A Method for Estimating Design Hourly Traffic Volumes

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A method is described for estimating traffic volumes in the 30th highest hour from the ADT at any location on the state trunk rural system, where 30 HV traffic volumes are not available, by utilizing the relationship between 30 HV and ADT at PTR installations. Before estimates of 30 HV can be made from ADT, the ADT must be readily available at any rural location. Estimates of ADT can readily be determined by developing a group mean monthly conversion factor for each PTR group. These factors are applied to 24-hour rural traffic counts to obtain statistically reliable estimates of ADT. Estimating 30 HV from ADT is also accomplished on a PTR group basis because this study shows that the 30 HV-ADT relationship at PTR installations is the relationship typical of all variates included in a PTR group. The equation for the line of average relationship fitted to the variates of each PTR group can, therefore, be used to estimate 30 HV on a PTR group basis.

Analyses of 30 HV-ADT variates at individual PTRs, PTR groups, and the variates of all PTRs in operation each year show that there is an existing relationship between X and Y which is at most of a linear form. The regression analysis made indicated that there is an existing linear relationship between 30 HV and ADT at PTR installations and this relationship is also characteristic of PTR group variates. The fitted least squares lines are good expressions of the existing average relationship between the individual PTR variates and between PTR group variates. High values of X are related to high values of Y, and low values of X to low values of Y; most of the change in Y can be explained by the change in X. The stability of the existing relationship shows that the group estimating equations can be used to obtain satisfactory working estimates of interpolated or extrapolated values of traffic volumes in the 30th hour.

•THIS STUDY was made for the purpose of developing a method for estimating traffic volumes in the 30th highest hour (30 HV) at any location on the rural state trunk highway system, where 30 HV traffic volumes are not directly available, by utilizing the existing relationship between 30 HV and average annual daily traffic (ADT) at the permanent traffic recorders (PTRs).

Average annual daily traffic and 30 HV are important criteria in highway design. ADT is readily understood and is an important indicator of annual highway usage; 30 HV is important because it has been established that "the hourly traffic volume used in design should be the 30th highest hourly volume of the year" (1, p. 55), which

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simply means that there are only 29 hours in the year having traffic volumes exceeding that of the 30th hour. The 30th hour of the future year chosen for design is termed the design hourly volume or DHV (1, p. 58).

Hourly traffic volumes are registered automatically at all of the PTRs in operation on the state trunk rural system. The number of PTRs has been increased from 7 in 1947 to 35 in 1961. Traffic volumes in the 30th hour are, therefore, readily available at all PTR locations. The PTR locations provide exact values of the 30 HV traffic volumes. There are many other locations at which PTRs have not been installed but for which estimates of 30 HV are desired. The purpose of this paper is to describe a method for estimating 30 HV for locations without PTR installations.

The practicality of this estimating procedure is dependent on two basic conditions: (a) availability of ADT at any rural location on the state trunk system, and (b) an equation describing a line of average relationship which can be used to estimate 30 HV from ADT.

The first restriction, availability of ADT, was removed when Wisconsin adopted a new system for counting traffic to improve the quality of the computed ADT estimates based on the 24-hour traffic counting operations conducted at the coverage stations (2). Basically, the new procedures provide that all rural highways be classified by traffic patterns determined on the basis of the monthly average weekday-ADT ratios at all PTRs. All PTRs having the same ratios (within prescribed percentage limits) are presumed to have the same annual traffic pattern. In the same manner, similar ratios are also computed for all seasonal control stations which are operated for one week each month from April through November.

When all PTRs have been allocated to a group, a mean monthly factor is computed for each group of PTRs. The seasonal control station factors are then compared with the PTR group mean monthly factors (GMFs) which serve as a guide in the allocation of all seasonal control stations to PTR groups. Each PTR group is given an identifying color and each station location on the state trunk rural system is identified by the same color as the PTR group to which it was assigned. By connecting the stations having the same color, it is possible to assign all mileage on the rural system to one of the currently established six PTR groups. Inasmuch as all rural highway mileage has been assigned to a PTR group on the basis of similarities in traffic patterns, any rural location on a highway assigned to a PTR group is also presumed to have the same traffic pattern. For that reason, estimates of ADT can be determined for any rural location by multiplying the 24-hour traffic count by the appropriate GMF.

The reliability of ADT estimates obtained in this manner was tested by statistical methods involving the simulation of coverage station operations at PTR locations. That is, samples of 24-hour traffic counts were randomly selected from PTR data, converted to estimates of ADT by the method previously described, and compared with the true ADTs computed from the population data. Analysis of the differences between the sample ADTs and population ADTs, based on the Chi-square test, showed that the errors or differences were normally distributed and that the normal probability concepts can be attributed to the sample statistics.

This analysis demonstrated that traffic characteristics at coverage stations reflect the traffic characteristics at PTR installations. The new procedures offer a convenient method for determining statistically reliable estimates of ADT. The availability of such estimates provides the means whereby estimates of 30 HV can be made when the ADT is known.

The proposed method for finding satisfactory working estimates of 30 HV is based on the relationship between the 30 HV (Y) and ADT (X) variates at the PTR installations. As any paired values of X and Y will seldom fall in a straight line, it is desirable to use a mathematical equation for the purpose of obtaining a close approximation to the observed values. The line of relationship selected for this purpose is based on the principle of least squares which reduces to a minimum the sum of the squares of the deviations of the actual values from the line fitted to the data. The equation for a line fitted by the least squares method is $y = a + b x$, in which a is the intercept and b is the slope of the line. This shows how much of the change in Y results from a change in X; for our purposes, X will always be ADT and Y is 30 HV or an estimate of 30 HV.

As the line of least squares is an expression of the average relationship between X and Y, the coefficient of correlation, r, measures the degree of association between the variates. The value of r can be any value between +1.0 and -1.0. A value of ±1.0 means that the coordinates of X and Y would all fall on the line of relationship. In this case, there would be no deviations in the observed values of Y from the theoretical or computed values of Y.

As r indicates the degree of association between paired values of X and Y, the square of r, denoted by R^2, shows how much of the variation in Y can be explained by the variation in X; and this is probably a more descriptive term. Thus, if a good measure of correlation between X and Y is r = 0.9, then $R^2 = 0.81$, or 81 percent of the change in Y is explained by the change in X.

A measure of the dispersion or scatter of actual values about the line of relationship is called the standard of estimate. The mean of the sum of all squared differences, or mean square error, between the actual or theoretical values derived from the equation for the line of relationship is the estimated variance, S_y^2. This term is used to describe the total variance in the scatter of observed values about the line of regression. Actually S_y^2 is the residual mean square error derived from the equation

TABLE 1

PAIRED VALUES OF SUCCESSIVE ADTs AT SELECTED PTRs

ADT							
PTR 2		PTR 16		PTR 18		PTR 23	
x_i	$x_{i+1} = y$	x_i	$x_{i+1} = y$	x_i	$x_{i+1} = y$	x_i	$x_{i+1} = y$
8,196	9,286	1,293	1,538	3,597	4,050	2,450	2,751
9,286	9,443	1,538	1,423	4,050	4,161	2,751	2,985
9,443	11,944	1,423	1,578	4,161	4,404	2,985	3,251
11,944	12,756	1,578	1,607	4,404	4,585	3,251	3,155
12,756	11,886	1,607	1,638	4,585	4,578	3,155	3,312
11,886	12,746	1,638	1,833	4,578	4,675	3,312	3,408
12,746	12,494	1,833	1,896	4,675	5,084	3,408	3,609
12,494	14,152	1,896	1,988	5,084	5,384	3,609	3,764
14,152	14,407	1,988	2,133	5,384	5,391	3,764	3,952
14,407	14,560	2,133	1,993	5,391	5,226	3,952	3,974
14,560	14,340	1,993	2,120	5,226	5,516	-	-
14,340	14,111	2,120	2,221	5,516	5,520	-	-
14,111	15,355	2,221	2,292	5,520	5,634	-	-
15,355	17,696	2,292	2,340	-	-	-	-

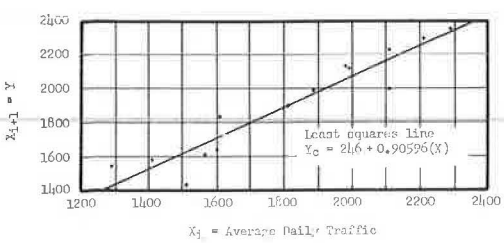

Figure 1. Serial correlation, PTR 16, 1947-1961.

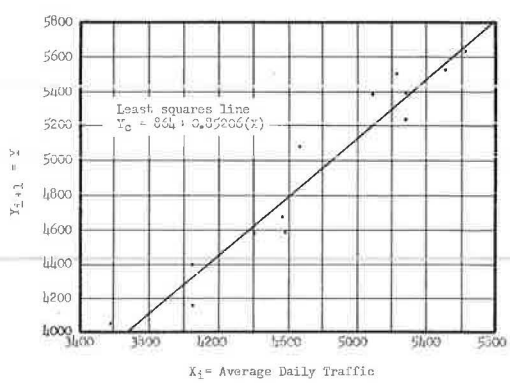

Figure 2. Serial correlation, PTR 18, 1947-1961.

$$S_y^2 = \frac{\Sigma (Y - Y_c)^2}{N} \tag{1}$$

Another common measure of dispersion is the average deviation, A.D., of the sum of the differences (signs ignored) between the computed values, Y_c, and the actual values of Y, or

$$A.D. = \frac{\Sigma |Y - Y_c|}{N} \tag{2}$$

With the preceding connotations of R^2 and S_y^2 in mind, R^2, S_y^2, and A.D. can all be considered indices of fit associated with the particular line of least squares to which they have reference.

The first approach to the problem of estimating 30 HV from ADT involved a determination of order or serial correlation between four groups of successive overlapping pairs of X and Y variates in PTR data. In this process, the x_i and x_{i+1} variates of the four PTRs selected for this purpose are paired and a line of relationship is fitted to the data. Trend or growth is a characteristic attribute of all ADTs at PTR installations, so the test of serial correlation was applied to only the four PTRs given in Table 1.

ADT is the x_i variate and x_{i+1} serves as the Y variate of the chosen PTRs. Figures 1 and 2 are scatter diagrams of the PTR variates with the fitted lines of least squares. Each plotted point is the relation between x_i and x_{i+1}. The equations for the lines of average relationship and other pertinent statistics of the selected PTRs are given in Table 2.

TABLE 2

PTR	Line of Least Squares	r	R^2	A.D. (veh)
2	$Y_c = 1954 + 0.89885(X)$	+0.897	0.8051	382
16	$Y_c = 246 + 0.90596(X)$	+0.942	0.8874	78
18	$Y_c = 864 + 0.85206(X)$	+0.961	0.9235	125
23	$Y_c = 601 + 0.86256(X)$	+0.969	0.9390	69

TABLE 3

AVERAGE LINES OF RELATIONSHIP, R^2 AND S_y^2 FOR PTRs HAVING SIX OR MORE YEARS' DATA[a]

PTR	N (yr)	Avg. Line Relationship ($Y_c = a + bX$)	R^2	S_y^2
2	15	$Y_c = 283 + 0.09966(X)$	88.82	7,453
13	15	$Y_c = 5 + 0.13127(X)$	80.07	6,563
14	15	$Y_c = 126 + 0.11032(X)$	81.20	1,127
15	15	$Y_c = 229 + 0.26645(X)$	94.02	601
16	15	$Y_c = -64 + 0.20081(X)$	95.03	216
17	15	$Y_c = 53 + 0.14932(X)$	96.80	63
18	15	$Y_c = -45 + 0.15299(X)$	87.06	1,245
21	12	$Y_c = 66 + 0.16621(X)$	83.00	1,138
22	12	$Y_c = 127 + 0.09593(X)$	75.84	1,750
23	11	$Y_c = 212 + 0.06968(X)$	71.35	415
24	8	$Y_c = 22 + 0.14630(X)$	96.69	193
25	8	$Y_c = 24 + 0.18056(X)$	93.60	1,281
26	7	$Y_c = -564 + 0.23362(X)$	82.47	5,236
27	8	$Y_c = 245 + 0.10673(X)$	44.92	1,643
28	8	$Y_c = 99 + 0.14085(X)$	95.31	183
29	8	$Y_c = 358 + 0.07774(X)$	63.63	324
30	6	$Y_c = -86 + 0.15034(X)$	98.02	106
31	6	$Y_c = 196 + 0.09210(X)$	46.82	393

[a]PTRs 3 to 12 and 32 to 39, inclusive, were in operation for only four or less years.

Based on the high values of r resulting from the test of serial correlation in the paired variates in Table 1, and from the visual inspection of Figures 1 and 2, it appears that: (a) there is good correlation between the paired variates, (b) good correlation is typical of data having an ascending series of values, (c) the high positive correlation is indicative of a lack of randomness in the arrangement of values, (d) the high value of r can be used as an indication of a simple test of linearity, (e) the relationship between the variates can be described in linear terms, (f) at all selected PTRs the least squares line is a good fit, and (g) in all cases at least 80 percent of the variation in Y (x_{i+1}) is explained by the variation in x_i. The fact that r for this kind of data is generally somewhat overstated does not disprove the relationship between the paired variates; rather, correlation is present, but care should be exercised in the interpretation of this value.

Proceeding on the assumption of linearity indicated by the serial correlation analysis, lines of least squares were fitted to the X and Y variates at each PTR in operation for six or more years. The

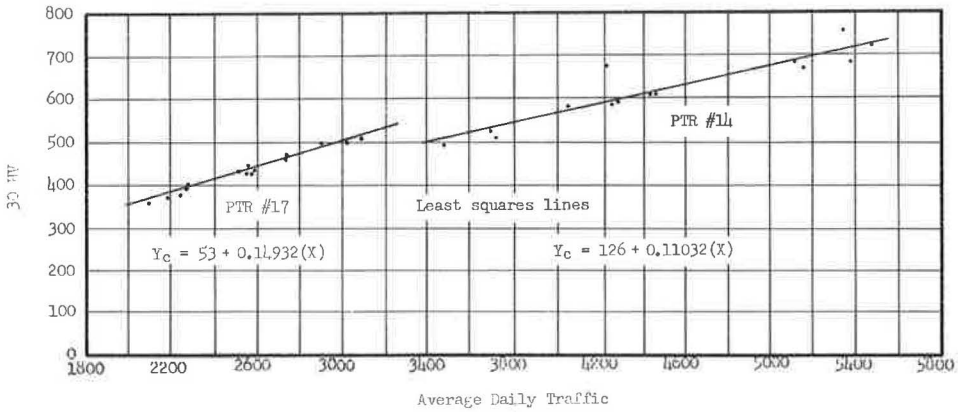

Figure 3. Relationship typical of PTR data.

TABLE 4

LINES OF AVERAGE ANNUAL RELATIONSHIP, 1947 - 1961

Year	N	Least Squares Line ($Y_c = a + bX$)	Indices of Fit R^2	Indices of Fit S_y^2
1947	7	$Y_c = 34 + 0.13292(X)$	96.21	3,181
1948	7	$Y_c = 70 + 0.13310(X)$	99.46	599
1949	8	$Y_c = 121 + 0.11600(X)$	97.36	2,311
1950	9	$Y_c = 155 + 0.10972(X)$	97.83	2,539
1951	10	$Y_c = 59 + 0.13489(X)$	99.08	1,672
1952	10	$Y_c = 134 + 0.11510(X)$	98.42	1,799
1953	10	$Y_c = 136 + 0.11452(X)$	98.61	2,016
1954	15	$Y_c = 203 + 0.10108(X)$	92.70	4,552
1955	15	$Y_c = 154 + 0.10654(X)$	95.61	4,825
1956	18	$Y_c = 173 + 0.10803(X)$	94.72	5,640
1957	18	$Y_c = 169 + 0.11062(X)$	93.59	7,077
1958	19	$Y_c = 159 + 0.10984(X)$	92.93	7,677
1959	25	$Y_c = 84 + 0.12356(X)$	91.22	11,337
1960	34	$Y_c = 55 + 0.12947(X)$	94.41	8,987
1961	35	$Y_c = 55 + 0.12692(X)$	95.28	8,466

values of the terms for the least squares lines, the number of years each PTR was in operation, R^2, and S_y^2 are shown in Table 3. This table indicates that, even though the value of R^2 is subject to some exaggeration because of the inherent serial relationship in these data, the relationship between X and Y is good. High values of X are related to high values of Y and low values of X to low values of Y. At 13 of the 18 PTRs, R^2 = 80 percent or more, which is a good indication that the change in Y can be explained by the change in X. PTRs 22 and 23 approach this figure but 29 and 31 are considerably below the 80 percent criteria.

Moderate to very good values for S_y^2 indicate that the line of least squares is a good fit to the data. The greatest mean square errors were prevalent at the high traffic volume PTRs such as 2, 13, 22, 26, and 27. Actually PTRs 2 and 13 are more characteristic of urban than rural traffic conditions and could be excluded from this analysis of X-Y relationship in rural areas.

A further aid to evaluation of the data at the PTRs is presented in Figure 3. Visual inspection of the least squares lines fitted to the X-Y variates of PTRs 17 and 18, selected as being representative examples of the type of data available at all PTRs, shows a definite linearity in the pattern of plotted points. The small scatter of points is reflected in the low average deviation of 25 vehicles about the least squares line of PTR 14 and only 7 vehicles for PTR 17. In both examples the indices of fit are good. The estimating equations can produce theoretical values of Y closely approximating the original actual values obtained at PTRs 14 and 17. Similar good approximations of computed values of Y can be expected at the other PTRs in view of the high values of R^2 and the relatively low mean square errors, S_y^2. The evidence of a good degree of association between the X-Y variates at PTR installations appears to be quite conclusive.

Another very important problem in regression analysis is the stability in the data. The relationship between X and Y must not only exist but must also be a repetitive or

recurring relationship persistent over the years before it can be used for interpolating and especially for extrapolation. Stability in these data was measured by fitting a line of least squares to the X and Y variates of all PTRs for each year from 1947 through 1961 and computing the indices of fit for each year. The values of the terms for the least squares line fitted to each year's X and Y variates, the number of annual observations N, R^2 and Sy^2, are shown in Table 4.

As can be seen from Table 4, very good results are obtained from the fitted lines of average relationship. The slopes of the lines, the coefficients of X, are in close agreement from year to year. The percent of change in Y explained by the change in X, R^2, is an annually recurrent high percentage, indicative of a good relationship between X and Y variates. The mean square errors are not unreasonable when the extreme variations in the data are taken into consideration.

Although the earlier serial correlation analysis gave evidence of an exaggeration in r because of the arrangement of values in the series, a similar arrangement of values is not characteristic of the annual data. There is, nevertheless, a high degree of

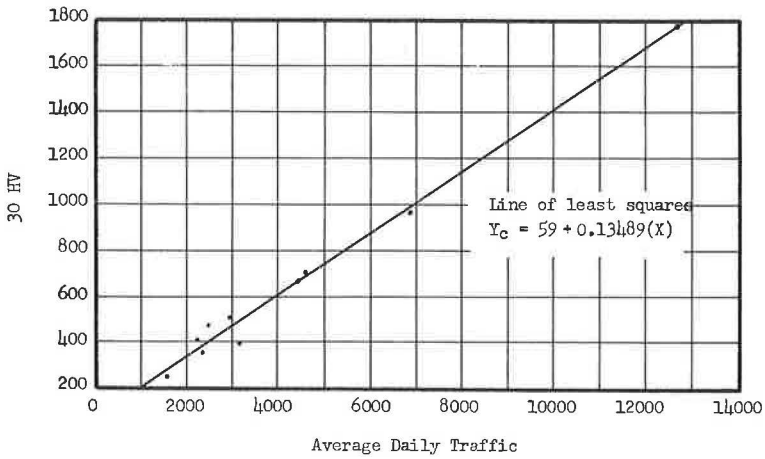

Figure 4. Line of average relationship, all PTR data, 1951.

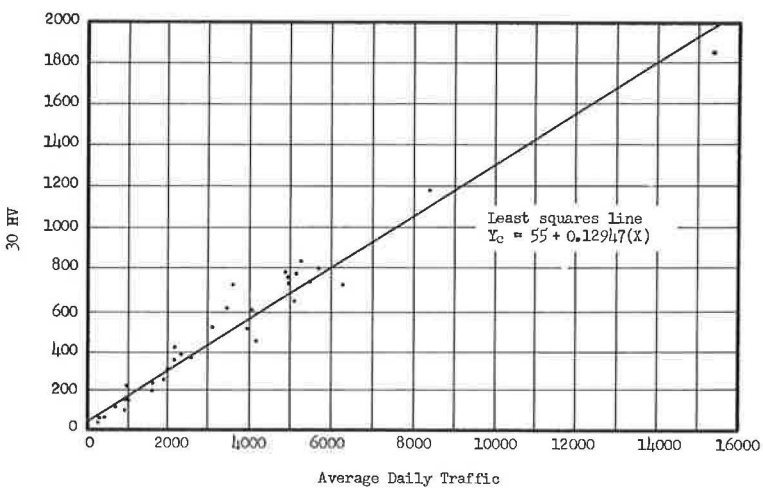

Figure 5. Line of average relationship, all PTR data, 1960.

TABLE 5

PTR GROUP I, 30 HV AND ADT VALUES, 1947 - 1961[a]

30 HV (Y)	ADT (X)	30 HV (Y)	ADT (X)
1,088	8,096	354	2,450
1,298	9,286	412	2,751
1,172	9,443	435	2,985
1,418	11,944	477	3,251
1,782	12,756	423	3,155
1,494	11,886	433	3,312
1,584	12,746	461	3,408
1,452	12,494	460	3,609
1,578	14,152	479	3,764
1,664	14,407	501	3,952
1,696	14,560	451	3,974
1,619	14,340	118	674
1,663	14,111	133	688
1,846	15,355	51	367
2,149	17,696	60	412

[a]Includes PTRs 2, 23, 37, and 39; actual values given as number of vehicles.

association between X and Y which cannot be attributed to the growth influence of an ascending series of values because the least squares lines for each year were fitted independently of the preceding or subsequent years' values.

The years 1951 and 1960 are used to illustrate the relationship typical of the X-Y variates of each year's annual data. The 10 observed values in 1951 are plotted in Figure 4, and the 34 observations in 1960 are plotted in Figure 5. Regardless of the number of values, the pattern of points for both years is definitely linear. The indices of fit for all years indicate that the least squares lines are a good fit to the annual data. In all years there is a high degree of association between X-Y variates. The similarity in the slopes of the lines and recurrent acceptable values of R^2 and S_y^2 give every indication of stability in the relationship between 30 HV and ADT.

Having established the fact that there is an existing relationship between the X-Y variates at the individual PTR installations and the apparent stability of this relationship, we can proceed with the determination of a series of estimating equations which describe the line of average relationship characteristic of the X and Y variates in each PTR group.

Table 5 gives the 30 HV and ADT values available at PTRs 2, 23, 37, and 39 comprising PTR Group I. A scatter diagram of the values in Table 4 is shown in Figure 6. As in other diagrams, each point represents the relation between each pair of observed values. It is evident from Figure 6 and Table 4 that the points do not fall exactly in a straight line, but the relationship between the X-Y variates of Group I is

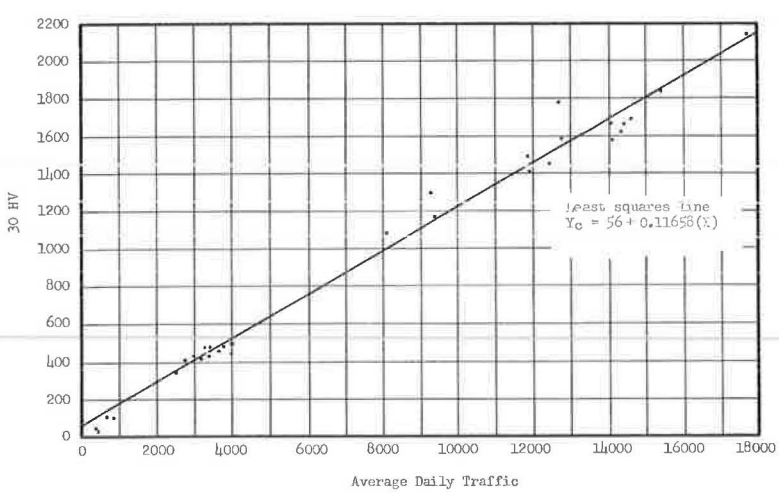

Figure 6. Average line of relationship, PTR Group I, 1947-1961.

TABLE 6

PTR GROUP II, 30 HV AND ADT VALUES, 1950 - 1961[a]

30 HV (Y)	ADT (X)	30 HV (Y)	ADT (X)
425	3,049	331	1,792
387	3,037	323	1,890
460	3,260	225	1,538
484	3,408	229	1,578
461	3,594	195	1,567
554	4,465	443	4,022
553	4,719	502	4,447
524	4,507	366	3,473
681	4,748	100	885
504	4,767	88	746
633	5,067	190	1,590
624	5,114	200	1,667
650	3,691	191	1,644
184	1,005	156	1,258
269	1,344	—	—

[a]Includes PTRs 3, 4, 9, 22, 25, and 34; actual values given as number of vehicles.

similar to a trend which can be described in linear terms. The equation for the least squares line fitted to Group I data is

$$Y_c = 56 + 0.11658(X) \qquad (3)$$

The estimate of 30 HV is Y_c, X = ADT, and b = 0.11658. This means that there is a corresponding increase of 11.658 vehicles in Y when there is an increase of 100 vehicles in X. Other statistical terms associated with the least squares line for Group I are shown in Table 11. The Group I statistics indicate that the relationship between X-Y is very good because $R^2 = 0.9877$ or 99 percent of the change in Y can be explained by the change in X. The variance, mean square error, is not unduly high. Most of the variance is attributable to PTR 2 which has ADT values ranging from 8,000 to 17,500 and 30 HV values from 1,100 to 2,150.

The average deviation of all differences (Eq. 2) about the line of least squares is 49 vehicles, or on an average basis we can expect that the estimates of 30 HV based on Group I estimating equation will vary about 49 vehicles from the actual values of 30 HV. Figure 6 is an illustration of good 30 HV-ADT relationships in Group I data, and the Group I estimating equation can be used to obtain satisfactory estimates of 30 HV from ADTs at rural locations on highways assigned to this group even though there is an extremely large range in the ADT values.

The actual values of ADT and 30 HV for Group II are given in Table 6, and the scatter diagram of the plotted points with the fitted least squares line is shown in Figure 7. Group III data are in Table 7 and Figure 8, Group IV in Table 8 and Figure 9, Group V in Table 9 and Figure 10, and Group VI in Table 10 and Figure 11.

Table 11 gives the equations describing the line of average relationship typical of each PTR group and PTRs 14, 28, and 29. This table also shows the number of observations in each group and the indices of fit for all groups and separately listed PTRs.

The interpretations of the applicable descriptive statistics associated with the line of least squares for Groups II to VI and PTRs 14, 28, and 29, shown in Table 11, are of necessity along the same lines as those made in connection with Group I. Therefore, to avoid redundancy, we believe an adequate description of Groups II to VI can be achieved by reference to Tables 6 through 10 and Figures 7 through 11.

The original observations of ADT and 30 HV values for PTRs 14, 28, and 29 are not presented; however, the values are plotted in Figure 12. These three PTRs are shown separately because even though their PTR grouping (14 in IV, 28 in III, and 29 in VI) is satisfactory for ADT estimations, they have individual 30 HV-ADT relationships that are at variance with the average relationship of the group to which they are assigned.

A further indication of the precision in estimates of 30 HV derived from the respective PTR group least squares equations is given in Table 12. It is evident from the comparison of actual mean 30 HV values with the computed estimates of 30 HV that the estimated group mean 30 HV values do not vary more than 35 vehicles from the actual group mean values. The percentages which the group mean estimates of 30 HV are of the actual group mean ADTs are likewise in close agreement.

TABLE 7

PTR GROUP III, 30 HV AND ADT VALUES, 1947-1961[a]

30 HV (Y)	ADT (X)	30 HV (Y)	ADT (X)
184	1,293	796	5,634
244	1,538	808	5,015
217	1,423	664	4,124
258	1,578	638	4,146
249	1,607	744	4,368
286	1,638	819	4,593
293	1,833	709	4,371
321	1,896	740	4,642
345	1,988	773	4,886
402	2,133	753	5,189
333	1,993	962	7,088
373	2,120	993	7,073
369	2,221	957	6,928
379	2,292	1,063	7,592
390	2,340	1,170	8,360
427	3,597	1,033	7,472
622	4,050	546	3,474
618	4,161	531	3,528
630	4,404	500	3,494
668	4,585	520	3,734
651	4,578	586	4,056
672	4,675	519	3,716
725	5,084	241	1,858
744	5,384	269	2,027
774	5,391	403	2,196
762	5,226	384	2,354
787	5,516	771	5,120
787	5,520	776	4,947

[a]Includes PTRs 16, 18, 27, 30, 31, 35, 36, and 38; actual values given in number of vehicles.

The use of the PTR group equations for estimating extrapolated values is dependent on the basic assumption that the history of past experience in this field will also be the history of future experience. In other words, it is presumed that the indicated linearity of past data will also be characteristic of these data in the future.

Justification of this premise is based on: (a) the serial correlation test of linearity, (b) the existence of an X-Y relationship at all PTRs and PTR groups, (c) the evidence of linearity in the various scatter diagrams, (d) the stability of the X-Y relationship manifested by the results of the regression analysis of annual data extending over a period of 15 years, and (e) the small variations in estimates of 30 HV, obtained by using the various estimating equations, from actual values. At any rate, there seem to be no valid reasons for anticipating that the existing average relationship typical of the period from 1947 to 1961 will not be a characteristic relationship in the future.

Estimates of DHV, traffic volumes in the 30th highest hour of the future year chosen for design, were made from extrapolated values of ADT and are given in Table 13. These extrapolations of ADT are based on a previous study of trends at each PTR. PTRs were grouped and a group mean ADT was computed for each PTR group. The PTR group mean ADT in 1961 is shown as a ratio of the PTR group mean ADT in 1981. The ratio of the 1981 group mean ADT to the group mean ADT in 1961 is the expansion factor

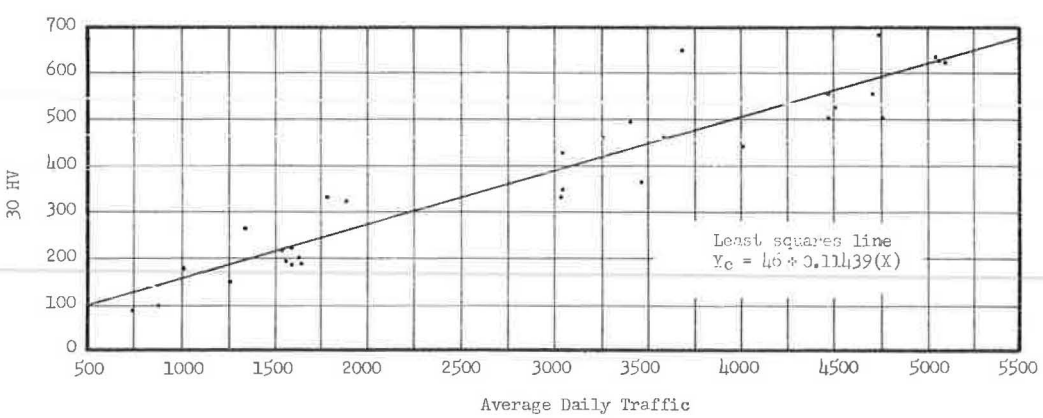

Figure 7. Average line of relationship, PTR Group II, 1950-1961.

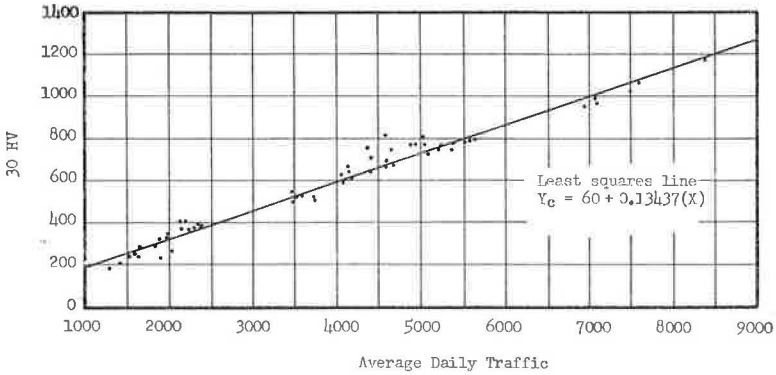

Figure 8. Average line of relationship, PTR Group III, 1947-1961.

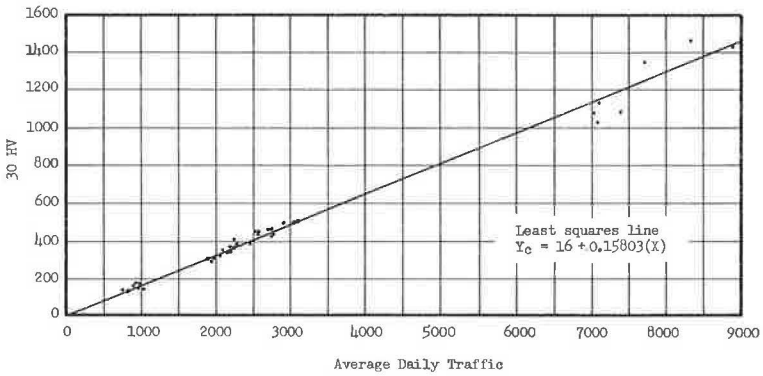

Figure 9. Average line of relationship, PTR Group IV, 1947-1961.

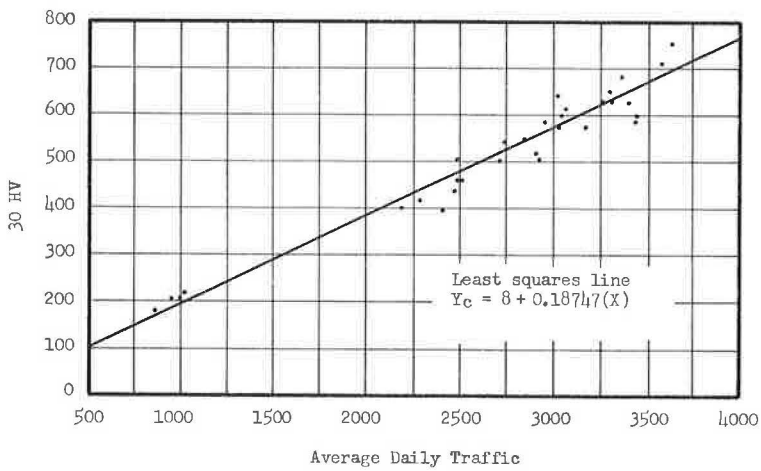

Figure 10. Average line of relationship, PTR Group V, 1947-1961.

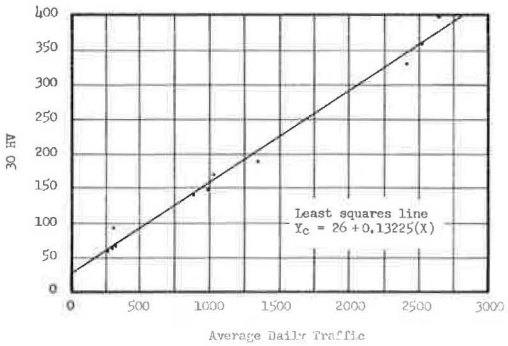

Figure 11. Average line of relationship, PTR Group VI, 1959-1961.

TABLE 8

PTR GROUP IV, 30 HV AND ADT VALUES, 1947-1961[a]

30 HV (Y)	ADT (X)	30 HV (Y)	ADT (X)
357	2,095	174	913
374	2,181	146	780
378	2,239	141	832
405	2,271	151	973
391	2,278	145	1,034
442	2,549	1,029	7,074
427	2,571	1,079	7,401
449	2,560	1,079	7,024
468	2,731	1,133	7,108
430	2,517	1,356	7,737
439	2,539	1,462	8,348
455	2,721	1,440	8,909
491	2,911	317	1,980
504	3,080	309	1,957
499	3,022	316	1,898
385	2,461	356	2,198
173	993	349	2,130
174	979	330	2,022

[a]Includes PTRs 5, 6, 17, 24, and 26; actual values given as number of vehicles.

TABLE 9

PTR GROUP V, 30 HV AND ADT VALUES, 1947-1961[a]

30 HV (Y)	ADT (X)	30 HV (Y)	ADT (X)
393	2,401	416	2,285
434	2,479	463	2,497
460	2,478	540	2,741
505	2,705	547	2,844
503	2,923	646	3,016
514	2,903	507	2,485
575	3,172	628	3,252
595	3,042	631	3,316
571	3,023	627	3,412
614	3,063	597	3,446
586	2,945	593	3,442
651	3,298	178	865
686	3,353	201	949
711	3,587	207	976
755	3,628	213	1,006
405	2,186	-	-

[a]Includes PTRs 15, 21, and 32; actual values given as number of vehicles.

TABLE 10

PTR GROUP VI, 30 HV AND ADT VALUES, 1959-1961[a]

30 HV (Y)	ADT (X)	30 HV (Y)	ADT (X)
401	2,646	187	1,338
359	2,534	59	255
330	2,406	91	309
166	1,034	62	300
147	995	65	304
140	878	-	-

[a]Includes PTRs 7, 8, 10, 11, and 12; actual values given as number of vehicles.

which is used to convert the 1961 group estimates of ADT to estimates of ADT in 1981. The indicated projected values of ADT in 1981 and the respective PTR group mean expansion factors were designed for our use and are not to be interpreted as being official estimates of ADT in 1981 or official factors for projecting ADTs in 1961 to estimates of ADT in 1981.

Obviously, the growth trend at all PTR installations is not the same. It should be remembered, however, that the proposed estimating procedures are geared to represent average conditions typical of each PTR group; therefore, even though there is a variation in trend at the individual PTRs, the adequacy of this procedure appears to be justified in view of the results obtained in the preceding analysis.

TABLE 11

LINES OF AVERAGE RELATIONSHIP AND INDICES OF FIT

PTR Group	No. of Observations	Line of Least Squares ($Y_c = a + bX$)	Indices of Fit		
			R^2	S_y^2	A. D.
I	30	$Y_c = 56 + 0.11658(X)$	98.77	5,124	49
II	29	$Y_c = 46 + 0.11439(X)$	89.17	3,298	44
III	56	$Y_c = 60 + 0.13437(X)$	96.70	1,801	32
IV	36	$Y_c = 16 + 0.15912(X)$	98.77	1,698	25
V	31	$Y_c = 8 + 0.18747(X)$	94.61	1,199	28
VI	11	$Y_c = 26 + 0.13225(X)$	98.83	165	9
PTRs					
14	15	$Y_c = 125 + 0.11032(X)$	81.20	1,127	25
28	8	$Y_c = 99 + 0.14085(X)$	95.31	183	11
29	8	$Y_c = 358 + 0.07774(X)$	63.62	324	15

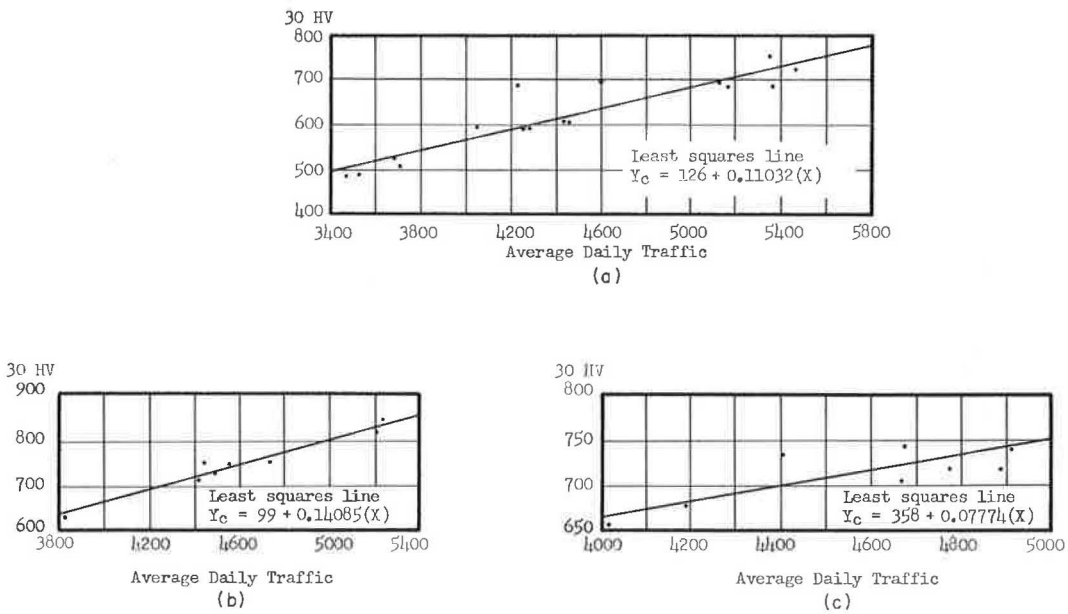

Figure 12. Average lines of relationship, selected PTR: (a) 14, Waupaca, 1947-1961; (b) 28, Fairchild, 1954-1961; and (c) 29, Superior, 1954-1961.

TABLE 12

30 HV ACTUAL OBSERVATIONS VS THEORETICAL AND PERCENT EACH IS OF ADT, 1961

PTR Group	ADT (veh)	Mean 30 HV (veh)		Percent 30 HV of ADT (veh)	
		Actual	Estimated	Actual	Estimated
I	5,693	693	720	12.2	12.7
II	2,463	293	328	11.9	13.3
III	4,133	617	615	14.9	14.9
IV	3,377	546	553	16.2	16.4
V	2,694	520	513	19.3	19.0
VI	1,232	180	189	14.6	15.4

Table 13 also shows the PTR group mean ADTs for 1961 and 1981, the expansion factor for each group and the percentage which each group estimate of 30 HV and DHV is of the group mean ADT. Estimates of DHV for each group were obtained by using the appropriate PTR group estimating equation. The presumptive linearity in the data produces percentage estimates of ADT which are in close agreement in all groups for 1961

TABLE 13

30 HV AND DHV AS PERCENT OF ADT, 1961 AND 1981

PTR Group	1961 Mean ADT (veh)	Expansion Factor	1981 Est. Mean ADT (veh)	Percent 30th Hour of ADT in	
				1961 Actual (30 HV)	1981 Est. (DHV)
I	5,693	3.1	17,650	12.2	12.0
II	2,463	4.2	10,350	11.9	11.9
III	4,133	2.4	9,920	14.9	14.0
IV	3,377	2.1	7,090	16.2	16.1
V	2,694	2.5	6,735	19.3	18.9
VI	1,232	2.2	2,710	14.6	14.2

and 1981. The differences between 1961 and 1981 percents for each group can be attributed to the error in the estimated observations and the rounding-off process in the 1981 estimated ADTs. Table 13 and also Table 12 show that there is a considerable difference between the percent that the 30th hour traffic volume is of ADT in the various PTR groups. According to the actual observations, Group II has the smallest percentage (11.9 percent) and Group V has the largest (19.3 percent).

On the basis of the preceding analysis of 30 HV-ADT data available at all PTRs in operation on the state trunk rural system from 1947 through 1961, it is concluded that the major findings of this study are as follows:

1. There is an existing relationship between 30 HV and ADT at PTR installations and this relationship is also characteristic of PTR group variates.
2. For all practical purposes, the relationship between 30 HV and ADT is presumed to be linear.
3. The fitted least squares lines are good expressions of the average relationship between the individual PTR variates and between PTR group variates.
4. The stability of the existing relationship supports the use of regression analysis as a method for obtaining interpolated or extrapolated estimates of traffic volumes in the 30th hour.
5. The PTR group estimating equations produce satisfactory working estimates of 30 HV.
6. The relationship between the variates is overstated because of the growth trend in an ascending series of values. The relationship should be discounted; nevertheless, there are strong indications that the relationship is good and that at least 80 percent of the change in 30 HV can be explained by the change in ADT.

Based on the findings in this study, it appears reasonable to conclude that regression analysis is a useful method of estimation and that the application of these procedures can serve a real purpose as a valuable aid in the preparation of current and future estimates of traffic volumes in the 30th highest hour from ADTs obtained at rural locations on the state trunk system where there are no PTR installations.

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2. Petroff, Boris B., and Blensly, Robert C. Improving Traffic-Count Procedures by Application of Statistical Methods. Highway Research Board Proc., Vol. 33, pp. 362-375, 1954.