

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. FHWA/TX-94/1099-2		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle AN EVALUATION OF THE PILOT WORKPLACE SURVEYS IN BEAUMONT-PORT ARTHUR, TEXAS				5. Report Date November 1993	
				6. Performing Organization Code	
7. Author(s) David F. Pearson				8. Performing Organization Report No. Research Report 1099-2	
9. Performing Organization Name and Address Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135				10. Work Unit No.	
				11. Contract or Grant No. Study No. 0-1099	
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Transfer Office P.O. Box 5080 Austin, Texas 78763-5080				13. Type of Report and Period Covered Interim: September 1993 - August 1994	
				14. Sponsoring Agency Code	
15. Supplementary Notes Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration. Research Study Title: Urban Travel in Texas: An Evaluation of Travel Surveys.					
16. Abstract A pilot survey of workplaces was conducted as part of the comprehensive travel survey in the Beaumont-Port Arthur, Texas, area. The methodology used in the pilot survey was significantly different than that used in the 1990-91 workplace surveys in Texas. The methodology used in the 1990-91 surveys was flawed in its theoretical basis. This paper analyzes the pilot surveys to determine the impact of the new methodology recommended for workplace surveys. The findings of this analysis indicate that the new methodology produces lower attraction rates for non-freestanding workplaces as compared to freestanding workplaces. Based on these findings, the new methodology produces more representative results; and a recommendation is made for the Texas Department of Transportation to continue conducting workplace surveys using the methodology described in the technical note, Workplace Survey Design.					
17. Key Words Workplace Surveys; Beaumont-Port Arthur, Texas; Attraction Rates			18. Distribution Statement No Restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161.		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 34	
				22. Price	

**AN EVALUATION OF THE PILOT WORKPLACE SURVEYS
IN BEAUMONT-PORT ARTHUR, TEXAS**

by

David F. Pearson
Associate Research Engineer

Research Report 1099-2
Research Study Number 0-1099
Study Title: Urban Travel in Texas: An Evaluation of Travel Surveys

Sponsored by the
Texas Department of Transportation
in cooperation with the
U.S. Department of Transportation
Federal Highway Administration

November 1993

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

IMPLEMENTATION STATEMENT

The findings of this report indicate that the new methodology recommended for workplace surveys produces lower attraction rates for non-freestanding workplaces. Based on these findings, a recommendation is made for the Texas Department of Transportation to continue conducting workplace surveys using the methodology described in the technical note, **Workplace Survey Design**.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation. Additionally, this report is not intended for construction, bidding, or permit purposes. David F. Pearson, P.E., (Registration Number 45457) was the Principal Investigator for the project.

TABLE OF CONTENTS

Introduction	1
Overview	1
Theory	3
Methodology	5
Survey Data Expansion	6
Freestanding Workplaces	7
Non-Freestanding Workplaces	9
Attraction Rate Development	10
Analysis Procedure	11
Analysis Results	12
Findings and Recommendations	19
References	23

LIST OF TABLES

1	Employment Type Definitions	4
2	Area Type Designations	5
3	Number of Workplaces Surveyed	13
4	Number of Surveyed Freestanding and Non-Freestanding Workplaces by Employment Type	13
5	Average Attraction Rates	16
6	Test Statistic Values for Freestanding versus Non-Freestanding Workplaces	17
7	Comparison of Attraction Rates between Urban Areas	18

AN EVALUATION OF THE PILOT WORKPLACE SURVEYS IN BEAUMONT-PORT ARTHUR, TEXAS

INTRODUCTION

In the spring of 1993 the Texas Department of Transportation (TxDOT), as part of a comprehensive travel survey in the Beaumont-Port Arthur, Texas, urbanized area, funded a pilot workplace survey. The purpose of the pilot survey was to determine the effectiveness of recommended changes to the methodology used in workplace surveys conducted in 1990-91 in other urbanized areas in Texas. This paper presents the results of the analysis conducted on the data obtained in the pilot survey. The first section presents an overview of background information on workplace surveys and previous research in this area. The second section discusses the theoretical foundation of workplace surveys and is followed by a section on the methodology employed. The fourth section presents some of the problems associated with workplace surveys. The fifth and sixth sections discuss the analysis procedure and the results of the analysis. The final section presents a summary of the findings and recommendations.

OVERVIEW

Workplace surveys are a relatively new aspect of travel surveys in terms of their purpose. Surveys have been conducted at the work end of travel for a number of years but have typically only determined the travel patterns of employees. In the late 1960's, Shunk (1) proposed that employee work trip patterns be used as the basis for estimating other travel patterns. It has been only recently that this type of survey was expanded to obtain more information for the specific purpose of improving the estimation of attractions in the trip generation phase of travel demand modeling.

The models used in estimating trip attractions have historically been developed through the use of data from origin-destination (O-D) surveys, many of which were conducted in the 1960's and 1970's. These were home interview surveys, and data represented travel patterns of sample households. Due to cost limitations, most household surveys conducted since the early 1970's have been small sample surveys.

Disaggregate trip production models, developed using household travel information collected in the O-D surveys or small sample household surveys, have been considered to be more accurate and reliable than trip attraction models. Attraction models typically have been developed using expanded data from the household surveys; the data were aggregated for large sub-areas in order to achieve sufficient numbers of observations for analysis. With the exception of special generator studies, until the mid-1980's, studies involving travel at the attraction trip end were done based on household-oriented surveys, such as the U.S. Census Journey to Work data, or involved the development of trip rates for specific land use categories such as those contained in the Institute of Transportation Engineers' (ITE) **Trip Generation Manual** (2).

Attraction estimates, generally based on land use or employment characteristics, have been considered relative values in the trip distribution process; final results are scaled to equal the estimated trip productions. The productions and attractions are basic inputs to the trip distribution process which estimates the number of trips being interchanged between zone pairs within a study area.

In 1984 the North Central Texas Council of Governments (NCTCOG) funded a comprehensive workplace survey in conjunction with a household survey (3). The intent of the workplace survey was to obtain information for developing models to estimate trip attractions in the Dallas-Fort Worth urban area. It was felt that more accurate estimates of attractions would yield better results and estimates of travel from the trip distribution process. The resulting estimates of attractions using the rates developed from the workplace survey in the Dallas-Fort Worth area were found to agree fairly well with the trip productions estimated using the trip rates developed from the household survey conducted at the same time.

In 1987 the Arizona Department of Transportation funded the collection of data for developing non-residential attraction rates in the Tucson, Arizona, urban area (4). The objectives of the Arizona study included collecting data on non-residential trip attraction rates, non-home based trips, and non-home based trip length.

In 1989 TxDOT funded a workplace survey in the Texarkana urban area as part of a comprehensive travel survey to obtain information for updating the travel demand models

being used in that area. This effort was followed by additional travel surveys in five Texas urban areas in 1990 and 1991. Those five surveys were patterned after the workplace survey done in the Dallas-Fort Worth area using consistent survey instruments and methodologies. Following those surveys, TxDOT funded a research project to analyze the survey data and determine the need for any changes and improvements to the survey instruments and methodologies. With respect to the analysis of the workplace surveys, it was recommended that the survey instruments be modified and the methodology be revised to address the survey of freestanding and non-freestanding workplaces (5).

A study conducted by the ITE Colorado/Wyoming Section Technical Committee on the trip generation characteristics of mixed use developments found that 46 percent of the surveyed individuals traveling to the mixed use sites had more than one purpose for coming to the site (implying they made more than one stop at the site) (6). It was, therefore, reasoned that since mixed use sites are non-freestanding workplaces, the treatment of such sites as freestanding would result in higher attraction rates, estimating more trip attractions than trip productions. The attraction rates developed from the urban areas surveyed in 1990-91, when applied to regional data, resulted in significant imbalances between the estimates of trip productions and trip attractions. Based on those findings, revisions to the workplace survey methodology were recommended to TxDOT. Using the revised methodology and survey instruments, a pilot survey of 26 establishments was undertaken in the Beaumont-Port Arthur urbanized area. This paper presents an analysis of the survey data collected in that pilot study and attempts to ascertain the effectiveness of the changes in the workplace survey methodology.

THEORY

The main objective of a workplace survey is to estimate the number of person trips and vehicle trips made to a workplace. These trips are made by employees that work at the workplace and by visitors to the workplace. Trips are generally grouped into three trip purposes, home based work (HBW), home based non-work (HBNW), and non-home based (NHB). Home based trips are those that begin or end at the home of the trip maker,

whereas non-home based trips are those that begin and end at locations other than the home of the trip maker.

Workplaces are stratified by employment type and area type. In Texas, three employment types and five area types are used. The employment types are basic, retail, and service. Table 1 presents the standard industrial classification groupings which fall into each category. The five area types used in Texas are based on a combination of employment and population density and are shown in Table 2.

Table 1
Employment Type Definitions

Employment Type	SIC Range	Industry Group
Basic	1000-1499	Mining
	1500-1799	Construction
	2000-3999	Manufacturing
	4000-4999	Transportation, Communications, Public Utilities
	5000-5199	Wholesale Trade
Retail	5200-5999	Retail Trade
Service	6000-6799	Finance, Insurance, Real Estate
	7000-8199	Services
	8200-8299	Education Services
	8300-8999	Services
	9000-9799	Government

First, the number of person and vehicle trips by trip purpose to a workplace are estimated. These values are divided by the total employment at the workplace to obtain the attraction rate. The attractions and total employment for surveyed workplaces are summed by employment type and area type and are used to develop attraction rates within those stratification categories. While straightforward in theory, the detailed steps involved in both

the survey and the expansion of the data become quite complex as discussed in the following section.

Table 2
Area Type Designations

Activity Density = (Population + 1.67 × Employment) / Acre ¹	
AREA TYPE	ACTIVITY DENSITY
Central Business District	> 125 / Acre
Outer Business District	30 - 125 / Acre
Urban Residential	7.5 - 30 / Acre
Suburban Residential	1.8 - 7.5 / Acre
Rural	< 1.8 / Acre

¹ This relationship may have minor variations between urban areas.

METHODOLOGY

The methodology for actually doing a workplace survey is described in considerable detail in a technical note titled **Workplace Survey Design (5)** submitted to TxDOT in August 1992. That report documents the determination of sample size and the specific details of accomplishing the survey. These are discussed only briefly herein.

Workplaces fall into two broad categories termed freestanding and non-freestanding. Freestanding workplaces are those whose points of access and parking are easily discernible and designed primarily for serving that workplace only. An example of this would be a manufacturing plant which has limited access and parking for its employees and customers only. A non-freestanding workplace is one where the points of access and parking serve more than just that workplace. An example would be a strip or community shopping center where the access and parking are designed to serve more than one establishment.

Two independent surveys are required for both types of workplaces. One is a survey of the employees which consists of each employee being requested to complete a travel diary documenting each trip the employee made on the day of the survey. Certain household characteristics are also obtained from the employee completing the survey. The

second survey required is a survey of the visitors (i.e., non-employees). At both freestanding and non-freestanding workplaces, visitors are randomly intercepted and interviewed. In each situation, the visitors are first asked if they work at that location. If they are visitors, they are asked about where they came from, where they are going when they leave the site, and their mode of travel, occupancy, and trip purpose. Visitors throughout the activity center are surveyed because all of the establishments within the center are felt to contribute to the attractiveness of the site. Persons traveling to the center may stop at one or more workplaces within the center. The attraction rate for workplaces within the center will normally be less than that for a freestanding workplace.

In addition to the two surveys, the data necessary to expand the survey data to estimate the total attractions consist of the 24-hour vehicle movement in and out of the workplace or activity center, the number of employees at work on the day of the survey, and the total employment. The employment data (i.e., employees at work and total employment) must be collected for all sites at a non-freestanding workplace. However, employment data for freestanding workplaces are necessary only for the site being surveyed. For locations where vehicle counts are not possible, the number of persons entering and exiting the location may be counted. Finally, the total trucks entering and exiting the site during the survey day must also be counted for developing truck attraction rates. The vehicle and/or person count data are extremely important because they establish the basis for the expansion of the survey data.

Survey Data Expansion

Expanding the survey data to estimate the person and vehicle trips attracted to the workplace is done differently for each of the workplace types. Vehicle occupancy is discussed first since the methodology for both involves using vehicle occupancy. In the random sampling procedure employed in these surveys, it was possible to double count vehicles. For example, a vehicle which arrives at an establishment with two occupants has a higher probability that one of those occupants will be surveyed than a vehicle with only one occupant. The mathematical formula used to obtain an estimate of average vehicle occupancy is:

$$AVG = \frac{\sum P_i}{\sum (\frac{1}{O_i})}$$

Where:

- AVG = average vehicle occupancy.
- P_i = i th person surveyed.
- O_i = reported vehicle occupancy for person P_i .

The same formula was used for both employee and visitor surveys to estimate the average vehicle occupancy for each survey.

The next step was to expand the survey data. Since the expansion is slightly different for freestanding versus non-freestanding workplaces, each is discussed separately in the following paragraphs.

Freestanding Workplaces

The first data expansion was done using the employee survey. One of the additional data elements obtained for the workplace being surveyed was the number of employees at work on the day of the survey. Dividing the number of employees at work by the number of employees actually surveyed yielded an expansion factor for the surveyed employee trips. It should be remembered that each employee was asked to complete a travel diary documenting all of their trips on the day of the survey. It was necessary to remove those trips for each employee that were non-site related and, therefore, not a part of the total trips being attracted to the establishment. The other item of note concerns trip purpose. If the employee came from or went to home, the trip was a home based attraction. If the employee came from a location other than home to the workplace, that trip was a non-home based attraction. If the employee traveled to another location other than home after leaving the workplace, that trip was a non-home based production and would not be included in the attraction rate developed for the workplace. Applying the expansion factor to the surveyed

trips for each trip purpose yielded an estimate of the total person trips for each trip purpose to the workplace made by employees.

The next step was dependent on the data being used to estimate the total trips to and from the workplace. If 24-hour vehicle counts were obtained at the workplace, the next step was to estimate the number of vehicles that were used by the employees. This was done by dividing the total person trips made by employees by the average vehicle occupancy for the surveyed employee trips. Subtracting this total from the 24-hour vehicle count yielded an estimate of the number of vehicles traveling to the site by non-employees (i.e., visitors). If total person counts were taken at the site and used for the control, the number of non-employee trips to and from the site was estimated by subtracting the total employee person trips from the total person count at the site.

The visitor survey was an intercept survey which, after determining that the person did not work at that location, asked visitors surveyed where they were coming from, the purpose of the trip, their mode of travel, the number of occupants in the vehicle (if the mode was private vehicle), and if they would be traveling directly home or not when they left the establishment. If they had traveled from home, the trip was a home based non-work attraction. If they had traveled from a location other than home, the trip was a non-home based attraction. If they were going directly home when they left, the trip was a home based non-work attraction; and if they were going somewhere besides home, the trip was a non-home based production which would not be included in the total attractions to the establishment.

The number of non-employee person trips to the site was estimated by multiplying the number of non-employee vehicles by the average vehicle occupancy computed from the reported occupancies in the non-employee (i.e., visitor) surveys. If person counts were used for the expansion, the non-employee person trips were computed directly by subtracting the employee person trips from the total counted person trips. Non-employee vehicle trips were then estimated by dividing the non-employee person trips by the average vehicle occupancy. Total trips for each trip purpose were estimated by applying the percentages observed in the sample to the total expanded person and vehicle trips. The same procedure was used for the employee trips.

Non-Freestanding Workplaces

As with freestanding workplaces, the expansion of the survey data began with the employee survey. In most cases, only one workplace in an activity center would be surveyed. The first step was to compute the average person and vehicle trips (by purpose) per employee for the employees surveyed. These were trips to and from the activity center only. These average trip rates were applied to the total number of employees at work in the entire activity center. The resulting estimates are for all employees at work in the activity center and not just the employee trips to the surveyed workplace. It was also necessary to keep estimates of trips by employment type within the activity center since, in most cases, different employment type establishments will exist in the same activity center. Since observed employee attraction rates from other surveys were very consistent, the assumption was made that the trip rate for the surveyed employees would provide a reasonable estimate for the employees at the other establishments in the activity center. The next step was to estimate the number of vehicle trips by dividing the total person trips by the average vehicle occupancy. The number of person and vehicle trips for each trip purpose was estimated by applying the percentage of trips observed in the survey to the total number of trips for the employees.

Estimates of the number of non-employee vehicles to and from the center were obtained by subtracting the number of employee vehicle trips from the 24-hour traffic count to the center. If person counts were taken, this estimate was obtained by subtracting the employee person trips from the counted person trips and dividing by the average vehicle occupancy computed from the non-employee (i.e., visitor) survey. Conversely, if vehicle counts were being used, the total non-employee person trips to the site were estimated by multiplying the non-employee vehicle trips by the average vehicle occupancy. The number of trips by trip purpose were estimated by applying the observed percentage of trips for each trip purpose from the non-employee survey to the estimates of total person and vehicle trips made by non-employees to the center.

The next step was to estimate the number of trips to the different employment types in the center. For example, an activity center might have two retail establishments, one basic establishment, and four service establishments. The estimates to this point were the

number of person and vehicle trips by trip purpose to the activity center. The question remaining was how to estimate the number to each of the different employment types within the center. This was done by making the assumption that the relative attractiveness between different employment type establishments would be the same for non-freestanding sites as it was for freestanding sites. Using the total attraction rates computed for each type of employment from the freestanding workplace surveys, the rates were applied to the appropriate employment (i.e., the number at work on the day of the survey in each workplace in the activity center) to develop relative estimates of attractions for each workplace by trip purpose. These were summed and the percentage of trips to each type of employment in the center was computed for each trip purpose. These percentages were then applied to the estimates of total trips by trip purpose to the activity center to estimate the number of trips to each employment type within the center. Attraction rates were computed by dividing the attractions by trip purpose for each employment type by the total employment of that type in the center.

In all cases, it should be noted that the estimation of attraction rates was done using the total employment for each workplace and not the number of employees at work on the day of the survey. This builds the consideration of absenteeism into the attraction rate. Since the data normally available in travel demand modeling were estimates of total employment and not employees at work on an average day, the attraction rates must be computed in the same manner as they will ultimately be applied.

Attraction Rate Development

Developing attraction rates for use in travel demand models is fairly straightforward. One product of the first step in the overall workplace survey design (5) is the development of estimates of the number of freestanding and non-freestanding workplace employees by type of employment and area type within the study area. Summing the total expanded attractions (from the survey) and total employment for freestanding and non-freestanding workplaces by employment type and area type allows the development of stratified attraction rates for each category of workplace within each employment type and area type. Applying these rates to the estimates of total freestanding and non-freestanding employees within

each stratification allows the computation of the total attractions which, when divided by the total employment, yields overall weighted average attraction rates per employee for each employment type and area type. These rates would then be used in travel demand models.

ANALYSIS PROCEDURE

In order to analyze the data from the Beaumont-Port Arthur urbanized area pilot workplace survey and determine the impact of the revised procedures, the following steps were performed:

1. Identify the workplaces surveyed in 1990-91 that were freestanding and non-freestanding. The number of freestanding and non-freestanding workplaces from the previous workplace surveys is limited because the survey design at that time did not distinguish between the two. The consultants that did the surveys in the urban areas of Amarillo and Brownsville did identify workplaces as freestanding and non-freestanding in their site evaluations.
2. Compile the survey data and compute the attraction rates for those workplaces identified in Step 1 as being freestanding and non-freestanding.
3. Compile the survey data from the pilot survey done in Beaumont-Port Arthur and compute the attraction rates for both freestanding and non-freestanding workplaces.
4. Conduct a comparative analysis of the attraction rates between freestanding and non-freestanding workplaces in the 1990-91 surveys.
5. Perform a comparative analysis of the attraction rates between freestanding and non-freestanding workplaces in the pilot survey.
6. Complete a comparative analysis of the attraction rates for non-freestanding workplaces in the 1990-91 surveys and those found in the 1993 pilot survey.
7. Determine if a significant difference can be found between the non-freestanding workplace attraction rates in the pilot survey and those from the 1990-91 surveys based on the comparative analyses.

ANALYSIS RESULTS

Workplace surveys were done in five urban areas in 1990 and 1991. Only two of those surveys documented the workplaces that were freestanding and non-freestanding. Therefore, a comparative analysis could be done using data only from Amarillo and Brownsville. In Amarillo, 174 workplaces were surveyed and 90 workplaces were identified as non-freestanding. In Brownsville, 78 workplaces were surveyed and 29 were non-freestanding. The pilot survey in Beaumont-Port Arthur involved 26 workplaces of which 8 were non-freestanding.

One of the first observations was that the number of workplaces that could be compared if they were stratified by employment type and area type was limited. Table 3 presents the number of workplaces surveyed in the three urban areas. As shown, there are several cells with no sites that were surveyed. In addition, the Amarillo and Brownsville totals do not match the numbers given in the preceding paragraph. In Amarillo, employee surveys were not obtained at two of the sites and these were not included in the analysis. In Beaumont, with the revised survey methodology and data expansion techniques, estimates of the attractions and subsequent rates were developed for those sites not surveyed in the activity centers where workplaces were surveyed. These sites were aggregated by employment type and included in the analysis. These are perhaps the best indicators as to any real difference in the attraction rates for non-freestanding workplaces. The second observation (not shown in Table 3) is the number of freestanding and non-freestanding workplaces surveyed within each stratification cell. This would represent another level of stratification and result in substantially more cells with very few or no observations. Since the objective of this analysis was to determine if a difference was apparent in the attraction rates between the workplaces surveyed using the original methodology and the revised methodology, using aggregate rates for each type of employment for the comparative analysis was deemed sufficient. Rates for three types of employment (i.e., basic, retail, and service) were compared. These comparisons were between freestanding and non-freestanding workplaces within each urban area. Comparisons were also done for freestanding and non-freestanding workplaces between the urban areas. Table 4 presents

the number of freestanding and non-freestanding workplaces surveyed by employment type for each urban area.

Table 3
Number of Workplaces Surveyed

Employment Type	Urban Area	Area Type					Totals
		1	2	3	4	5	
Basic	Amarillo	5	7	6	13	3	34
	Brownsville	0	0	3	13	4	20
	Beaumont	0	2	2	1	5	10
Retail	Amarillo	4	24	19	20	3	70
	Brownsville	0	5	6	13	4	28
	Beaumont	1	4	3	1	1	10
Service	Amarillo	9	19	14	22	4	68
	Brownsville	1	2	3	21	3	30
	Beaumont	2	5	3	2	0	12
Totals	Amarillo	18	50	39	55	10	172
	Brownsville	1	7	12	47	11	78
	Beaumont	3	11	8	4	6	32

Table 4
Number of Surveyed Freestanding and Non-Freestanding Workplaces by Employment Type

Employment Type	Amarillo		Brownsville		Beaumont-Port Arthur	
	Free	Non-Free	Free	Non-Free	Free	Non-Free
Basic	17	17	16	4	8	2
Retail	30	40	17	11	4	6
Service	36	32	16	14	6	6
Totals	83	89	49	29	18	14

The attraction rates were computed for each workplace surveyed using the methodology previously discussed. Rates were computed for each employment type by trip

purpose for both freestanding and non-freestanding workplaces. Average attraction rates per employee were computed weighted on the employment at each workplace surveyed. The attraction trip rates by trip purpose, employment type, and workplace category (i.e., freestanding and non-freestanding) are presented in Table 5. The rates shown in Table 5 are fairly consistent, except for the retail rates for Brownsville and the non-freestanding basic rates for Beaumont-Port Arthur. The retail rates for Brownsville may reflect the influence of external trips from across the border. The basic rates for Beaumont are low simply because only two non-freestanding sites were surveyed, and this was not considered sufficient for reliability.

The means were compared using a test statistic, t , to test the hypothesis that the difference between two means was zero (7). If the value of the test statistic falls outside the range -1.96 to +1.96, the difference between the two means is considered significantly different from zero.

Table 6 presents the computed test statistic values for comparing freestanding versus non-freestanding workplaces by trip purpose in each urban area. In the Amarillo study, none of the observed mean attraction rates were found to be significantly different between freestanding and non-freestanding workplaces. The same observation was noted for Brownsville with the exception of HBW auto driver attractions per employee for retail establishments. The more notable differences were for the Beaumont-Port Arthur area where all of the attraction rates for basic establishments were significantly different. It must be noted, however, that only two non-freestanding basic workplaces were surveyed; and these results may be misleading. None of the freestanding retail attraction rates were significantly different from the non-freestanding rates. Only two of the freestanding service attraction rates were significantly different from the non-freestanding service rates. Those were the NHB attraction rates. The test statistic was computed as follows (7):

$$t = \frac{(x_1 - x_2) - \delta}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where:

t	=	normally distributed test statistic.
x_1	=	mean attraction rate for freestanding workplaces.
x_2	=	mean attraction rate for non-freestanding workplaces.
δ	=	difference being tested (i.e., 0).
s^2_1	=	freestanding attraction rate variance.
s^2_2	=	non-freestanding attraction rate variance.
n_1	=	number of freestanding workplaces.
n_2	=	number of non-freestanding workplaces.

The next comparison was the attraction rates for freestanding and non-freestanding workplaces between the urban areas. Table 7 presents the resulting statistic values for those comparisons. Care should be exercised in drawing conclusions from the statistical test being used because the observed variance in the attraction rate in most cases was very large, indicating wide differences in the attraction rates. High variances indicate large ranges in the confidence intervals for the estimates and can mask the difference in the trip rate between two areas, especially when the sample size is small. For example, the person trip attraction rate in Brownsville for HBNW trips to retail freestanding workplaces was 67.3. In Beaumont-Port Arthur, the same rate was 30.8. The value of the test statistic comparing these two rates (shown in Table 7) is 1.32, indicating no significant difference between the rates. The reason for this finding was that the variance for the Brownsville trip rate was over 10,000, and the variance for the Beaumont-Port Arthur rate was over 500. This is an extreme example and does not reflect the overall comparison of the trip rates. It illustrates the care that must be used in drawing conclusions from such statistics when there is high variability in the sample data. No consistent pattern was observed in the test statistic values

Table 5
Average Attraction Rates

Trip Type	Emp Type	Trip Purpose	Amarillo		Brownsville		Beaumont-Port Arthur	
			Free	Non-Free	Free	Non-Free	Free	Non-Free
Person Trips	Basic	HBW	1.17	1.05	1.58	1.07	1.28	0.98
		HBNW	0.71	0.27	1.47	0.94	0.22	0.08
		NHB	1.14	1.13	0.96	0.92	0.55	0.24
		Total	3.02	2.45	4.01	2.93	2.05	1.30
	Retail	HBW	1.09	0.86	1.33	0.81	0.96	1.04
		HBNW	13.29	21.77	67.33	29.60	30.82	24.49
		NHB	8.80	11.81	30.55	26.49	9.73	7.63
		Total	23.18	34.44	99.21	56.89	41.51	33.16
	Service	HBW	0.94	0.87	1.21	1.35	1.34	1.47
		HBNW	3.46	4.23	7.81	7.47	5.47	3.46
		NHB	2.99	3.20	4.04	6.56	4.20	2.40
		Total	7.39	8.30	13.06	15.38	11.01	7.33
Auto Driver Trips	Basic	HBW	1.06	0.92	1.23	0.60	1.21	0.91
		HBNW	0.56	0.23	0.90	0.68	0.20	0.08
		NHB	0.96	0.97	0.79	0.71	0.48	0.24
		Total	2.58	2.12	2.92	1.99	1.89	1.23
	Retail	HBW	0.97	0.72	1.12	0.56	0.92	0.99
		HBNW	9.75	14.52	39.68	17.64	23.08	19.83
		NHB	6.55	8.04	19.06	15.65	7.31	5.93
		Total	17.27	23.28	59.86	33.85	31.31	26.75
	Service	HBW	0.83	0.77	1.01	1.01	1.15	1.26
		HBNW	2.62	3.22	5.17	4.90	3.77	2.80
		NHB	2.41	2.64	3.26	5.21	2.97	1.97
		Total	5.86	6.63	9.44	11.12	7.89	6.03

Table 6
Test Statistic Values for
Freestanding versus Non-Freestanding Workplaces

Urban Area	Emp Type	Person Trip Attractions				Auto Driver Trip Attractions			
		HBW	HBNW	NHB	Total	HBW	HBNW	NHB	Total
Amarillo	Basic	0.52	0.59	0.01	0.27	0.62	0.56	- 0.00	0.26
	Retail	1.31	- 0.88	- 0.51	- 0.76	1.48	- 0.61	- 0.33	- 0.51
	Service	0.31	- 0.31	- 0.17	- 0.26	0.32	- 0.30	- 0.22	- 0.26
Brownsville	Basic	0.66	0.41	0.02	0.34	0.77	0.32	0.05	0.43
	Retail	1.81	1.40	0.29	1.08	2.16	1.21	0.39	1.00
	Service	- 0.54	0.02	- 0.45	- 0.10	0.03	0.02	- 0.50	- 0.10
Beaumont	Basic	2.10	1.09	1.26	2.70	2.14	1.01	1.02	2.40
	Retail	- 0.30	0.25	0.32	0.26	- 0.42	0.17	0.29	0.19
	Service	- 0.37	0.60	1.17	0.94	- 0.37	0.43	0.98	0.68

shown in Table 7. Taking into consideration the small sample sizes, there does not appear to be significant differences between the freestanding and non-freestanding workplace attraction rates except in certain instances which may be explained as chance variation.

Since there were some valid questions concerning the use of the test statistic as an indicator of differences, the attraction rates were reviewed individually to determine if any valid observations could be made. The following observations were made based on a review of the trip rates observed in the surveys and the variances associated with those rates:

- Average HBW attraction rates had the least amount of variation within employment type for all three urban areas with little difference being observed between freestanding and non-freestanding workplaces.
- The non-freestanding basic employment workplaces surveyed in the Beaumont-Port Arthur pilot survey did not constitute a large enough sample to base any findings.
- The comparison of average attraction rates between freestanding and non-freestanding workplaces in Amarillo and Brownsville indicated no consistent pattern of lower or higher values.

Table 7
Comparison of Attraction Rates between Urban Areas

Trip Type	Emp Type	Trip Purpose	Amarillo and Brownsville		Amarillo and Beaumont		Brownsville and Beaumont	
			Free	Non-Free	Free	Non-Free	Free	Non-Free
Person Trips	Basic	HBW	-1.55	-0.03	-0.51	0.44	1.26	0.13
		HBNW	-0.56	-1.13	0.75	-1.47	1.04	0.25
		NHB	0.08	0.20	0.58	0.88	0.20	2.13
		Total	-0.28	-0.34	0.58	0.84	0.62	3.66
	Retail	HBW	-1.06	0.21	0.50	-1.12	1.27	-0.91
		HBNW	-2.12	-0.60	-1.49	-0.11	1.32	0.21
		NHB	-2.08	-1.29	-0.18	0.57	2.00	1.60
		Total	-2.19	-0.94	-1.17	0.04	1.57	0.69
	Service	HBW	-1.34	-1.86	-1.24	-2.52	-0.38	- 0.48
		HBNW	-0.25	-0.43	-0.62	0.30	0.13	0.55
		NHB	-0.22	-1.05	-0.81	0.62	-0.03	1.30
		Total	-0.25	-0.69	-0.94	0.27	0.10	0.80
Auto Driver Trips	Basic	HBW	-0.72	0.40	-0.75	0.05	0.12	- 0.39
		HBNW	-0.42	-1.03	0.71	0.46	1.10	1.97
		NHB	0.10	0.29	0.55	0.87	0.21	1.52
		Total	-0.14	0.10	0.49	0.77	0.49	1.07
	Retail	HBW	-0.78	0.68	0.29	-1.72	1.08	-1.78
		HBNW	-1.70	-0.34	-1.58	-0.27	0.87	- 0.12
		NHB	-1.70	-1.14	-0.20	0.38	1.66	1.35
		Total	-1.77	-0.68	-1.25	- 0.14	1.12	0.28
	Service	HBW	-1.01	-0.92	-1.08	-5.56	-0.44	-1.08
		HBNW	-0.19	-0.40	-0.52	0.21	0.11	0.53
		NHB	-0.25	-1.23	-0.55	0.64	0.08	1.60
		Total	-0.22	-0.76	-0.73	0.21	0.09	0.91

- The non-freestanding retail workplaces surveyed in Beaumont-Port Arthur had a 20 percent lower average person trip attraction rate for HBNW trips than the same rate for freestanding workplaces. The average retail HBNW auto driver attraction rate was over 14 percent lower.
- The non-freestanding service workplaces surveyed in Beaumont-Port Arthur had a 37 percent lower average person trip attraction rate for HBNW trips than the average rate for freestanding workplaces. The average service HBNW auto driver attraction rate was 26 percent lower.
- The non-freestanding retail workplaces surveyed in Beaumont-Port Arthur had a 22 percent lower average person trip attraction rate for NHB trips than the average rate for freestanding workplaces. The average retail NHB auto driver attraction rate was 19 percent lower.
- The non-freestanding service workplaces surveyed in Beaumont-Port Arthur had a nearly 43 percent lower average person trip attraction rate for NHB trips than the average rate for freestanding workplaces. The average service NHB auto driver attraction rate was 34 percent lower.

FINDINGS AND RECOMMENDATIONS

The analysis of the workplace surveys done in the Amarillo, Brownsville, and Beaumont-Port Arthur areas has focused on the comparison of trip attraction rates between workplaces identified as freestanding and non-freestanding. The objective of this comparison was to determine if the revised survey methodology as implemented in the Beaumont-Port Arthur area would produce attraction rates more representative of travel patterns. The revised methodology for the workplace surveys was predicated on the theory that non-freestanding workplaces should have significantly lower attraction rates than freestanding workplaces due to multiple activities and employment located at the same center which jointly contribute to the overall attractiveness of the center. The following summarizes the findings of the analysis:

1. No discernible difference could be found between freestanding and non-freestanding workplace attraction rates in the surveys done in Amarillo and

Brownsville. This was expected since identical methodology was used for surveying both types of workplaces.

2. No significant difference could be found in the HBW attraction rates for freestanding and non-freestanding workplaces surveyed in the Beaumont-Port Arthur area. This was expected since HBW attraction rates are trips generated by employees only and have been observed to be fairly stable for all workplaces with the same type of employment. Employees would be expected to generate the same amount of attractions regardless of whether they work in a freestanding or non-freestanding workplace.
3. The HBNW and NHB attraction rates (both person and auto driver) for non-freestanding workplaces surveyed in the Beaumont-Port Arthur area were found to be consistently less than the rates for freestanding workplaces. The differences ranged from 14 to 43 percent lower. Since HBNW and NHB attractions are those generated mostly by non-employees, these are the trips which would be expected to differ between freestanding and non-freestanding workplaces. With the possibility of serving more than one trip purpose at an activity center with more than one workplace, the overall non-employee trip rate per employee for workplaces located in such a center would be expected to be lower. This is what the data indicate.

The impact of the lower attraction rates for non-freestanding workplaces will not be known until the full workplace survey is completed. The implementation of the revised survey methodology will provide a basis for expanding the survey results for freestanding and non-freestanding workplaces independently by area type and employment type. The resulting average attraction rates should produce more accurate estimates of trip attractions within the study area.

Based on the findings of the analysis of the pilot workplace survey in the Beaumont-Port Arthur area and the analysis of the surveys done in Amarillo and Brownsville, it is recommended that TxDOT complete the full workplace survey in Beaumont-Port Arthur using the recommended methodology. In addition, it is recommended that the full

workplace survey be analyzed in detail to ensure that the findings of the analysis of the pilot survey are consistent.

Finally, it is suggested that more specific groupings of similar activities be considered when developing attraction rates. For example, the present groupings place convenience and furniture stores in the same classification. Placing these and other activities in more homogeneous classes will decrease the variance of the attraction rates. More research is needed in this area.

REFERENCES

1. G.A. Shunk. *The Journey to Work: A Singular Basis for Travel Pattern Surveys*. Thesis, Purdue University, January 1968.
2. ITE Technical Council Committee 6A-32. *Trip Generation*. Institute of Transportation Engineers, Washington, D.C., 1987.
3. Barton-Aschman Associates, Inc. *Regional Travel Surveys Volume II, Workplace Surveys*. Final Report. North Central Texas Council of Governments, 1985.
4. P. Shapiro and M. Doherty. *Trip Attraction Rates Study*. Final Report - Volume 1. Report FHWA-AZ87-233. Arizona Department of Transportation, December 1987.
5. D.F. Pearson and G.B. Dresser. *Workplace Survey Design*. Texas Transportation Institute, Technical Note, Research Study 2-10-90-1235. Texas Department of Transportation, August 1992.
6. ITE Colorado/Wyoming Section Technical Committee. "Trip Generation for Mixed-Use Developments." *ITE Journal*, February 1987, pp. 27-32.
7. I. Miller and J.E. Freund. *Probability and Statistics for Engineers*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1965.