

Trip Generation for Mixed-Use Developments

by Colorado/Wyoming Section Technical Committee—Trip Generation

During the preparation of traffic impact studies for a proposed new development, discussions between transportation engineering consultants representing the developer and traffic engineers representing the local government usually include the applicability of ITE trip generation rates (as reported in *Trip Generation*¹) to the development.

A frequently raised question concerns whether ITE rates are strictly applicable to each land use in a mixed-use development when estimating total trip generation for the development. Should allowances be made for the fact that mixed-use developments have the ability to satisfy some trips internal to the site, as when office workers at such a development spend their lunch hour at shops and restaurants within the development, or several trip purposes within the development, as when shoppers at the development's supermarket also patronize the bank located within the development? This issue has sparked interest at the national level, as indicated by inquiries received in response to a previously published report on factoring pass-by trips into traffic impact analysis.²

The Colorado/Wyoming Section of ITE formed a technical committee to investigate trip generation rates at mixed-use developments. The committee's purpose was to determine whether trip generation rates for mixed-use developments are lower than those predicted by the strict application of ITE trip generation rates to each use within such a development. The committee collected driveway count data and conducted interviews at mixed-use developments in Colorado.

Study Scope

One of the study objectives was to

count trips at driveways serving existing mixed-use developments in Colorado. Twenty-four-hour counts were obtained at each driveway serving the mixed-use developments included in the study. These data were then compared with trip generation estimates based on ITE rates and modified by the methodology described in *Using the ITE Trip Generation Report*.³

Interviews were also conducted of persons entering and exiting mixed-use sites to determine whether they had come for multiple purposes. Each committee member supplied data for at least one mixed-use site included in the study.

Study Objectives

The main objectives of this study were to

- Establish criteria for selecting mixed-use sites suitable for inclusion in the study.

- Using the established criteria, select mixed-use development sites suitable as study locations.
- Obtain 24- to 48-hour count data at each driveway serving the selected sites.
- Obtain accurate land use information for each site.
- Estimate trip generation (a.m. peak, p.m. peak, and 24 hours) for each mixed-use site using rates contained in ITE's *Trip Generation*¹ and additional ITE trip generation publications⁴⁻⁶ as well as land use information provided by the local planning and community development departments.
- Compare the estimated number of trips generated (based on the ITE rates) with the actual driveway counts for each site.
- Interview drivers entering and exiting mixed-use sites to determine how many were there for multiple purposes.

Table 1. Sites Included in the Driveway Count Comparison Study

Site	Development	Size (sq.ft.)	Jurisdiction	Location
1	Mission Trace I	154,436	City of Lakewood	Northwest Corner of Wadsworth Blvd. and Girton Ave.
2	Mission Trace II	86,381	City of Lakewood	Southwest Corner of Wadsworth Blvd. and Girton Ave.
3	Union Square (East)	731,846	City of Lakewood	East of Union Blvd. between Ellsworth Ave. and 4th Ave.
4	Union Square (West)	500,000	City of Lakewood	West of Union Blvd. between Ellsworth Ave. and 2nd Pl.
5	Parkridge Plaza	61,198	City of Lakewood	Northwest Corner of Wadsworth Blvd. and 20th Ave.
6	Green Mountain Shopping Center	115,000	City of Lakewood	Northwest Corner of Alameda and Union Blvd.
7	Academy Park	1,773,500	City of Lakewood	Southeast Corner of Hampden Ave. and Wadsworth Blvd.
8	Orchard Shopping Shopping Center	177,277	City of Loveland	Northeast Corner of U.S. 287 and 29th St.
9	Pueblo Mall Convenience Center	95,104	City of Pueblo	29th St. and Hart Rd.

- Draw conclusions from the comparisons of the trip generation estimates with the actual driveway counts and the interview data.
- Publish the study's findings.

Study Methodology

Site Selection Criteria

To obtain data for as many suitable mixed-use sites as possible, a list of the data required for both the driveway count study and the interview study was sent to each member of the technical committee.

The committee established minimum criteria for selecting appropriate sites for inclusion in the study.

1. The site should be fully developed. If a site is not fully developed, land use data for the phases already constructed should be available.
2. Driveways at each site should serve only that site, and not adjacent properties.
3. The mixed-use site should include two or more different land uses capable of satisfying several trip purposes. A list of sites included in the driveway count comparison study is provided in Table 1; a list of sites where interviews were conducted is provided in Table 2.

Adjacent Street Count Data

To obtain some idea of traffic levels in the surrounding area, average daily traffic volumes are obtained for streets adjacent to each study site (summarized in Tables 3 and 4). The ADT data indicate the degree of pass-by traffic and the level of peak-hour congestion in the area surrounding each study site.

Land Use Data and Site Access

Accurate land use data were obtained for each mixed-use site included in the driveway count comparison study; the land use data, together with site access information, are summarized in Table 5. The information was provided by the planning and community development departments of the jurisdictions in which the study sites were located. Detailed land use data were needed so that trip generation would be accurately estimated using ITE rates.

The land uses and site access for each site included in the interview study

are summarized in Table 6.

Trip Generation Estimates

Trip generation estimates for each site were calculated using land use data and the rates contained in *Trip Generation*¹ and more recently published reports⁴⁻⁶; the estimates were adjusted by the methodology provided in the users' guide³.

No allowances were made for transit usage or variations in vehicle occupancy by trip purpose. Seasonal fluctuations were not taken into account because only limited ITE data are available in *Trip Generation*.

Study Dates

Driveway count dates for each study site are listed in Table 7. The specific

Table 2. Sites Included in the Interview Study

Site	Development	Size (sq.ft.)	Jurisdiction	Location
1	Mission Trace I Mission Trace II	240,917	City of Lakewood	West Corner of Wadsworth Blvd. and Girton Ave.
2	Union Square (East)	731,846	City of Lakewood	East of Union Blvd. between Ellsworth Ave. and 4th Ave.
3	Union Square (West)	500,000	City of Lakewood	West of Union Blvd. between Ellsworth Ave. and 2nd Pl.
4	Green Mountain Shopping Center	115,000	City of Lakewood	Northwest Corner of Union Blvd. and Alameda Pkwy.
5	Westland Shopping Center and Westland Plaza	1,000,000	City of Lakewood	Colfax Ave.-Miller St. to Quail St.
6	Green Mtn. Plaza Shopping Center	110,000	City of Lakewood	Alameda Ave. at Xenon Ct.
7	Pueblo Mall Convenience Center	95,104	City of Pueblo	29th St. and Hart Rd.
8	Time Square	300,000	City of Wheat Ridge	Wadsworth Blvd. and 42nd Ave.

Table 3. Average Daily Volume on Adjacent Streets—Driveway Count Comparison Study

Site	Adjacent Streets	Classification	Average Daily Traffic Volumes
1	Wadsworth Blvd.	Arterial	40,000
1	Girton Ave.	Collector	5,000
2	Wadsworth Blvd.	Arterial	40,000
2	Girton Ave.	Collector	5,000
3	4th Ave.	Collector	5,000
3	Union Blvd.	Arterial	40,000
4	2nd Pl.	Collector	10,000
4	Union Blvd.	Arterial	40,000
4	Van Gordon	Collector	5,000
5	Wadsworth Blvd.	Arterial	40,000
5	20th Ave.	Collector	12,000
6	Union Blvd.	Arterial	40,000
6	Alameda Dr.	Collector	4,000
6	Alameda Ave.	Arterial	25,000
7	Wadsworth Blvd.	Arterial	40,000
7	Hampden Svc. Rd.	Collector	4,000
7	Pierce St.	Collector	4,000
8	U.S. 287	Arterial	16,000/22,000
8	29th St.	Arterial	7,600
8	Lincoln St.	Local	5,000
9	29th St.	Arterial	15,000

dates are provided to indicate the seasonal spread of the count information. The effect of seasonal variations on the count comparison study results should be investigated in more detail in future studies.

Data Collection—Count Comparison Study

To obtain 24-hour counts, automatic tube counters were placed at each driveway serving the study sites; the counts were broken down by each hour. No at-

tempt was made to factor count data to account for seasonal variations, as no such factors were available for ITE trip generation rates. The driveway count data are based on the raw count information provided by committee members and are summarized in Table 8.

Data Collection—Interview Study

The interview data were provided by committee members stationed at each site included in the study. To obtain the interview data, the committee members followed specific steps:

1. Obtain permission from the manager or owner of the mixed-use site.
2. Conduct a minimum of 200 interviews at each site, if possible.
3. Alternate interviews of persons leaving their vehicles after entering the parking lot with persons returning to their vehicles after completing their trip purpose.
4. Sample locations of high activity within the mixed-use site at specific times of the day; circulate throughout the study site during the entire day.
5. Clearly identify themselves.
6. Ask questions aimed at determining how many of the people entering a mixed-use development intended to

Table 4. Average Daily Volume on Adjacent Streets—Interview Study

Site	Adjacent Streets	Classification	Average Daily Traffic Volumes
1	Wadsworth Blvd.	Arterial	40,000
1	Girton Ave.	Collector	5,000
2	Union Blvd.	Arterial	40,000
2	4th Ave.	Collector	5,000
3	2nd Pl.	Collector	10,000
3	Union Blvd.	Arterial	40,000
3	Van Gordon	Collector	5,000
4	Union Blvd.	Arterial	40,000
4	Alameda Dr.	Collector	4,000
4	Alameda Ave.	Arterial	25,000
5	Colfax Ave.	Arterial	35,000
5	Oak St.	Collector	5,000
5	Miller St.	Local	5,000
6	Alameda Ave.	Arterial	25,000
7	29th St.	Arterial	15,000
8	Wadsworth Blvd.	Arterial	40,000
8	44th Ave.	Arterial	15,000
8	38th Ave.	Arterial	15,000

Table 5. Land Uses and Site Access—Driveway Count Study Sites

Site	Site Land Uses	Adjacent Land Uses	Site Access
1	Retail, Office, Government Office, Restaurants, Sports Club	Similar Mixed Uses Residential	Unsignalized Collector Street Access
2	Retail, Bank, Restaurants	Similar Mixed Uses Residential	Unsignalized Arterial and Collector Street Access
3	Retail, Hotel, Restaurants, Office	Similar Mixed Uses	Signalized and Unsignalized Arterial Street Accesses
4	Retail, Office, Restaurants, Motel, Theaters	Similar Mixed Uses	Signalized and Unsignalized Arterial and Collector Street Accesses
5	Retail, Office	Neighborhood Commercial Residential	Unsignalized Arterial and Collector Street Access
6	Retail, Restaurants, Hardware Store, Supermarket	Similar Mixed Uses Residential	Unsignalized and Signalized Arterial and Collector Street Accesses
7	Restaurants, Bank, Hotel, Medical Office, Office, Training Center	Office Uses Residential	Signalized Arterial Street Accesses
8	Savings and Loan, Office, Hardware Store, Supermarket, Medical Office, Bank, Health Club, Theater, Retail, Restaurants	Residential Commercial Vacant Warehouses	Signalized Access and Five Unsignalized Accesses onto Adjacent Streets
9	Supermarket, Restaurants, Bank, Medical Office, Savings and Loan, Retail	Similar Mixed Uses	Signalized and Unsignalized Arterial Street Accesses

Table 6. Summary of Land Uses Site Access for Interview Study Sites

Site	Site Land Uses	Adjacent Land Uses	Site Access
1	Office, Retail, Restaurant, Bank, Government Office, Sports Club	Similar Mixed and Residential Uses	Unsignalized Accesses onto Collector Streets
2	Retail Office, Hotel, Restaurants	Similar Mixed Uses	Signalized and Unsignalized Accesses onto Adjacent Arterial and Collector Streets
3	Retail Office, Motel, Restaurants, Theaters	Similar Mixed Uses	Signalized and Unsignalized Accesses onto Arterial and Collector Streets
4	Retail, Restaurants, Hardware Stores, Supermarkets	Mixed and Residential Uses	Signalized and Unsignalized Accesses onto Arterial and Collector Streets
5	Regional Mall, Retail, Restaurants, Banks, Offices, Theaters	Mixed and Residential Uses	Signalized and Unsignalized Accesses onto Arterial Collector and Local Streets
6	Theaters, Restaurants, Banks, Retail	Mainly Residential Uses	Signalized and Unsignalized Accesses onto Arterial Collector and Local Streets
7	Savings and Loan, Retail, Supermarkets, Restaurants, Medical	Similar Mixed Uses	Signalized and Unsignalized Accesses onto Arterial Streets
8	Hardware, Supermarkets, Restaurants, Post Office, Retail	Similar Mixed and Residential Uses	Signalized and Unsignalized Accesses onto Arterial Streets

satisfy more than one trip purpose, and how many leaving the development did satisfy more than one trip purpose.

7. Complete all interviews during July, August, and September 1985.

Study Results

Driveway Count Comparison

After comparing ITE trip generation estimates with actual driveway counts averaged over all nine study sites contained in Table 8, the committee found the estimated total daily trip generation for all sites, based on ITE rates, to be 8% higher than the actual driveway counts. This difference is not statistically significant at the 95% confidence level.

Comparison of total daily volumes with peak hour volumes found the results shown in Table 9.

Interview Data

The results of 1,132 interviews at nine study sites are summarized in Tables 10 and 11. The primary destination was determined by observation, by interview location, or by interviewee response.

Table 12 summarizes the reasons given at two study sites as to why the interviewees selected a mixed-use site to satisfy several trip purposes, rather than going to several different locations.

A significant number of the 1,132 persons interviewed (23%) stated that they

Table 7. Driveway Count Dates

Site	Development	Date
1	Mission Trace I	December 3, 1984
2	Mission Trace II	August 5, 1985
3	Union Square (East)	December 4, 1984
4	Union Square (West)	September 15, 1985
5	Parkridge Plaza	December 3, 1984
6	Green Mountain Shopping Center	September 22, 1985
7	Academy Park	September 10, 1985
8	Orchard Shopping Center	July 11 and 12, 1985
9	Pueblo Mall Convenience Center	March 27, 1985

had come to the site for two or more purposes; 16% stated that they had come for two purposes, and 7% for three or more purposes (approximated by 3.5 trip purposes). It has been estimated that the 1,132 persons interviewed would have generated 3,022 total trips had they made separate trips to each destination, rather than combining trips by using a mixed-use site. An estimated 758 trips were thus eliminated by multipurpose trips to mixed-use sites, a reduction of 25%.

Conclusion

Total daily trips generated by a mixed-use site can be accurately estimated using ITE rates (as reported in *Trip Gen-*

eration) applied to individual uses within a mixed-use development. The 8% difference found in this study is not statistically significant.

Peak-hour trip generation for a mixed-use development based on ITE rates applied to individual uses within the development may be overestimated by an average 2.5%.

Based on the interview study, 77% of the persons entering a mixed-use site were there for one purpose, 16% for two purposes, and 7% for three or more purposes.

Mixed-use developments could reduce trip generation of individual uses within the development by 25%. Because the driveway volumes in the count comparison study indicated a nonsta-

Table 8. Comparison of Estimated Trip Generation (using ITE rates) with Driveway Counts

Site	Daily Trips (VPD)		a.m. Peak-Hour Generator (VPH)		a.m. Peak-Hour Street (VPH)		p.m. Peak-Hour Generator (VPH)		p.m. Peak-Hour Street (VPH)	
	Estimated	Counted	Estimated	Counted	Estimated	Counted	Estimated	Counted	Estimated	Counted
1	7,015	7,910	712	682 (11a.m.-noon)	374	365 (7-9a.m.)	920	700 (noon-1p.m.)	866	700 (4-6p.m.)
2	10,578	6,830	952	565 (11a.m.-noon)	248	247 (7-9a.m.)	1,368	586 (noon-1p.m.)	1,076	513 (4-6p.m.)
3	13,661	11,706	1,734	1,012 (11a.m.-noon)	1,391	855 (7-9a.m.)	1,806	1,038 (noon-1p.m.)	1,701	821 (4-6p.m.)
4	14,815	13,718	1,339	1,334 (11a.m.-noon)	1,136	640 (7-9a.m.)	1,984	1,576 (noon-1p.m.)	1,460	1,138 (4-6p.m.)
5	5,388	5,179	445	389 (11a.m.-noon)	164	184 (7-9a.m.)	682	503 (noon-1p.m.)	624	504 (4-6p.m.)
6	12,182	13,695	1,219	1,043 (11a.m.-noon)	549	625 (7-9a.m.)	1,455	1,254 (4-5p.m.)	1,185	1,254 (4-5p.m.)
7	27,004*	24,462	3,603*	2,448 (7-8a.m.)	3,639*	2,448 (7-8a.m.)	3,827*	2,891 (4-5p.m.)	3,765*	2,891 (4-5p.m.)
8	14,481	18,303	1,575	1,160 (11a.m.-noon)	343	551 (7-9a.m.)	1,810	1,556 (4-5p.m.)	1,334	1,556 (4-5p.m.)
9	11,873	7,372	1,162	527 (11a.m.-noon)	676	247 (7-9a.m.)	1,479	697 (4-5p.m.)	1,200	697 (4-5p.m.)
TOTAL	116,997	109,175	12,740	9,160	8,436	6,162	15,331	10,801	13,211	10,074

NOTE: Estimated figures are based on rates provided in cited reference 1.

*These numbers reflect a 25% office vacancy rate estimated by Grubb & Ellis, March 31st, 1985, for the Denver office market.

tistically significant difference of 8%, the committee concluded that most of the secondary trip purposes indicated by interviewees result from the availability of multiple retail outlets in close proximity to major primary destinations, such as offices, supermarkets, banks, restaurants, hotels, and theaters, in mixed-use developments. If the secondary destinations were not close to the primary destinations, trips to the secondary destinations would not occur or would occur at a much lower level. Trip generation for mixed-use sites is largely a function of the square footage of the primary destination.

The committee recommends that:

1. ITE trip generation rates be used to estimate total daily trip generation from a proposed mixed-use development for traffic impact studies.
2. The peak-hour trip generation estimates based on ITE trip generation rates be reduced by 2.5%. This will provide a more accurate estimate of the peak-hour traffic impacts of a proposed mixed-use development.
3. Studies be conducted on mixed-use developments in other states to determine if the results of this study can be validated.
4. Engineers interested in the detailed

Table 9. Comparison of Total Daily Volumes with Peak Hour Volumes

Hour	Percentage of Total Daily Volume		Difference
	Estimate	Actual Count	
a.m. Peak Hour of Generator	11.0	8.4	2.6*
a.m. Peak Hour of Street	7.2	5.6	1.6
p.m. Peak Hour of Generator	13.1	9.9	3.2*
p.m. Peak Hour of Street	11.2	9.2	2.3*

*Statistically significant at the 95% confidence level. The Wilcoxon Matched Pairs Signed-Ranks Non-Parametric Test was used as no inference could be made about the population distribution of the sample data; the samples being tested were also related.

Table 10. Persons Entering Mixed-Use Sites by Number of Purposes and Primary Destination

Destination	Number of Persons (%)			Total Persons (%)
	1 Purpose	2 Purposes	3+ Purposes	
Bank/Savings and Loan	27 (90.0)	2 (6.6)	1 (3.4)	30 (100.0)
Hardware Store	20 (66.7)	9 (30.0)	1 (3.3)	30 (100.0)
Supermarket	189 (79.1)	40 (16.7)	10 (4.2)	239 (100.0)
Theater	27 (93.1)	2 (6.9)	0 (0.0)	29 (100.0)
Office/Work Location	48 (67.6)	22 (30.0)	1 (1.4)	71 (100.0)
Small Retail Shop, etc.	120 (72.7)	21 (12.7)	24 (14.6)	165 (100.0)
Restaurant	105 (80.8)	18 (13.8)	7 (5.4)	130 (100.0)
Health Club	7 (100.0)	0 (0.0)	0 (0.0)	7 (100.0)
Post Office	19 (51.4)	12 (32.4)	6 (16.2)	37 (100.0)
Other	4 (100.0)	0 (0.0)	0 (0.0)	4 (100.0)
TOTAL (Average)	566 (76.3)	126 (17.0)	50 (6.7)	742 (100.0)

Table 11. Persons Exiting Mixed-Use Sites, by Number of Purposes and Primary Destination

Destination	Number of Persons (%)			Total Persons (%)
	1 Purpose	2 Purposes	3+ Purposes	
Bank/Savings and Loan	17 (73.9)	2 (8.7)	4 (17.4)	23 (100.0)
Hardware Store	22 (88.0)	3 (12.0)	0 (0.0)	25 (100.0)
Supermarket	39 (67.3)	10 (17.2)	9 (15.5)	58 (100.0)
Hotel	4 (100.0)	0 (0.0)	0 (0.0)	4 (100.0)
Office/Work Location	15 (71.4)	6 (28.6)	0 (0.0)	21 (100.0)
Small Retail Shop, etc.	82 (73.2)	18 (16.1)	12 (10.7)	112 (100.0)
Restaurant	100 (89.2)	11 (9.8)	1 (1.0)	112 (100.0)
Health Club	3 (42.8)	4 (57.2)	0 (0.0)	7 (100.0)
Post Office	20 (80.0)	3 (12.0)	2 (8.0)	25 (100.0)
Other	2 (100.0)	0 (0.0)	0 (0.0)	2 (100.0)
TOTAL (Average)	304 (78.2)	57 (14.6)	28 (7.2)	389 (100.0)

Table 12. Reasons for Using Retail Outlets in Mixed-Use Developments

Reason	No. of Interviews	Percentage of
		Total
Good planning to save gas and time	2	0.62
Convenient	4	1.22
Going to a "sale"	1	0.31
Convenient for out of towners	3	0.92
Availability of a particular retail outlet	10	3.05
Passing by	6	1.83
Availability of several shops in one convenient location	17	5.21
Close to home	11	3.36
Close to work	7	2.14
No reason stated	266	81.34
TOTAL	327	100.00

analysis of this study request a copy of the full report from the authors.

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This article is a summary of a report prepared by the Colorado/Wyoming Section Technical Committee—Trip Generation. The full report is available from Nazir Lalani, Sr. Transportation and Development Engineer, 123 East Anapamu Street, Santa Barbara, California 93101 USA.

The report was based on research data collected by transportation engineering professionals in the Colorado/Wyoming Section.

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