# A Study of Urban Travel Times In Pennsylvania Cities

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Because traffic congestion or vehicular delay is a logical factor to consider when programing new construction in urban areas, it becomes necessary to compare the degree of congestion at one location with that at any other location. Inasmuch as information is not available to make such comparisons, it was the purpose of this study to investigate methods by which relative traffic congestion (or vehicular delay) could be estimated at any given location when only limited information of the local conditions was available. This study was confined to urban state highways but does not include limited access expressways.

To develop estimating parameters it was necessary to measure the effect that many variable factors have on travel time, such as traffic volume, traffic controls and regulations, classification of streets, percentage of heavy vehicles, street width, type of area. Trip times were sampled through 15 test sections located in five cities. These sections varied in length from 0.3 to 1.5 miles. All data were recorded on Esterline Angus tapes as vehicles entered and left the test sections. Information was then transferred to IBM cards using a 650 computer for analysis.

It is believed that the relationship between travel time and volume/capacity ratio was the most useful method for estimating travel time. This study is limited to the problem of developing estimating parameters and does not include their application to a statewide evaluation of relative traffic congestion for programing new construction.

● IF TRAFFIC CONGESTION or vehicular delay is used as a warrant for programing urban highway improvements, it is necessary that the degree of congestion at one location be compared with the degree of congestion at any other location. Such a comparison is useful either in terms of accumulated vehicular delay or of total costs resulting from "excessive" delay.

Because such information is not available for use in statewide urban programing, it was the purpose of this study to investigate methods by which relative traffic congestion (or resultant vehicle delay) could be estimated at any given location when only limited information about the location is known.

Because vehicle delay in a given section is proportional to the time required to traverse the section, it follows that relative travel time could be a measure of relative congestion. Therefore, this study is concerned with travel time and the interrelated factors that affect it. Such factors include the classification of streets, types of area through which streets pass, traffic controls and regulations, traffic volumes, street width, etc.

Fifteen test sections were selected in five different cities ranging in population from 28,000 to 100,000 persons. These test sections were located in both central business districts (CBD) and adjoining intermediate areas. They included both local and arterial streets and one-way and two-way streets. Lengths of test sections varied from 0.3 to 1.5 miles. Trip times were determined by recording license numbers as vehicles entered and left the test section. Data were recorded on Esterline Angus tapes during both peak and off-peak hours for 30-min periods. Each 30-min period was broken down into five 6-min intervals and placed on IBM cards for analysis. A 650 computer program was written in which license numbers were matched and resultant travel times analyzed in a continuous operation.

Over-all results showed that mean travel time equaled 3.69 min per mi during periods with less than critical density and 6.12 min per mi during periods where critical density had been exceeded. Equivalent speeds are 16.3 and 9.8 mph, respectively.

A significant difference existed between mean travel time through central business districts and intermediate areas on both one-way and two-way arterial streets. However, the difference in travel time between one-way and two-way streets was not significant in either type of area.

The correlation between travel time and street width or travel time and percent heavy commercial vehicles was less than ten percent, indicating neither variable, separately, has much effect on travel time.

Traffic signals were timed for progressive movement in four of the fifteen locations studied. Although the mean travel time in coordinated sections was less than non-coordinated sections (3.50 and 3.75 min per mi, respectively), the difference was not statistically significant.

It was found that a stratightline relationship existed between mean travel time and signal density, below critical volume densities. Combining data from all locations, regression equations were developed for various volume/capacity ratio levels. Thus, by knowing only the average number of signals per mile, mean travel time could be estimated with reasonable accuracy, so long as critical densities were not exceeded.

The most useful parameter found was the relationship of travel time to volume/capacity ratio. Volume used in the ratio refers to the equivalent hourly volume (10 times actual 6-min counts) in a given test section, whereas capacity refers to the average of the practical capacities of individual intersections within the test section. By using this ratio, changes in traffic volume, signal timing and other variables affecting travel time, are combined into a single variable. This relationship is described by parabolic curves for one-way arterial streets, two-way arterial streets, and two-way local streets.

Although volume/capacity correlation with travel time is not as high as the correlation with signal density, the volume/capacity relationship can be used to estimate travel time above and below critical densities. On one-way arterials a coefficient of correlation of 0.65 was obtained, and on two-way arterials the correlation equaled 0.72. Standard error of estimate for each was 0.15. Although the coefficients are relatively low, in view of the many variables that affect travel time, it is believed that the parabolic equations developed for arterial streets will be adequate for estimating mean travel time for the statewide evaluation program. On two-way local streets, however, a coefficient of correlation of only 0.45 was obtained. Inasmuch as this was based on only twelve samples, it is believed that additional data should be collected to determine if a higher correlation exists or if other parameters than volume/capacity ratio should be used to estimate travel time.

## OBJECTIVE

In programing urban improvements, it is usually desirable to expend funds at locations where the most relief from traffic congestion can be obtained per dollar spent. Thus, it is necessary to be able to evaluate relative traffic congestion and compare the intensity of congestion at one location with any other location. Such a comparison can be made in terms of average travel time, accumulated delay, "excessive" delay, or costs of excessive delay.

It is the purpose of this study to develop a method of estimating travel time on urban state highways, when only limited information of local conditions is available, such as contained in the 210 Needs Study. (Highway Needs Study of all road systems as required under Section 210 of the Federal-Aid Highway Act of 1956). To do this, it is necessary to measure the effect many variable factors have on travel time. Some of these factors include: traffic volumes, traffic controls, street width, percent of heavy commercial vehicles, classification of streets, type of area, direction of flow, etc.

If a relationship of travel time to any of these factors or combination of factors can be found by studying several different locations, then it would be possible to use this relationship, together with the information in 210 Needs Study to estimate travel time (and therefore the degree of existing congestion) on all urban state highways. This report, however, is limited to the problem of developing estimating parameters and does not include this application to statewide evaluation of relative traffic congestion and future programing of urban improvements.

## DEFINITIONS

Arterial street. — A major state highway within an urban area, with little or no control of access, serving both "local" and "through" traffic; usually a continuous, U.S. numbered route.

Local street. — A minor street within an urban area, used primarily for access to abutting property and for "local" traffic; usually an unnumbered secondary state highway carrying very little "through" traffic.

Central business district. — The "downtown" area of the city where the abutting property is used principally for retail business and commercial purposes.

Intermediate area. — The area adjacent to the central business district where the abutting property is a combination of commercial, residential, or industrial land uses.

Critical density. — The density where the volume of traffic appeared to have reached the possible capacity of the test section.

## METHOD

Many successful methods have been developed for measuring efficiency of traffic movement or relative traffic congestion on urban streets. Congestion ratings, which are often expressed in terms of travel time, occupancy time, or speed, usually relate actual values with optimum values.

The method investigated in this study, in which travel time is considered, is based on two previous studies: (a) the use of the volume/capacity ratio concept as a congestion index by Rothrock (1), and (b) the change in travel time as related to the changes in traffic volume by Rothrock and Keefer (2).

To measure the effect many variable factors have on travel time, 15 sections of streets were sampled in five cities in eastern Pennsylvania. Population ranged from

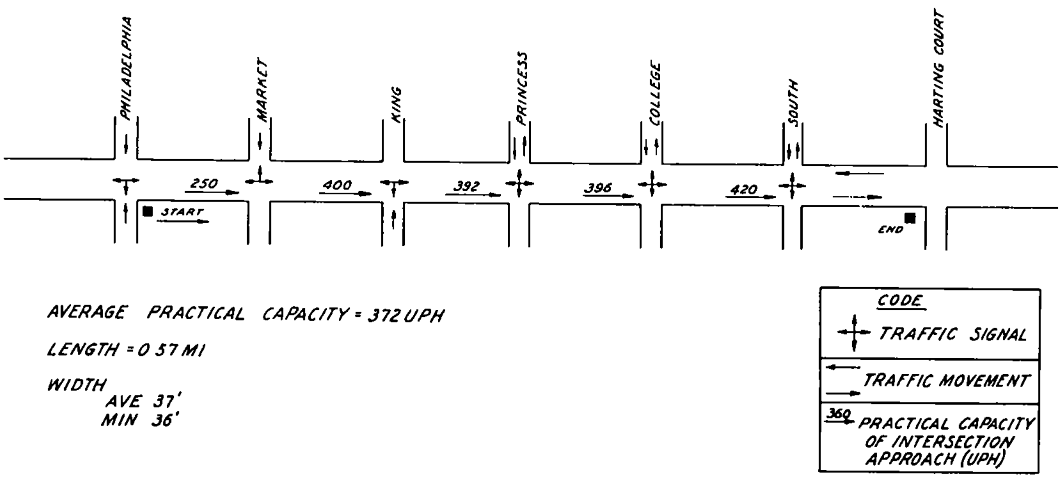


Figure 1. Typical urban test section.

28,000 to 100,000 persons. Six streets were located in CBD's and nine were in intermediate areas adjacent to CBD's. Seven were one-way streets and eight were two-way. Twelve streets were classed as "arterial", whereas three were classed as "local". The lengths of the test sections through which vehicle trips were timed varied from 0.31 to 1.54 miles. There were at least three signalized intersections within each test section.

Figure 1 shows a typical test section. The entrance (Station A) to the section is located on the outbound throat of the adjoining intersection, whereas the exist (Station B) is located midblock or at a non-signalized intersection. Traffic would normally be free flowing past each station.

Vehicles were timed in one direction only as they entered and left the test section. At a predetermined time, recorders were started simultaneously at both stations. The last three digits of license numbers were recorded on tape as each vehicle entered or left the test section. License plates containing letters in any of the last three places were not recorded, to simplify the problem of later matching license numbers. It was not necessary to record entrance and exit times of each vehicle because both tapes were started together and were moving continuously at a constant speed. Therefore, trip time for a given vehicle was the time difference recorded at Stations A and B. Because tape speeds were set at 6 in. per minute, there was little problem of writing three digits at the proper location on the tape at the instant a vehicle passed the station point. The maximum recording error observed was 2 sec. In addition to recording license numbers, all vehicles were counted and classified on tape as they passed each station.

Two operators were required at each station. Also, an observer was needed to observe traffic movements between Stations A and B, noting any unusual conditions that would affect trip time, particularly those periods when the critical density had apparently been reached or exceeded.

All measurements were made in clear, dry weather during both peak and off-peak hours and at times when there were no unusual obstructions to normal traffic flow. Data was collected continuously for 33- to 35-min periods. Each of these periods was later subdivided into five 6-min intervals and all data were transferred to IBM cards for analysis. A 650 computer program was written which would match the license numbers, compute the mean travel time of each 6-min interval and perform statistical analysis of the results. To later relate capacity to travel time, the practical capacity was calculated for each signalized intersection in all test sections, by the methods outlined in the Highway Capacity Manual (3). The average capacity computed for each test section is the average of the practical capacities of the signalized intersections within the section.

TABLE 1

MEAN TRAVEL TIME AT ALL LOCATIONS COMBINED

| | Below Critical Density | Above Critical Density |
|---|---|---|
| Mean travel time (min/mi) | 3.69 | 6.12 |
| Standard error of estimate | 0.10<br>(5.2%) | 0.20<br>6.6%) |
| Confidence level (%) | 95 | 95 |
| No. of 6-min sample | 118 | 17 |
| Equivalent mean speed (mph) | 16.3 | 9.8 |

## ANALYSIS OF DATA

Previous studies by Berry (4) indicated that during congested conditions, at least 36 license matches are needed on two-lane urban streets, whereas 102 matches were needed on multi-lane streets to determine mean travel time within 5 percent error at 95 percent confidence level. A somewhat smaller number of matches are needed during uncongested conditions.

Because it was intended to expand the 6-min counts to equivalent hourly volumes, it was believed that at least six license matches in each 6-min interval (or 60 per hr) would be necessary to achieve 90 percent accuracy or better. Therefore, with few exceptions, all 6-min periods with less than 6 samples were discarded. The exceptions were those in which the individual travel times were nearly equal and were well-spaced over the 6-min period.

A total of 10,899 vehicles passed through the entering stations (Station A) during all checks. License numbers were recorded for 6,100 vehicles at Station A from which 1,550 valid license matches were obtained. Thus, the over-all sample amounted to 14 percent of the traffic stream. Of the 190 6-min intervals, 135 contained sufficient samples to warrant further analysis. Although the usable number of license matches averaged slightly higher than 11 for each 6-min interval, actual matches varied from three to 26 per interval. Of the 135 6-min intervals used in the analysis, 17 occurred during highly congested periods when the critical density appeared to have been exceeded. It was necessary to establish a maximum allowable travel time for each test section to eliminate the short-time parker from the data analysis. Maximum allowable times were generally set at 2½ times the estimated average travel time.

Combining data at all locations, the over-all mean travel time, below critical density, equaled 3.69 min per mi which is equivalent to 16.3 mph (Table 1). Above critical density the mean travel time was 6.12 min per mi or 9.8 mph. Standard errors of estimate were less than 7 percent at 95 percent confidence levels in both instances.

It was desired, however, to determine the relative effects each variable had on travel time and, if possible, derive a general parameter which would express these effects. Such a parameter would be used to estimate travel time on urban highways when a limited amount of information was known about the highways. The variable factors studied were (a) the type of area through which the street passes (that is, CBD and intermediate urban sections adjacent to the CBD), (b) street type (arterial or local), (c) direction of flow (one-or two-way), (d) street width, (e) traffic volume, (f) percent of heavy commercial vehicles, and (g) traffic signal coordination.

TABLE 2

EFFECT OF LOCATION AND STREET TYPE ON TRAVEL TIME (BELOW CRITICAL DENSITY)

| Location | Type Street | Mean Travel Time (min/mi) | Equivalent Mean Speed (mph) |
|---|---|---|---|
| Central business district | Arterial (one-way) | 4.45 | 13.5 |
| | Arterial (two-way) | 3.94 | 15.2 |
| Intermediate area | Arterial (one-way) | 3.12 | 19.2 |
| | Arterial (two-way) | 3.07 | 19.5 |
| | Local (two-way) | 4.22 | 14.2 |

## Area, Direction of Flow, and Street Type

Table 2 gives a comparison of travel times in the CBD and intermediate areas adjoining the CBD. Because an equal proportion of samples taken above the critical density to the total number of samples was not obtained from each street type, travel times included in this table are only those which occurred during periods below the critical density. Within the CBD there was no significant difference in mean travel time between one- and two-way arterial streets, although, surprisingly, traffic moved slightly faster on two-way arterials. Also, there was no significant difference between travel times on one- and two-way arterials in intermediate areas. However, in comparing travel times in CBD's with intermediate areas, a significant difference did exist on both one-way and two-way arterials. Of the three local streets checked, all were two-way, located in intermediate areas. As would be expected, the travel time on local streets was higher than on arterials and the difference in mean travel times was significant.

## Heavy Commercial Vehicles

To examine the effect of heavy commercial vehicles on travel time, the three classes — one-way arterial, two-way arterial, and two-way local — were again used except that no differentiation was made between CBD and intermediate areas.

Although the volume of commercial vehicles reached as high as 28 percent of total traffic during individual 6-min periods, the mean for each of the three classes was less than 10 percent. On local streets the coefficient of correlation of travel time with heavy commercial percentage equaled 0.23, indicating that only 6 percent of the variation in travel time could be attributed to heavy commercial vehicles. To reduce the effect changes in volume might have on travel time for constant commercial vehicle percentages, a correlation was made at various volume/capacity ratio levels. It can

TABLE 3

EFFECT OF HEAVY COMMERCIAL VEHICLES ON TRAVEL TIME (BELOW CRITICAL DENSITY)

| Type Street | Volume/ Capacity Ratio | No. of Samples | Mean Travel Time (min/mi) | Commercial Vehicles (%) | Coefficient of Correlation |
|---|---|---|---|---|---|
| Arterial (one-way) | Less than 0.4 | 5 | 3.11 | 8.8 | 0.10 |
| | 0.4-0.59 | 22 | 3.45 | 7.3 | 0.28 |
| | 0.6-0.79 | 18 | 4.52 | 7.4 | 0.21 |
| | 0.8-0.99 | 9 | 4.86 | 7.5 | 0.12 |
| Arterial (two-way) | Less than 0.4 | - | - | - | - |
| | 0.4-0.59 | - | - | - | - |
| | 0.6-0.79 | 14 | 2.67 | 7.2 | 0.25 |
| | 0.8-0.99 | 9 | 3.81 | 7.1 | 0.01 |
| | 1.0 & over | 7 | 4.32 | 7.1 | 0.06 |
| Local (two-way) | 0.37-1.0 | 12 | 4.21 | 7.9 | 0.23 |

TABLE 4

EFFECT OF STREET WIDTH ON TRAVEL TIME (BELOW CRITICAL DENSITY)

| Type Street | No. of Samples | Street Widths (ft) | Mean Travel Time (min/mi) | Coefficient of Correlation | Equivalent Speed (mph) |
|---|---|---|---|---|---|
| Arterial (one-way) | 49 | 35, 40, 47, 48 | 3.92 | 0.23 | 15.3 |
| Arterial (two-way) | 31 | 37, 43, 45, 49 | 3.46 | 0.02 | 17.3 |
| Local (two-way) | 8 | 35, 36 | 4.21 | 0.52 | 14.2 |

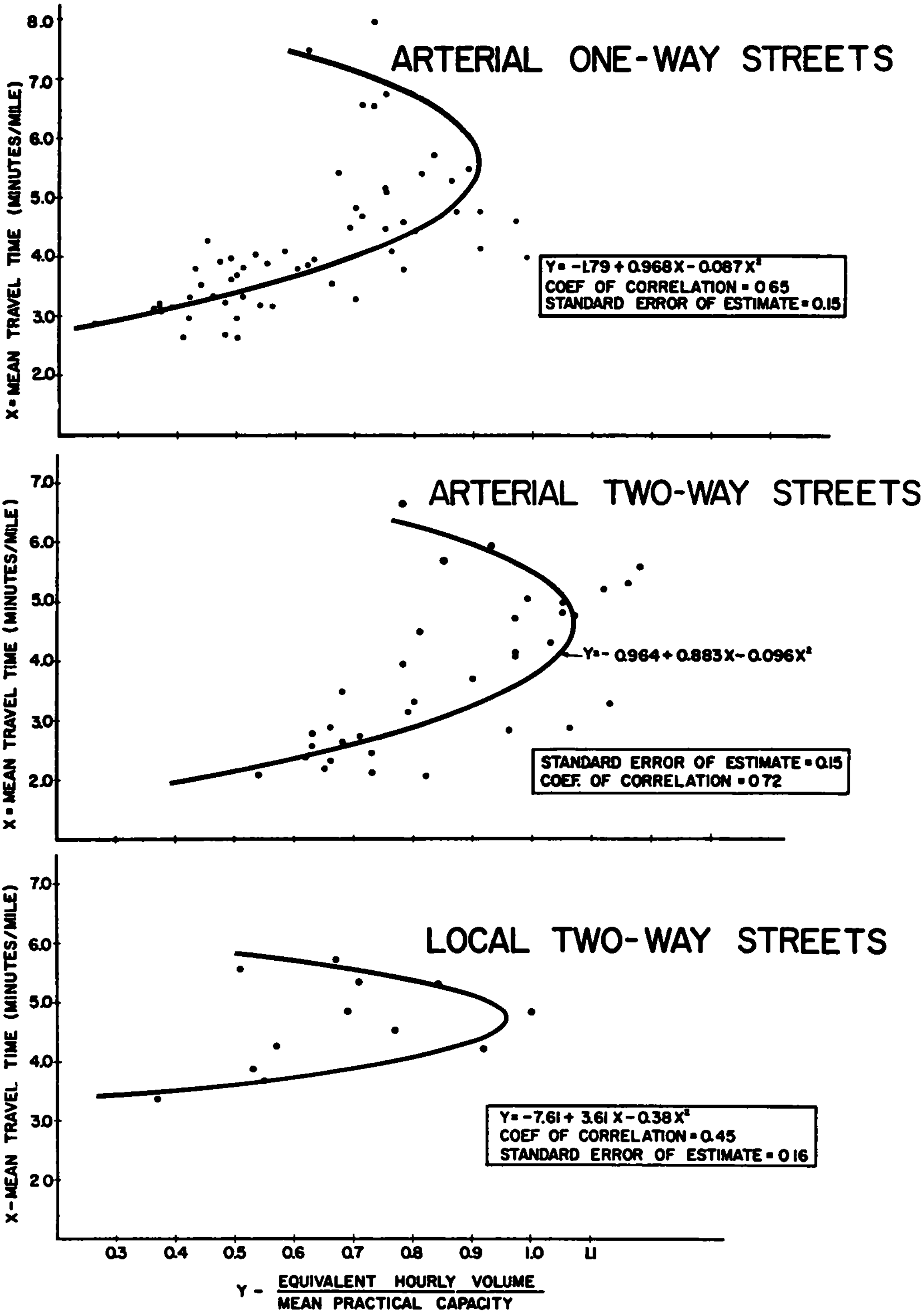


Figure 2. Relationship between travel time and volume/capacity ratio.

be seen (Table 3) that the highest correlation coefficient is 0.28 which indicates only an 8 percent effect on travel time. Thus it can be concluded that if a linear relationship is assumed, commercial vehicles had little influence on travel time within the volume percentages occurring during these studies. It should also be pointed out, however, that with the exception of one short 4 percent grade, all test areas were nearly flat.

## Street Width

It was generally expected that as street width increased, speeds would increase, as does capacity. Table 4 gives the relationship between street width and travel time. On local streets the coefficient of correlation was 0.52. This, however, was based on only two streets whose widths were nearly equal. On arterial streets the highest coefficient was 0.23 which indicates that less than 5 percent of the variation in travel time could be explained by the change in street width.

## Signal Coordination

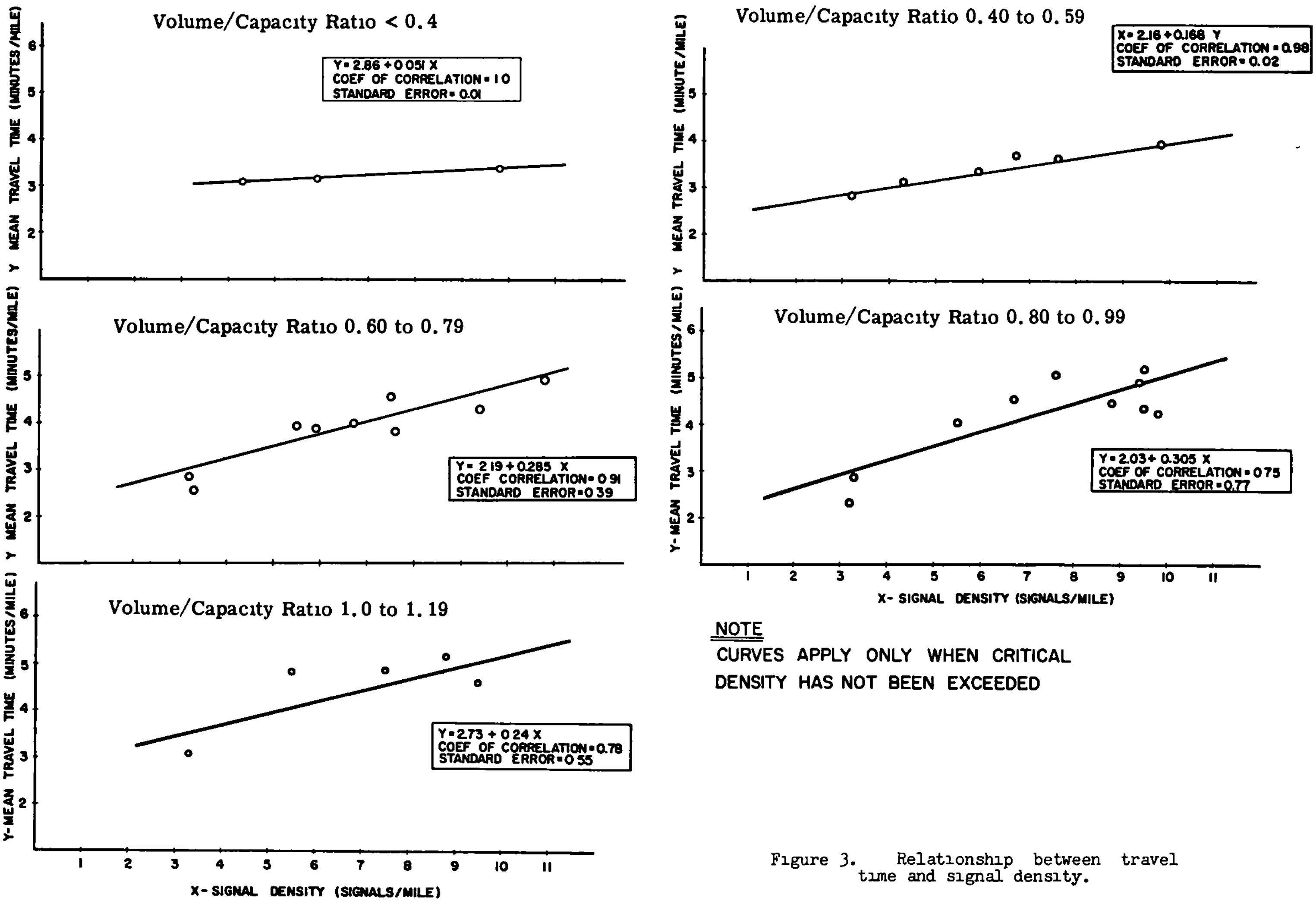
Of the 15 locations studied, it was found that only four streets had signals timed for progressive movement. The remaining locations were either partially coordinated or were not coordinated at all. Table 5 gives a comparison of travel times when critical densities were not exceeded. The mean travel time in coordinated sections was slightly lower than non-coordinated sections; nowever, the difference was not statistically significant. In examining the four coordinated streets further, it was noted that 3 were arterials, one of which was in the CBD. Two were one-way and two were two-way. The signal density on the coordinated streets averaged 7.1 signals per mile as compared to 7.3 per mile on non-coordinated streets.

TABLE 5

EFFECT OF SIGNAL COORDINATION ON TRAVEL TIME
(BELOW CRITICAL DENSITY)

| Signal System | Volume/ Capacity Ratio | No. of Samples | Mean Travel Time (min/mi) | Equivalent Speed (mph) |
|---|---|---|---|---|
| Coordinated | Less than 0.4 | 2 | 3.26 | 18.4 |
| | 0.4-0.59 | 14 | 3.55 | 16.9 |
| | 0.6-0.79 | 14 | 3.12 | 19.2 |
| | 0.8-0.99 | 9 | 4.16 | 14.4 |
| | 1.0 & over | 2 | 3.08 | 19.5 |
| | Over-all | 41 | 3.50 | 17.2 |
| Non-Coordinated | Less than 0.4 | 5 | 3.14 | 19.1 |
| | 0.4-0.59 | 15 | 3.24 | 18.5 |
| | 0.6-0.79 | 30 | 3.62 | 16.6 |
| | 0.8-0.99 | 19 | 4.14 | 14.5 |
| | 1.0 & over | 8 | 4.68 | 12.8 |
| | Over-all | 77 | 3.75 | 16.0 |

Signal density was found, as will be discussed later, to have high correlation with travel time. The results of signal coordination were somewhat unexpected particularly at the lower volume/capacity ratio levels. Walker (7), in his discussion of probable effects of coordination on speed, concluded that a wide range of over-all speeds could be expected near the level of possible capacity in either system and there would be little, if any, difference between coordinated and non-coordinated systems.



NOTE

CURVES APPLY ONLY WHEN CRITICAL
DENSITY HAS NOT BEEN EXCEEDED

Figure 3. Relationship between travel time and signal density.

## Volume/Capacity Relationship

Rothrock and Keefer (2) related changes in travel time to changes in traffic volume. Inasmuch as their study was limited to one location, capacity remained constant and could be neglected. Because of the variation of capacities in the 15 test sections in the study, it became necessary to use a volume/capacity ratio rather than volume alone. For each of the 15 sections, the volume refers to the equivalent hourly volume (ten times the actual 6-min interval count), whereas the capacity refers to the average of the practical capacities of each signalized intersection in the test section in direction of flow being measured. Practical capacities were calculated by the method outlined in the Highway Capacity Manual. Turning movements at each intersection were based on 10-min traffic counts. Thus, by using the volume/capacity ratio, many of the variables which might affect travel time were combined into one variable, which would permit ready comparison of one section with another.

Although it was found that type of area significantly affected travel time on a given class of street, it would not be possible to determine the limits of a CBD from the adjacent intermediate areas without an extensive field survey. Therefore, for future application to a statewide evaluation of urban highways, type of area, as a variable, was neglected and travel times were related to volume/capacity ratio for each of the 3 classes of streets regardless of their location. Parabolic curves were fitted to this data and estimating equations were developed (Fig. 2). For each type street the travel time increases with increase in volume/capacity ratio until the apparent critical density is reached. At that point the travel time continues to increase, although the volume/capacity ratio decreases. This characteristic is discussed by Greenshields (5) and was found in studies by Huber (6) as well as Rothrock and Keefer (2).

Considerable scatter occurs particularly at high volume/capacity ratios near the point of critical density. This wide variation in travel times is believed to have been caused when saturation occurred for short periods of time (for example, one to two minutes) or within only a short portion of the test section. Either of these conditions would cause relatively high mean travel times for some 6-min intervals as compared to other intervals at the same volume/capacity ratio where these conditions did not occur. In both instances the travel times were recorded as occurring below critical density because the major portion of test sections was not saturated for the full 6-min interval. A second cause for scatter was the variation of volume within the test sections. The volume used in determining the ratio was based on the volume entering the section at Station A. Thus, if the actual average volume of the test section varied greatly from the Station A volume because of turning movements between Stations A and B, resultant changes in volume which affected travel time would not be accounted for in establishing the volume/capacity ratio. A third cause of scatter might be the wide range of practical capacities that existed at individual intersections within a given test section. For example, at one location the average capacity was 490 vehicles per hour although the range varied from 204 to 798 vehicles per hour at the individual intersections. As volume through the section increased, low capacity intersections would become congested first, causing greater over-all delay than would occur at locations where the individual intersection capacities were more nearly equal to the average.

Other conditions, such as double parking and left turns, directly cause a difference in travel times under otherwise apparently similar conditions. It is believed, therefore, that the correlation obtained between travel time and volume/capacity ratio for arterial streets is reasonably good.

The curves for both one-way and two-way arterial streets are similar in general shape, although travel time on one-way streets was higher than on two-way streets for a given volume/capacity ratio. The apparent critical density on two-way arterials occurred slightly above a ratio of 1.0, whereas on one-way streets it occurred just below a ratio of 1.0. Theoretically, the critical density would be expected to occur near the point of possible capacity which would be equivalent to a volume/capacity ratio of 1.2.

The curve for local streets is flatter than those for arterial streets. This would indicate that after the critical density had been reached, the entering volume decreases rapidly although the rate of increase in travel time is slight. This curve, however, is based on only twelve 6-min intervals. The coefficient of correlation was 0.45. Additional study of local streets is needed to determine if a higher correlation exists or if parameters other than volume/capacity ratio would better describe the variation of travel time.

### Signal Density

Traffic signals are known to be the greatest single cause of delay to through movement on urban streets. In examining the over-all effects of traffic signals on trip times, it was found that a straightline relationship existed between mean travel time and signal density expressed in number of signals per mile, so long as the critical density was not exceeded. Figure 3 shows this relationship at various volume/capacity levels. Data for all 3 classes of streets were combined and regression equation were developed as shown. As would be expected, travel time increased as signal density increased, although it should be noted the rate of increase below a volume/capacity ratio of 0.4 is much less than rates above 0.4.

Of the five volume/capacity ratio levels examined, the lowest coefficient of correlation (0.75) was obtained at the 0.80-0.99 level. The highest standard error of estimate (0.77) also occurred at this level. However, it appears that travel time could be estimated reasonably well over a given section of urban streets based on the average signal density in that section, regardless of the other variables that exist. This relationship is limited to volume levels below critical density. Further study would be required to determine if a similar relationship existed above critical density.

## CONCLUSIONS

Results of this study lead to the following conclusions:

1. The volume/capacity ratio is a suitable parameter for estimating travel time on any given urban highway.
2. The parabolic curves developed in this study relating travel time to volume/capacity ratio for arterial streets can be applied to the statewide evaluation of traffic congestion on urban state highways.
3. Although a parabolic curve is developed for local streets, more study should be made of local streets before using this curve because of the low correlation obtained.
4. Traffic volume and signal timing have major effects on travel time, whereas other measurable quantities such as street width, percent of heavy commercial vehicles, direction of flow, and type of area have minor effects, when considered as separate variables.
5. Travel time along any section of urban highway is directly proportional to the average number of traffic signals per mile in that section so long as the critical traffic density has not been reached. Thus, signal density could be used to estimate mean travel time within this limitation. More study is needed to determine the relationship above critical density.

## ACKNOWLEDGMENTS

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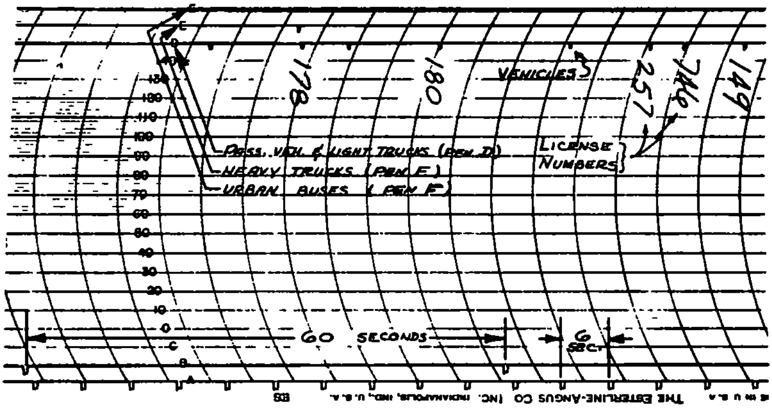
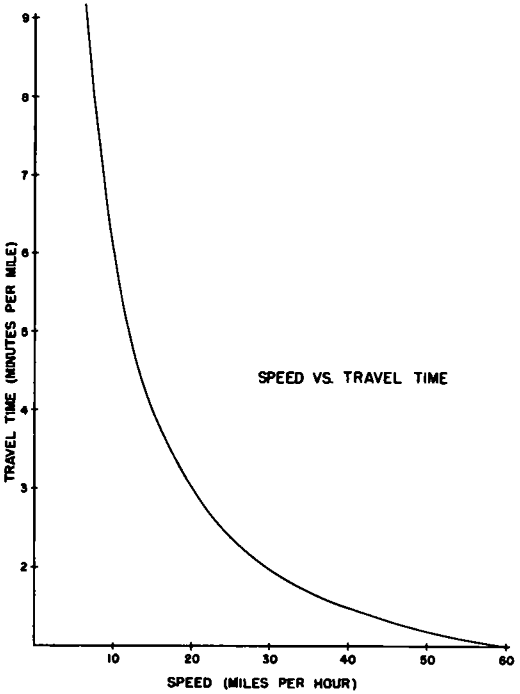
## *Appendix*



SAMPLE TAPE SHOWING FIELD DATA



## STATION A (TYPE R CARD)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0001 | | | | 0002 | | 0003 | | 0004 | |
| 1 2 | 3 4 | 5 6 | 7 8 9 10 | 11 12 13 14 15 16 | 17 18 19 20 | 21 22 23 24 | 25 26 27 28 29 30 | 31 32 33 34 35 36 | 37 38 39 40 |
| STATION | DATE | PERIOD | | | LICENSE NO | | TIME<br>HR MIN SEC | | MAX TIME ALLOWED |
| 52 | 08 | 01 | | | 194 | | 12 18 16 | | 0500 |

## STATION B (TYPE Q CARD)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0001 | | | | 0002 | | 0003 | | 0004 |
| 1 2 | 3 4 | 5 6 | 7 8 9 10 | 11 12 13 14 15 16 | 17 18 19 20 | 21 22 23 24 | 25 26 27 28 29 30 | 31 32 33 34 35 36 37 38 39 40 |
| STATION | DATE | PERIOD | | | LICENSE NO | | TIME<br>HR MIN SEC | |
| 52 | 08 | 00 | | | 194 | | 12 21 39 | |

## OUTPUT CARD (ONE VEHICLE)

| | | | | | | |
|---|---|---|---|---|---|---|
| 0027 | | | | 0028 | | |
| 1 2 | 3 4 | 5 6 | 7 8 9 10 | 11 12 13 14 15 16 | 17 18 19 20 | 21 22 23 24 25 26 27 28 29 30 |
| STATION | DATE | PERIOD | TIME<br>HR MIN | | LAPSED TIME MIN. | |
| 52 | 08 | 01 | 12 00 | | 0323 | |

## CONTROL CARD (INPUT) (ONE 6 MINUTE PERIOD)

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0001 | | | | 0002 | | 0003 | | 0004 | | | 0005 | | | 0006 | |
| 1 2 | 3 4 | 5 6 | 7 8 9 10 | 11 12 13 14 15 16 | 17 18 19 20 | 21 22 23 24 25 26 | 27 28 29 30 | 31 32 33 | 34 35 36 37 | 38 39 40 | 41 42 43 | 44 45 46 47 | 48 49 50 | 51 52 53 54 55 56 | 57 58 59 60 |
| STATION | DATE | PERIOD | TIME<br>HR MIN | | EQUIV VOLUME (VPH) | | CAPACITY (VPH) | NO. OF PASS. CARS | | NO. OF TRUCKS | NO. OF BUSSES | | TOTAL VEH | | LENGTH OF SECTION |
| 52 | 08 | 81 | 12 00 | | 0510 | | 0865 | 046 | | 005 | 000 | | 051 | | 0059 |

## OUTPUT CARD (ONE 6 MIN. PERIOD)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0027 | | | | 0028 | | 0029 | | 0032 | | 0033 | | 0034 | |
| 1 2 | 3 4 | 5 6 | 7 8 9 10 | 11 12 13 14 15 16 | 17 18 19 20 | 21 22 23 24 25 26 | 27 28 29 30 | 51 52 53 54 55 56 | 57 58 59 60 | 61 62 63 64 65 66 | 67 68 69 70 | 71 72 73 74 75 76 | 77 78 79 80 |
| STATION | DATE | PERIOD | TIME<br>HR MIN | | MEAN TRAVEL TIME (MIN/MILE) | | EQUIV VOLUME (VPH) | | PERCENT TRUCKS | | PERCENT BUSSES | | PERCENT PASS. CARS |
| 52 | 08 | 81 | 12 00 | | 0393 | | 0510 | | 0981 | | 0000 | | 9019 |

## STATISTICAL OUTPUT CARD (ONE 6MIN PERIOD)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 2 | 3 4 | 5 6 | 7 8 9 10 | 11 12 13 14 15 16 | 17 18 19 20 | 21 22 23 24 25 | 26 27 28 29 30 | 31 32 33 34 35 | 36 37 38 39 40 | 41 42 43 44 45 46 | 47 48 49 50 |
| STATION | DATE | PERIOD | HR MIN | | MEAN TRAVEL TIME (MIN/MILE) | | STANDARD DEVIATION | | $\sqrt{\text{NO. OF SAMPLES}}$ | | STANDARD ERROR |
| 52 | 08 | 81 | 12 00 | | 0393 | | 08490 | | 40000 | | 2122 |

## SUMMARY OF DATA – CHART NO. 1

| | | | | | | | Width (Ft.) | | Traffic Signals | | | | Practical Capacity (Veh./Hour) | | | Below Critical Density | | Above Critical Density | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| City | Code | Street Name | Type of Area | Class of Street | Direction of Flow | Length of Section (Mi.) | Average | Minimum | Number | Number Per Mile | Progressive Timing | Cycle Length (Sec.) | Average | Maximum | Minimum | Mean Travel Time (Min.) | Equiv. Speed (MPH) | Mean Travel Time (Min.) | Equiv. Speed (MPH) |
| York | 11 | Philadelphia | CBD | Arterial | One Way | 0.45 | 35 | 32 | 3 | 6.7 | Partial | 37 5o 54 | 935 | 990 | 895 | 4.01 | 14.9 | 6.91 | 8.7 |
| | 12 | Princess | Inter. | Local | Two Way | 0.67 | 35 | 32 | 5 | 7.5 | Partial | 45 to 54 | 297 | 360 | 234 | 4.72 | 12 7 | | |
| | 13 | George | CBD | Arterial | One Way | 0 66 | 48 | 46 | 5 | 7.6 | Partial | 45 to 56 | 870 | 1030 | 684 | 4.52 | 13.3 | | |
| | 14 | George | Inter | Arterial | One Way | 0 51 | 48 | 48 | 3 | 5.9 | YES | 45 | 1150 | 1380 | 980 | 3.48 | 17 2 | | |
| | 15 | Queen | Inter. | Arterial | Two Way | 0.57 | 37 | 36 | 5 | 8.8 | Partial | 45 to 53 | 372 | 420 | 250 | 4.94 | 13.4 | 6.65 | 9.0 |
| Ardmore | 21 | Lancaster, Pa. | CBD | Arterial | Two Way | 0.74 | 43 | 40 | 6 | 9.5 | Partial | 45 to 60 | 517 | 621 | 398 | 3.62 | 16.6 | 5.50 | 10.9 |
| Chester | 31 | Ninth St. | Inter. | Local | Two Way | 0.82 | 36 | 36 | 8 | 9.8 | YES | 50 | 490 | 798 | 204 | 3.29 | 18.2 | 5.38 | 11.1 |
| Lebanon | 51 | Cumberland | CBD | Arterial | One Way | 0.56 | 40 | 38 | 1 | 10.8 | Partial | 50 to 70 | 703 | 846 | 614 | 4.92 | 12.2 | | |
| | 52 | Walnut | Inter | Arterial | One Way | 0.70 | 40 | 40 | 3 | 4.3 | Partial | 45 to 70 | 1062 | 1175 | 970 | 3.11 | 19.3 | | |
| | 53 | Chestnut | CBD/Inter. | Local | Two Way | 0.42 | 37 | 32 | 4 | 9.5 | None | 50 to 70 | 424 | 465 | 381 | 3.95 | 15.2 | 6.01 | 10.0 |
| Harrisburg | 62 | Second | CBD | Arterial | One Way | 0.53 | 47 | 43 | 5 | 9.4 | YES | 80 | 1077 | 1250 | 890 | 4 82 | 12.4 | 7.25 | 8.3 |
| | 63 | Market | CBD | Arterial | Two Way | 0 54 | 49 | 48 | 3 | 5.5 | Partial | 70 | 411 | 447 | 346 | 4.26 | 14.1 | 5.93 | 10.1 |
| | 64 | Paxton | Inter. | Arterial | Two Way | 0.91 | 45 | 44 | 3 | 3.3 | YES | 50 | 887 | 980 | 740 | 2.69 | 22.3 | | |
| | 65 | Front/Paxton | Inter. | Arterial | One Way | 1 54 | 43 | 30 | 5 | 3.2 | Partial | 70 | 1284 | 1460 | 1160 | 2.67 | 22 5 | | |
| | 66 | Forster | Inter. | Arterial | Two Way | 0.52 | 84* | 84 | 4 | 7.7 | Partial | 70 | 905 | 1340 | 560 | 3.36 | 17.9 | | |

* 42' Each Side of 10' Median