Truck Equivalency

EUGENE F. REILLY and JOSEPH SEIFERT, New Jersey Department of Transportation

A two-lane, dual-dual, 50 mph, level, tangent roadway having a 1967 AADT of 68,000 vehicles with a high percentage of trucks was studied under uninterrupted flow conditions. A relationship between mixed volume (cars and trucks on a local roadway) and equivalent passenger car volume (only cars on an express roadway) was determined for 20, 40, 60 and 80 percent truck groups. The passenger car equivalent of trucks was found to approach a value of two as the percent of trucks in the stream approached 100 percent. The relationship between cars and trucks was determined on the basis of equal speeds.

•THE Highway Capacity Manual states that a truck on a level, tangent road is equivalent to two passenger cars, regardless of truck percentage. Other studies show that this value may not be as high as two, and may vary with percentage of trucks. Whatever its value, the relationship can be shown in the form of a mixed volume-equivalent passenger car volume graph as the truck percentage varies. To derive this relationship, volumes and speeds on a local roadway for various truck percentage groups were compared to volumes and speeds on an express roadway.

The following definitions of terms have been used throughout this report:

Truck—a vehicle with more than four tires;

Dual-dual highway—a highway with four separated roadways: an express roadway and a local roadway for both directions;

Express roadway—a two-lane roadway with only passenger car traffic;

Local roadway—a two-lane roadway with both passenger car and truck traffic;

Equivalent passenger car volume—an expanded volume (vph) from the express roadway that includes cars only;

Mixed volume—an expanded volume (vph) from the local roadway that includes both cars and trucks;

Factor—the passenger car equivalent of a truck as determined from the relation $Q = C + F(T)$, where Q is equivalent passenger cars, C is the number of cars, T is the number of trucks, and F is a factor;

Variable lane headway—the difference in time (seconds) between consecutive vehicles (regardless of lane) crossing a reference line; this term applies to vehicles in adjacent lanes as well as vehicles in the same lane (vehicles are measured head to head; if two vehicles are crossing the reference line at the same time, the variable lane headway is zero).

The dual-dual section of US 1-9 in Elizabeth, New Jersey, was an ideal study site. The roadway was level and tangent, flow was uninterrupted, and a high percentage of trucks was included in the 1967 AADT of 68,000 (both directions). Based on a 16-hour count in 1958, there were approximately 25 percent trucks over the entire roadway, or approximately 50 percent trucks on the local roadway, northbound. This road has a posted speed limit of 50 mph.

STUDY METHOD

Using a pneumatic-tube, junior counter, 20-pen recorder system, the following data were collected: chronological times at which a vehicle crossed a pair of reference lines, vehicle type (car or truck), and lane used (right or left). Three 12-hour days

Paper sponsored by Committee on Highway Capacity.

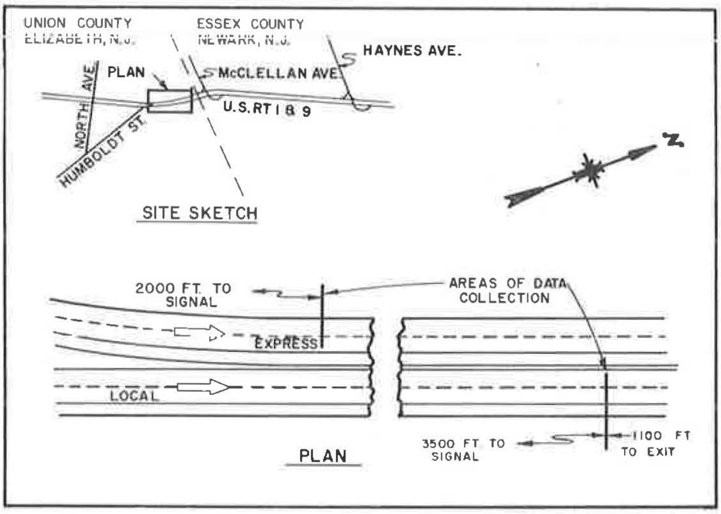

Figure 1. Site sketch and plan.

of data from the express roadway and two 12-hour days of data from the local roadway were collected. Although data were collected by individual lanes, both lanes were used in computing volumes and average speeds.

The data were coded, punched onto cards, and compiled by computer programs. The first programs (AVGSPD, PLATON, and PLASUM) defined the data using time interval and platoon methods. Tables of average speed, with volume and truck percentage, were produced. From these tables, second-degree curves of volume vs speed were fitted, using the computer program polynomial curve fitting. These curves were extended to 35 mph and adjusted to a maximum volume of 4,000 vph for a two-lane road. Then 20, 40, and 60 percent truck curves were constructed equidistantly between the express curve and the 80 percent truck curve. These curves were used to plot a mixed volume-equivalent passenger car volume relationship. This relationship is based on the assumption that, for a constant speed, the mixed volume is equivalent to the corresponding express roadway volume.

DATA COLLECTION

Site

The study site was US 1-9 in Elizabeth, New Jersey, a dual-dual highway, downstream from a signalized intersection (Fig. 1). The northbound direction, which includes a local and an express roadway of two lanes each, was studied. The speed limit was 50 mph.

The express roadway site was 2,000 ft downstream from the traffic signal, and the local roadway site was 3,500 ft downstream from the traffic signal. There is no access within 1,000 ft of the local roadway site.

The local roadway is tangent, with a 10-ft shoulder on the right and an 18-in. wide tapered concrete separator to the left. The express roadway has a 1-deg curve to the left, a 9-ft shoulder on the right, and a sloping curb and a wide grass median on the left. Both roadways have 12-ft wide portland cement concrete lanes and bituminous concrete shoulders.

Express roadway data were taken during 1967 on Friday, May 26, from 8:30 a.m. to 7:00 p.m.; Wednesday, May 31, from 7:15 a.m. to 7:00 p.m.; and Thursday, June 1, from 7:15 a.m. to 7:15 p.m. Local roadway data were taken on Wednesday, June 14, from 7:30 a.m. to 7:15 p.m.; and Thursday, June 15, from 6:30 a.m. to 7:15 p.m.

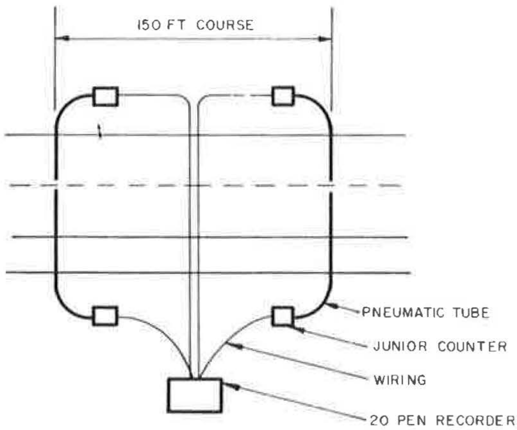

Figure 2. Data collection system.

The weather was clear and the roadway was dry during the data collection periods.

Collection Method

As described earlier, a pneumatic-tube, junior counter, 20-pen recorder system was used to collect the data (Fig. 2). Two reference lines were established 150 ft apart. Pneumatic tubes along these lines recorded each lane separately. The time at which a vehicle crossed a tube was registered, and vehicle type (car or truck) was manually classified.

DATA COMPILATION

The recorder chart consisted of six lines; each lane had a line for truck indication and a line for each end of the speed course. To find the time difference for a vehicle on the 150-ft course, "blips" on two adjacent lines had to be matched. Speed, in 5-mph intervals, was determined by measuring this time difference with a specially constructed scale. Chronological time at which a vehicle crossed a reference line, vehicle type, lane, and speed were coded for each vehicle.

Time Interval Method

A constant time interval was used to define data samples. All vehicles (regardless of lane in the time interval), starting with the first vehicle, made up the first sample. Thereafter, time samples were taken consecutively to the end of the study.

The first set of samples was formed using 15-second time intervals, and another set of samples was formed using 30-second time intervals. The number of vehicles in a time interval was expanded to vehicles per hour.

If there were less than three vehicles in a sample or if more than half the speeds were missing for the vehicles in a sample, then that sample was not used.

Platoon Method

Samples were also defined by platoons. A platoon was defined using variable lane headway criteria between consecutive vehicles (in time), regardless of lane. If a pair of consecutive vehicles were in the same lane, the second vehicle was assumed to be influenced by the first vehicle for variable lane headways up to 6 seconds. If a pair of consecutive vehicles were in adjacent lanes, the second vehicle was assumed to be influenced by the first vehicle for variable lane headways up to 3 seconds. In the event that two vehicles passed the reference line at the same time in adjacent lanes, the 6-second criterion was used for a following vehicle.

A condition could occur where the variable lane headway between two adjacent lane vehicles (vehicles 4 and 5 in Fig. 3) is greater than 3 seconds, but the headway between two same-lane vehicles (vehicles 4 and 6) is less than 6 seconds. For this condition, neither vehicle 5 nor 6 is considered to be influenced by vehicle 4. Vehicle 6, in this position, is assumed to be primarily influenced by vehicle 5. Vehicles 1, 2, 3, and 4 form a platoon. Vehicles 5 and 6 are the start of another possible platoon. A valid platoon was required to have a minimum of four vehicles and a minimum total platoon time (i.e., variable lane headway sum) of 15 seconds. Volume was

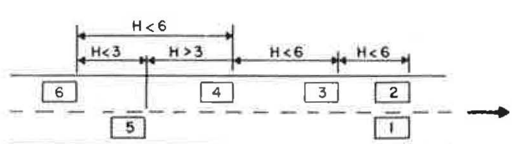

Figure 3. Special condition for platoon method.

determined by expanding number of vehicles/total platoon time to an hour. Volumes were grouped by 100-vph class intervals.

Procedure

For each sample of data, the expanded hourly volume, average speed, and truck percentage were determined. Each sample was then grouped by volume and truck percentage. Trucks were grouped as follows:

Roadway	Percent of Trucks	Assumed Percent of Trucks
Express	0.0	0.0
Local	0.0- 5.0	0.0
	5.1- 29.9	20.0
	30.0- 49.9	40.0
	50.0- 69.0	60.0
	70.0- 89.0	80.0
	90.0-100.0	95.0

For each volume and truck percentage group, the average speed, the standard error, and the number of samples were tabulated (see Tables A-1, A-2, and A-3 in Appendix).

DATA ANALYSIS

A second-degree relationship between volume and speed was determined for each truck percentage group and for each method (15-second time interval, 30-second time interval, and platoon). At this point some of the curves were eliminated—the 15-second curves due to wide variations and the 95 percent truck curves due to small sample size and low volume range. The data have a speed range between 40 and 50 mph, but the curves were extended to 35 mph.

The maximum volume (4,000 vph for a two-lane road, according to the Highway Capacity Manual) was assumed to occur at 35 mph. Since the volume at 35 mph for both methods exceeded 4,000 vph, the curves were corrected by a factor of 4,000 vph/volume at 35 mph. The corrected corresponding truck percentage curves for the 30-second time interval and platoon curves were then averaged together. The 60 percent truck group curve was an exception; only the platoon curve was used in this case because the 30-second curve was so flat (Table 1 and Fig. 4).

TABLE 1

SPEED-VOLUME CURVES[a]

$Y = AX^2 + BX + C$

Y = Speed (mph)

X = Volume (vph)

Coefficient	Express	Truck Percent				
		0	20	40	60[b]	80
A	-1.11×10^{-6}	-3.26×10^{-6}	-1.62×10^{-7}	-1.25×10^{-6}	-1.60×10^{-6}	-5.42×10^{-6}
B	1.78×10^{-3}	6.49×10^{-3}	3.31×10^{-4}	7.41×10^{-4}	1.42×10^{-3}	1.16×10^{-2}
C	4.57×10^{1}	4.46×10^{1}	4.45×10^{1}	4.60×10^{1}	4.40×10^{1}	3.75×10^{1}

[a]These curves represent the average between the 30-second time interval and the platoon methods, adjusted so that the express volume is 4,000 vph at 35 mph.

[b]The 60 percent curve is based only on the platoon method.

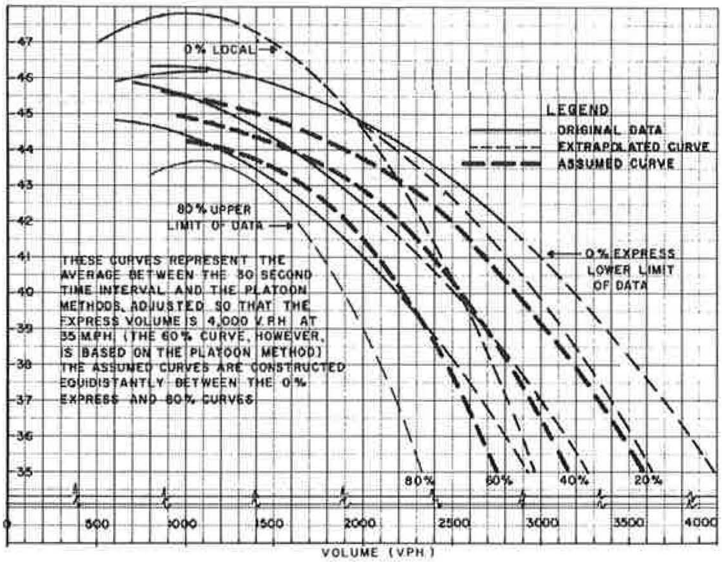

Figure 4. Speed-volume curves for varying truck percentage groups.

Many speed-volume curves showed a speed increase with volume to a peak speed at the lower volumes, and then the expected speed decrease. Only the decreasing portions of these curves were used.

It was found that the speed-volume curves had an almost uniform variation between the limiting express and 80 percent truck curves. Therefore, assumed curves were constructed for 20, 40, and 60 percent truck groups. (A family of curves was thus formed that consisted of the limiting curves and the assumed curves.) In the speed range from 35.0 to 43.7 mph, the assumed curves were constructed equidistantly between the limiting curves. For speeds greater than 43.7 mph, the assumed curves were extended to proportioned points along a chord between the vertices of the two limiting curves (Fig. 4 and Appendix Table A-5). This family of curves was used to plot a mixed volume-equivalent passenger car volume graph.

Mixed Volume-Equivalent Passenger Car Volume Graph

Using the family of speed-volume curves in Figure 4, equivalent passenger car volumes can be determined for each truck percentage group using the express curve as the base. The following is an example, using 40 percent trucks:

Speed (mph)	Volume (vph)	
	Mixed	Express
35	3,200	4,000
40	2,500	3,200

Because the express volume consists of all passenger cars, it is considered to be the equivalent passenger car volume at the given speeds. Hence, Figure 5 is constructed using express volume as the ordinate and mixed volume as the abscissa.

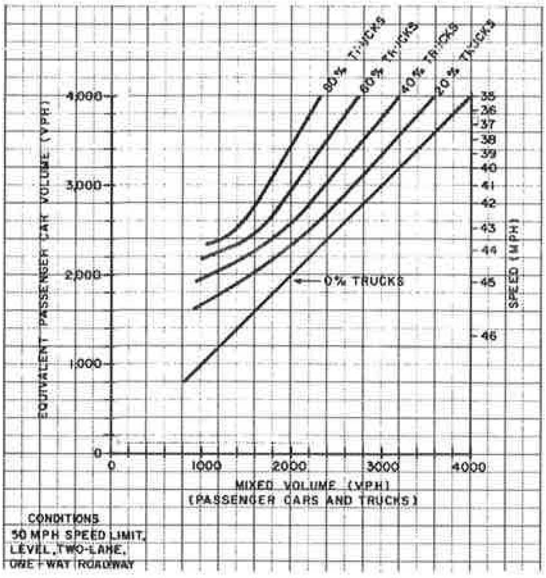

Figure 5. Mixed volume vs equivalent passenger car volume.

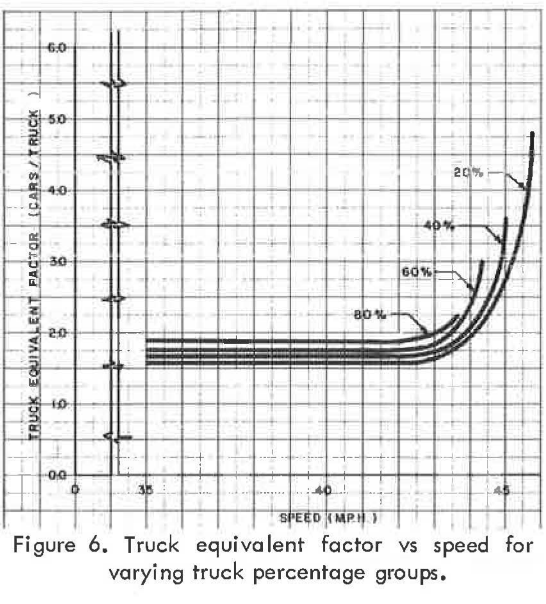

Figure 6. Truck equivalent factor vs speed for varying truck percentage groups.

Truck Equivalent Factor Curves

A factor (defined earlier) was computed for each truck percentage group for speeds between 35 and 46 mph. These factors are tabulated in Appendix Table A-6 and are shown in Figure 6.

DISCUSSION OF RESULTS

Speed-Volume Curves

The expected pattern for the various truck percentage groups is a family of decreasing curves with the express curve outermost (Fig. 4). Some exceptions occur in the 15-second curves, with both the 60 and 80 percent truck group curves flatter than expected. The 30-second, 60 percent truck group curve was inexplicably flat. The zero percent local truck curve was expected to approximate the express curve but did not. It was initially above and then fell below the express curve (Fig. 4). No explanation could be found for the higher speeds on the local roadway at the lower volumes. However, the local curve data cover a shorter and lower volume range than the express curve data, and an extension of this curve cannot be expected to yield much similarity to the express curve. This may explain the difference at the higher volumes where the local roadway data were extended.

In comparing the same truck group curves (by percentages), the time interval curves fall below the platoon curves. This can be expected because of the different techniques used to compute volume. Platoon volume is based on the average headway from the first to the last vehicle in a platoon. The time interval is used as the base for volume in the other method. Because there is "lost" time in the time interval method, the computed volume for the time interval method will appear to be slightly less than for the platoon method.

These curves were extended to 35 mph, based on the assumption that the maximum capacity for all truck percentage groups occurs at this speed. However, maximum capacity for high truck percentage groups could possibly occur at lower speeds. This concept was not investigated.

Many of the speed-volume curves show a speed increase with volume to a peak speed at about 800 vph for the two-lane roadway. A possible explanation for this is that below this volume most drivers do not seem to be affected by other traffic. The driver chooses his own speed, which is below the peak speed. Above this volume, more of the traffic is restricted, and the average speed is lowered.

Mixed Volume-Equivalent Passenger Car Volume Graph

After correcting each curve for maximum volume, combining data from the time interval and platoon methods, and determining the family of speed-volume curves for all truck percent groups, the mixed volume-equivalent passenger car volume graph (Fig. 5) was drawn. To find the equivalent passenger car volume, the mixed volume is entered, its intersection with the desired truck percentage group curve is found, and the coordinate is read. For example, using a mixed volume of 3,000 vph, the equivalent passenger car volumes in vph are 3,000 (0 percent trucks), 3,300 (20 percent trucks), and 3,800 (40 percent trucks). This graph has certain limitations. No relationships are shown for mixed volumes below 1,000 vph. Also, since the equivalent passenger car volume is based on average speed, which reaches a maximum for each truck percentage group, no relationship can be shown for speeds greater than the maximum average speed attained by each truck percentage group.

Truck Equivalent Factor Curves

The approximate truck equivalent factors, as computed for the speed range of 35 to 43 mph, are as follows:

Truck Percentage Group	Factor
20	1.60
40	1.65
60	1.75
80	1.90

These factors are affected exponentially by the leveling off of speeds between 43 and 46 mph. However, this leveling off occurs in the lower volume region where truck factors on 50-mph roads may not be meaningful.

CONCLUSIONS

For the dual-dual roadway under the conditions studied, a relationship between mixed volume and equivalent passenger car volume was determined for 20, 40, 60 and 80 percent truck groups. At a constant speed, a mixed volume was assumed to be equivalent to the corresponding express roadway volume. As would be expected, this relationship shows that, for a constant mixed volume and with increasing truck percent, the equivalent passenger car volume increases and average speed decreases.

A truck appears to be equivalent to less than two cars.

The best fit second-degree speed-volume curves for several truck percentage groups showed an increase in speed with volume to a peak speed at 800 vph for a two-lane road and then the expected speed decrease. Below this volume there is apparently little restriction of movement and the driver chooses a speed below the peak speed. Above this volume traffic restriction increases and lower speeds result.

Various errors occurred in recording and coding the data. Sometimes a vehicle was not recorded at both ends of the speed course. Thus, speeds were not available for every vehicle. A few errors may have occurred in manually classifying vehicle type.

If, in coding the data, an undetected passing maneuver occurred, or if an incorrect pair of "blips" on the recorder chart were used, or if the time difference were measured incorrectly, then the speed was also incorrect. A small error in the time difference results in a larger error at higher speeds than at lower speeds. Errors in coding chronological time were detected by computer programs as headway errors.

Coding the data for this study was an enormous job. This method is not practical for large quantities of data or headway data for more than two lanes. With more than two lanes, overlapping pneumatic tubes are required, and interpreting the recorder chart becomes more complicated.

REFERENCES

1. Highway Capacity Manual. HRB Spec. Rept. 87, pp. 101-104, 1965.
2. Moskowitz, K., and Newman, L. Effect of Grades on Service Volume. Highway Research Record 99, pp. 224-243, 1965.
3. Daou, A. On Flow Within Platoons. Australian Road Research, pp. 4-13, March 1966.
4. Drake, J., Schofer, J. L., and May, A. D. A Statistical Analysis of Speed Density Hypotheses. Highway Research Record 154, pp. 53-87, 1967.

Appendix

TABLE A1
VOLUME-SPEED COMPILATION (15-SECOND TIME INTERVAL METHOD)

		Express			Local Roadway (Truck Percent Groups)																	
		Cars Only			0 - 5%			5 - 30%			30 - 50%			50 - 70%			70 - 90%*			90 - 100%		
Size[1]	Vol[2]	#[3]	Spd[4]	SE[5]	#	Spd	SE	#	Spd	SE	#	Spd	SE	#	Spd	SE	#	Spd	SE	#	Spd	SE
3	720	200	46	4.1	205	47	4.9	-	-	-	233	46	4.6	168	44	4.7	114	44	4.8	83	43	5.1
4	960	186	47	4.1	155	49	4.5	206	46	4.5	-	-	-	180	45	4.5	65	44	4.1	44	44	4.5
5	1200	163	47	4.0	109	48	4.5	147	47	4.3	152	45	4.9	109	44	4.7	,35	44	4.1	21	43	5.7
6	1440	135	46	3.4	75	48	4.3	105	47	4.3	99	46	3.6	164	45	3.8	54	43	3.9	19	45	4.2
7	1680	122	46	3.5	46	47	4.9	145	46	3.7	80	46	3.9	62	45	4.6	27	44	3.2	3	44	0.7
8	1920	106	46	3.3	20	48	3.8	87	45	4.5	49	45	3.7	81	44	3.0	9	43	2.8	2	43	0.4
9	2160	70	46	3.0	18	46	4.5	52	45	4.3	65	44	4.4	42	42	4.4	14	44	4.7	-	-	-
10	2400	79	46	3.6	6	46	2.2	33	46	4.5	36	45	4.8	27	43	3.5	4	45	5.1	-	-	-
11	2640	51	45	2.6	-	-	-	35	43	4.7	28	43	3.3	15	41	3.9	-	-	-	-	-	-
12	2880	54	45	3.0	-	-	-	14	43	3.9	14	40	3.7	13	43	2.7	-	-	-	-	-	-
13	3120	41	44	3.1	-	-	-	9	44	3.3	15	39	4.0	2	38	3.5	-	-	-	-	-	-
14	3360	41	43	3.6	-	-	-	-	-	-	6	37	6.8	5	42	6.0	-	-	-	-	-	-
15	3600	24	42	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	3840	24	42	3.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	4080	22	42	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	4320	10	41	3.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	4560	2	39	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	4800	6	38	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	5040	3	40	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL		1339			634			833			777			868			322			172		

[1]Size: Veh./15-Sec

[2]Vol: Volume (vph)

[3]#: Number of observations

[4]Spd.: Average Speed (mph)

[5]SE: Standard Error (mph)

*Note: These values resulted in a concave curve. This line was not used.

TABLE A2

VOLUME-SPEED COMPILATION (30-SECOND TIME INTERVAL METHOD)

		Express Cars Only			Local (Truck Percent Groups) 0 - 5%			Local 5 - 30%			Roadway (Truck Percent Groups) 30 - 50%			50 - 70%			70 - 90%			90 - 100%		
Size[1]	Vol[2]	#[3]	Spd[4]	SE	#	Spd	SE	#	Spd	SE	#	Spd	SE	#	Spd	SE	#	Spd	SE	#	Spd	SE
3	360	79	46	4.5	54	46	4.2	-	-	-	60	46	4.5	38	44	4.7	-	-	-	14	42	5.1
4	480	71	46	4.0	41	48	4.4	45	47	4.3	-	-	-	46	44	4.3	29	42	3.6	7	45	2.4
5	600	73	46	3.5	38	49	4.1	76	47	4.4	59	45	4.7	38	43	4.6	25	44	3.6	5	45	5.6
6	720	74	47	3.7	32	48	3.8	52	48	4.7	46	46	2.9	74	44	4.0	16	42	3.6	2	45	0.0
7	840	63	46	3.5	29	48	2.7	84	46	4.2	46	45	3.8	28	44	4.2	35	43	3.0	3	48	2.1
8	960	63	46	3.5	11	52*	2.4	65	47	3.5	38	45	3.7	54	44	3.1	26	43	4.6	2	44	0.8
9	1080	53	47	3.6	7	48	3.2	68	46	3.9	68	45	3.9	38	45	3.2	11	45	4.3	2	43	5.4
10	1200	47	46	2.7	15	46	4.6	49	46	4.2	55	47	2.9	47	45	3.4	27	44	3.6	4	43	3.2
11	1320	46	46	3.0	4	47	3.2	61	47	3.9	43	47	3.3	28	44	2.8	10	46	3.2	2	44	0.5
12	1440	47	46	3.0	5	47	2.5	51	47	4.1	36	45	4.4	33	45	2.9	9	42	2.8	2	44	0.5
13	1560	40	45	2.7	5	48	3.1	33	47	2.7	47	44	2.9	35	43	3.6	8	43	2.7	-	-	-
14	1680	37	45	2.8	3	47	2.8	28	45	2.3	26	44	4.1	19	45	3.7	7	42	2.8	-	-	-
15	1800	29	44	4.2	-	-	-	30	46	3.8	25	45	3.2	19	42	3.4	4	42	2.2	-	-	-
16	1920	25	46	2.6	-	-	-	24	46	3.5	31	43	3.4	18	43	3.5	3	42	1.9	-	-	-
17	2040	18	46	2.0	-	-	-	13	45	3.3	18	42	3.9	6	41	2.9	4	43	0.9	-	-	-
18	2160	18	45	3.4	-	-	-	15	46	3.8	15	43	4.1	4	45	1.9	2	36	1.5	-	-	-
19	2280	24	46	3.2	-	-	-	5	45	4.7	10	44	2.5	5	45	4.7	-	-	-	-	-	-
20	2400	15	44	1.8	-	-	-	3	45	4.2	11	43	2.3	6	43	3.2	-	-	-	-	-	-
21	2520	14	45	1.4	-	-	-	6	44	4.9	3	41	2.7	3	42	1.8	-	-	-	-	-	-
22	2640	9	44	3.3	-	-	-	4	43	3.2	3	45	1.6	-	-	-	-	-	-	-	-	-
23	2760	8	45	3.0	-	-	-	-	-	-	6	41	4.4	-	-	-	-	-	-	-	-	-
24	2880	16	44	3.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	3000	6	44	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	3120	6	44	3.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	3240	9	44	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	3360	4	43	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	3480	3	42	5.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	3600	11	42	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	3720	4	40	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL		912			244			712			646			539			216			43		

[1]Size: Veh./30-Sec.
[2]Vol: Volume (vph)
[3]#: Number of observations
[4]Spd: Average Speed (mph)
[5]SE: Standard Error (mph)
*This value seems too high and was not used in the analysis.

TABLE A3
VOLUME-SPEED COMPILATION (PLATOON METHOD)

	Express Cars Only			Local Roadway (Truck Percent Groups) 0 - 5%			5 - 30%			30 - 50%			50 - 70%			70 - 90%			90 - 100%		
Vol[2]	#[3]	Spd[4]	SE[5]	#	Spd	SE	#	Spd	SE	#	Spd	SE	#	Spd	SE	#	Spd	SE	#	Spd	SE
650	-	-	-	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
750	-	-	-	-	-	-	1	46	-	-	-	-	1	47	-	-	-	-	-	-	-
850	-	-	-	1	46	-	-	-	-	1	46	-	-	-	-	-	-	-	-	-	-
950	-	-	-	-	-	-	-	-	-	1	47	-	3	42	6.6	-	-	-	-	-	-
1050	2	46	0.7	-	-	-	3	42	2.5	-	-	-	3	44	5.5	1	45	-	-	-	-
1150	1	45	-	1	49	-	4	47	3.5	2	48	0.7	3	44	3.0	1	44	-	-	-	-
1250	4	48	5.3	-	-	-	7	44	6.0	2	46	2.8	6	44	4.5	2	43	4.9	-	-	-
1350	5	46	3.5	3	43	3.0	2	46	2.8	5	44	4.2	2	46	4.2	6	44	2.2	-	-	-
1450	3	47	1.7	1	49	-	4	48	5.0	11	45	3.3	10	44	3.9	3	38	2.0	-	-	-
1550	4	46	1.2	3	49	2.6	12	47	4.3	8	47	3.3	10	46	3.4	2	45	0.7	-	-	-
1650	9	45	1.8	4	48	2.1	12	46	2.5	4	45	2.1	6	46	3.9	6	43	2.3	-	-	-
1750	4	51	2.5	2	49	0.7	13	48	3.1	13	46	2.8	9	43	1.6	7	43	2.7	-	-	-
1850	8	46	1.8	2	47	2.8	9	44	3.8	10	44	2.9	10	41	3.6	2	48	5.6	-	-	-
1950	11	47	3.8	-	-	-	9	46	2.5	12	44	3.2	14	42	4.1	3	43	4.9	-	-	-
2050	7	45	2.8	2	51	0.0	9	46	3.8	11	43	4.0	14	43	2.7	4	41	3.3	-	-	-
2150	17	46	2.5	-	-	-	13	47	2.9	9	45	3.0	11	44	4.5	1	46	-	-	-	-
2250	15	45	2.3	-	-	-	8	46	4.9	14	45	3.0	3	41	4.0	1	40	-	-	-	-
2350	15	44	1.8	1	48	-	11	47	3.4	14	42	2.6	8	43	3.9	2	40	7.0	-	-	-
2450	10	46	2.7	-	-	-	11	43	4.0	6	45	2.7	8	39	5.3	4	44	2.9	-	-	-
2550	14	44	3.1	1	47	-	10	46	3.6	8	43	3.6	7	43	4.0	1	40	-	-	-	-
2650	14	46	2.5	1	43	-	8	44	2.2	6	43	3.8	5	43	5.1	1	43	-	-	-	-
2750	4	46	2.2	-	-	-	5	46	3.3	7	41	3.3	2	44	4.9	-	-	-	-	-	-
2850	15	46	2.9	-	-	-	6	46	5.3	3	40	2.0	4	36	3.7	1	35	-	-	-	-
2950	7	43	3.5	-	-	-	2	43	1.4	2	44	1.4	3	40	5.5	-	-	-	-	-	-
3050	3	42	1.1	-	-	-	3	44	4.5	2	43	3.5	-	-	-	-	-	-	-	-	-
3150	5	46	3.1	-	-	-	2	41	1.4	3	42	4.1	-	-	-	-	-	-	-	-	-
3250	10	43	2.1	-	-	-	2	44	5.6	3	41	3.4	-	-	-	-	-	-	-	-	-
3350	9	42	3.3	-	-	-	2	44	1.4	2	42	2.1	-	-	-	-	-	-	-	-	-
3450	8	43	2.5	-	-	-	1	43	-	-	-	-	-	-	-	-	-	-	-	-	-
3550	11	41	3.2	-	-	-	-	-	-	1	35	-	-	-	-	-	-	-	-	-	-
3650	2	44	6.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3750	6	42	1.2	-	-	-	-	-	-	1	42*	-	-	-	-	-	-	-	-	-	-
3850	6	42	5.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3950	1	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4050	2	39	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4150	1	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4250	2	40	0.7	-	-	-	-	-	-	1	42*	-	-	-	-	-	-	-	-	-	-
TOTAL	235			23			169			161			142			48					

[2]Vol: Volume (vph) [3]#: Number of observations [4]Spd: Average Speed (mph) [5]SE: Standard Error (mph)

*Not used.

TABLE A4

SPEED-VOLUME CURVES (UNCORRECTED)

$Y = A X^2 + B X + C$
Y = Speed (mph)
X = Volume (vph)

Method	Express	Truck Percent 0.0	20	40	60	80
15 Sec.*						
A	-2.45×10^{-2}	-1.01×10^{-1}	-2.27×10^{-2}	-1.24×10^{-1}	-2.57×10^{-2}	-**
B	1.21×10^{-1}	1.04×10^{0}	-1.36×10^{-2}	1.36×10^{0}	7.24×10^{-3}	-
C	4.66×10^{1}	4.54×10^{1}	4.71×10^{1}	4.24×10^{1}	4.50×10^{1}	-
RMS	0.67	0.61	0.78	0.69	1.28	-
30 Sec.						
A	-5.93×10^{-7}	-1.40×10^{-6}	-5.56×10^{-7}	-5.63×10^{-7}	-6.81×10^{-7}	-2.58×10^{-6}
B	1.11×10^{-3}	2.46×10^{-3}	3.86×10^{-4}	7.36×10^{-5}	1.45×10^{-3}	6.07×10^{-3}
C	4.56×10^{1}	4.67×10^{1}	4.70×10^{1}	4.59×10^{1}	4.34×10^{1}	4.01×10^{1}
RMS	0.70	0.89	0.62	1.16	1.11	1.12
Platoon						
A	$-6.76 - 10^{-7}$	-2.33×10^{-7}	-1.30×10^{-6}	-8.63×10^{-7}	-9.09×10^{-7}	-3.62×10^{-6}
B	1.58×10^{-3}	7.34×10^{-3}	4.61×10^{-3}	1.04×10^{-3}	1.07×10^{-3}	1.14×10^{-2}
C	4.56×10^{1}	4.25×10^{1}	4.20×10^{1}	4.61×10^{1}	4.46×10^{1}	3.49×10^{1}
RMS	1.52	2.04	1.47	1.50	1.91	2.50

Note: RMS = Root mean square value.
*"X" in vehicles/15 seconds.
**This curve was concave and was not used.

TABLE A5

ASSUMED VOLUMES

Speed (mph)	Express*	Truck Percent 20	40	60	80*
35.0	4000	3580	3170	2750	2330
36.0	3860	3460	3060	2660	2260
37.0	3710	3320	2940	2560	2180
38.0	3550	3180	2820	2460	2090
39.0	3380	3030	2690	2340	2000
40.0	3190	2870	2540	2220	1890
41.0	3000	2690	2380	2080	1770
42.0	2780	2490	2200	1910	1620
43.0	2540	2260	1980	1700	1420
43.7	(2360)	(2040)	(1720)	(1390)	(1070)
44.0	2256	(1900)	(1600)	(1240)	-
44.3	(2180)	(1770)	(1440)	(1000)	-
45.0	1903	(1400)	(940)	-	-
45.7	(1600)	(860)	-	-	-
46.0	1358	-	-	-	-

Note: Volumes for 20%, 40%, and 60% trucks are assumed to fall equidistantly between the express and 80% truck sets of values. These volumes in parentheses are taken from the "Speed-Volume Curves, Fig. 4."

*Limiting values.

TABLE A6

TRUCK EQUIVALENT FACTORS (car/truck)

Speed (mph)	Truck Percent 20	40	60	80
35.0	1.58	1.66	1.76	1.89
36.0	1.58	1.65	1.75	1.88
37.0	1.57	1.65	1.74	1.88
38.0	1.57	1.64	1.74	1.87
39.0	1.57	1.64	1.74	1.86
40.0	1.57	1.64	1.73	1.86
41.0	1.57	1.64	1.74	1.86
42.0	1.58	1.66	1.76	1.89
43.0	1.62	1.70	1.82	1.98
43.7	1.78	1.93	2.16	2.51
44.0	1.94	2.02	2.36	-
44.3	2.16	2.28	2.97	-
45.0	2.80	3.56	-	-
45.7	5.30	-	-	-
Approx. Avg. (for speeds between 35 mph and 43 mph.)	1.60	1.65	1.75	1.90