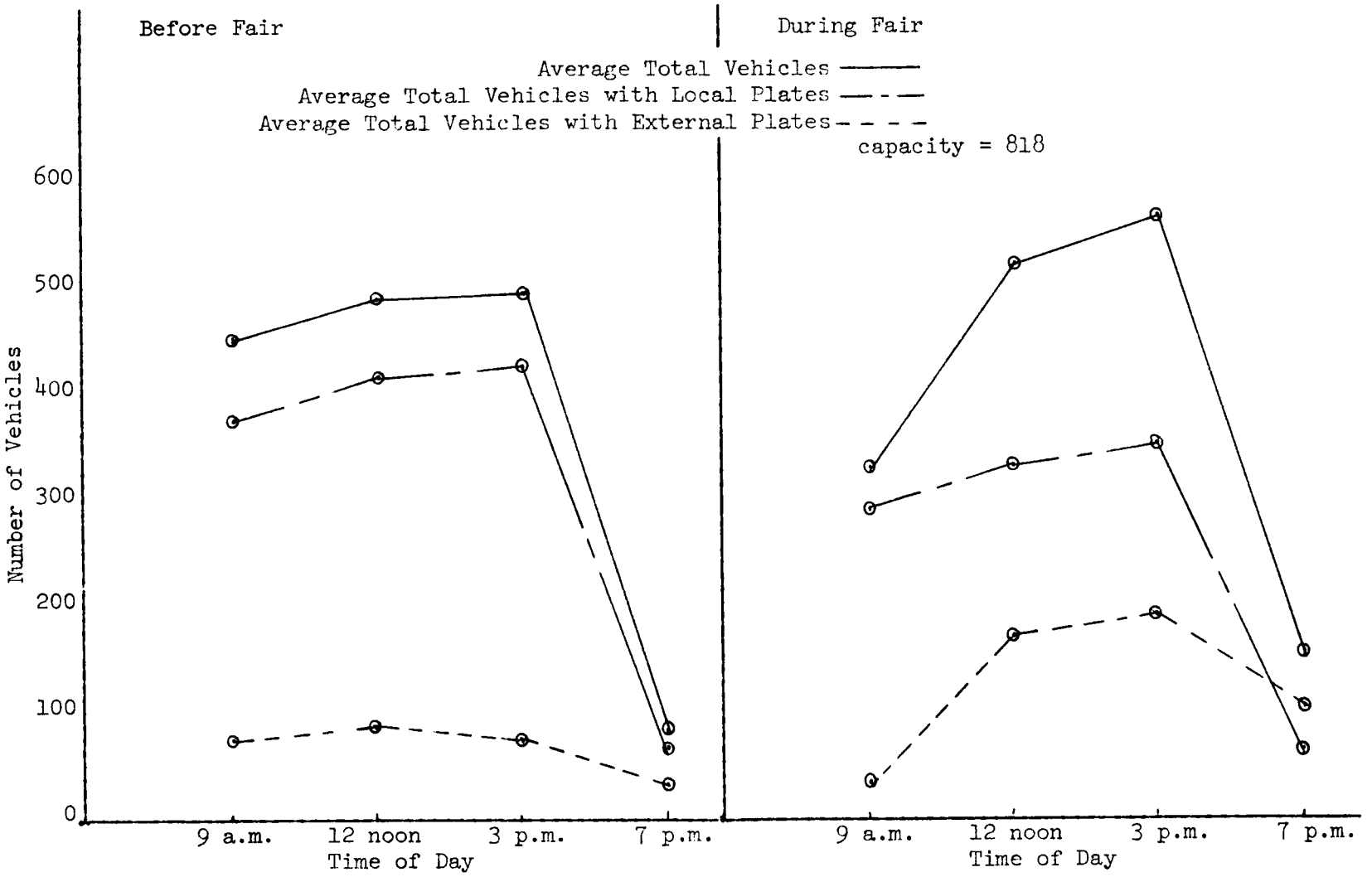


Figure A.25. Before/During Vehicle Characteristics Data for Facility 2095

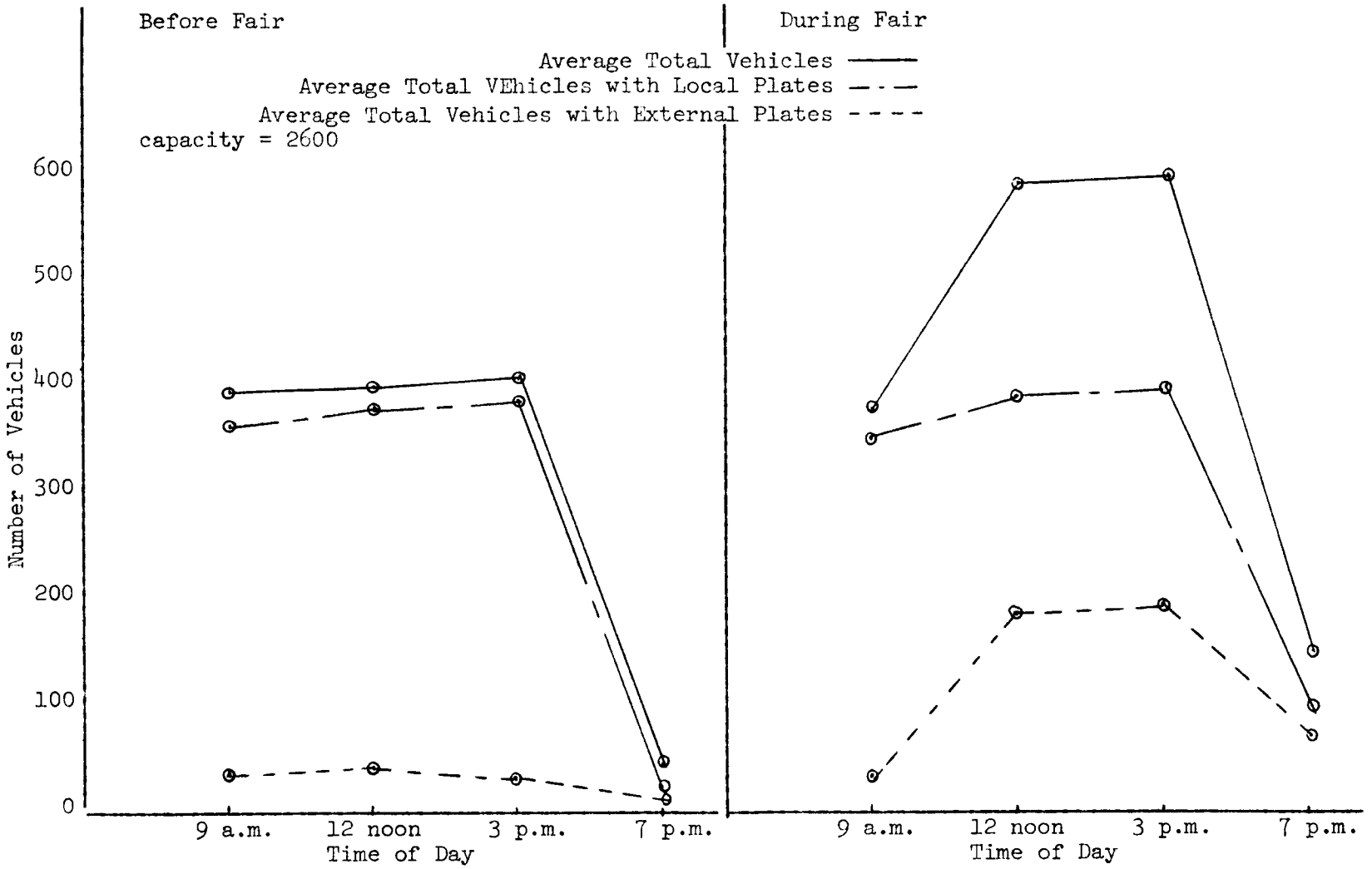


Figure A.26. Before/During Vehicle Characteristics Data for Facility 100

VITA

William Hollis Loveday was born in Knoxville, Tennessee, on September 18, 1958. He attended elementary and junior high schools in that city and was graduated from Central High School in June 1976. He then entered the University of Tennessee and received a Bachelor of Science degree in Civil Engineering in June 1981. He then accepted a research assistantship with the Civil Engineering Department and began study toward a Master of Science degree in Civil Engineering.

The author completed coursework requirements for the Master of Science degree in June 1982. Between June 1982 and August 1982, the author worked on a Tennessee Department of Transportation ridesharing project and continued to work on his thesis requirement.

In December 1982 he began working as a Traffic Engineer for the City of Memphis. During his employment he finalized his thesis requirement.

Mr. Loveday is a member of the American Society of Civil Engineers and the Institute of Transportation Engineers.

He is married to the former Elizabeth L. Beam of Knoxville, Tennessee.