Characteristics of Travel on Indiana Highways

Harold L. Michael
Assistant Director, Joint Highway Research Project
Purdue University

INTRODUCTION

The highway problem has been the subject of considerable discussion during the past few years and has assumed proportions subject to national concern. This Road School is, in fact, a discussion of this Number One domestic problem. The interest of almost every individual in highways and their operation is increasing, and each year more highway technology is made available through research, more planning is originating in our various highway departments, more qualified men are contributing their energies, and more money is being invested—all for the production of an efficient, economical and safe national highway system.

The development of such a system, however, requires the proper planning, and planning requires basic information on the characteristics of highway travel. Just as a good businessman does not plan additions to his store without studying the characteristics of his customers, the highway planner cannot wisely plan new facilities and the traffic engineer cannot wisely initiate operational procedures without factual data on motor vehicle travel. For locations where major improvements are required these characteristics are usually obtained by the performance of the necessary traffic surveys. Of these surveys the comprehensive traffic survey has attained its rightful place as a major source of traffic information. For adequate information on a metropolitan area there is no doubt but that the conduct of such a survey is a necessity.

Many occasions arise, however, where a general knowledge of the travel characteristics would be of major assistance in the planning or operation of highway facilities. In such cases the collection of the required data might be so time-consuming and expensive that the performance of a survey would be impractical or uneconomical. Some of the characteristics of highway travel are remarkably similar throughout Indiana and are unusually repetitive in nature. A determination of typical characteristics from comprehensive surveys made throughout the

state should, therefore, be of considerable use to the highway planner and traffic engineer.

During the past three years the Joint Highway Research Project has cooperated with the Metropolitan Area Traffic Survey Unit of the State Highway Department of Indiana in the conduct of seven comprehensive traffic surveys in seven cities located in various parts of the state. In the analysis of these studies it was apparent that certain characteristics of travel were similar for the various cities. As a result, these travel characteristics have been summarized for the seven cities, additional data were secured from the state-wide Highway Planning Survey Unit of the State Highway Department, other information was obtained from our various research projects, and information on several travel characteristics is presented in this paper. The characteristics discussed here are not the only ones which require definition and have been selected only because of the availability of information. Other characteristics are receiving continuing study and are to be discussed in future reports.

The travel characteristics which are presented in this paper are not fixed characteristics and may vary considerably for different locations on our street and highway systems. They have been remarkably similar, however, in a sample of locations throughout the state and if used with proper precautions can be utilized for general planning and operational purposes in Indiana.

VOLUME VARIATION CHARACTERISTICS

Perhaps the most important factor affecting the highway is that of traffic volume. Without sufficient traffic volumes a need for a highway ceases to exist, and nearly every relationship between the road and the vehicles which travel on it is one of volume. It is for these reasons that the highway planner must have a thorough knowledge of the volumes of traffic on every facility with which he is concerned.

Volumes of traffic are usually expressed as so many vehicles in some unit of time. Often this unit of time is per day or per hour. A common unit of time in the area of highway planning is average annual daily traffic—the average number of vehicles which passed a certain point each day for an entire year. Analysis of traffic volumes shows that the average daily traffic for Indiana roads and streets will vary from one to two vehicles per day on local roads in some of the sparsely settled areas to more than 50,000 on some urban thoroughfares. An evaluation of the volume on any particular road must of necessity be the result of a traffic count of some type, but since traffic volumes are subject to cyclic variations some knowledge of these variations must be had if the counted volumes are to be wisely evaluated.

Three of these cyclic variations occur with startling similarity over and over again. They are the variations with time or season of the year, variations with the day of the week, and variations with the hour of the day.

Seasonal Variations

The seasonal pattern is the most repetitive and reflects the demands for highway travel as affected by seasonal weather and economic and social patterns. We would, of course, expect heavy traffic during the traditional vacation weather of an Indiana summer and low volumes during the post-Christmas holiday season in mid-winter. That is exactly

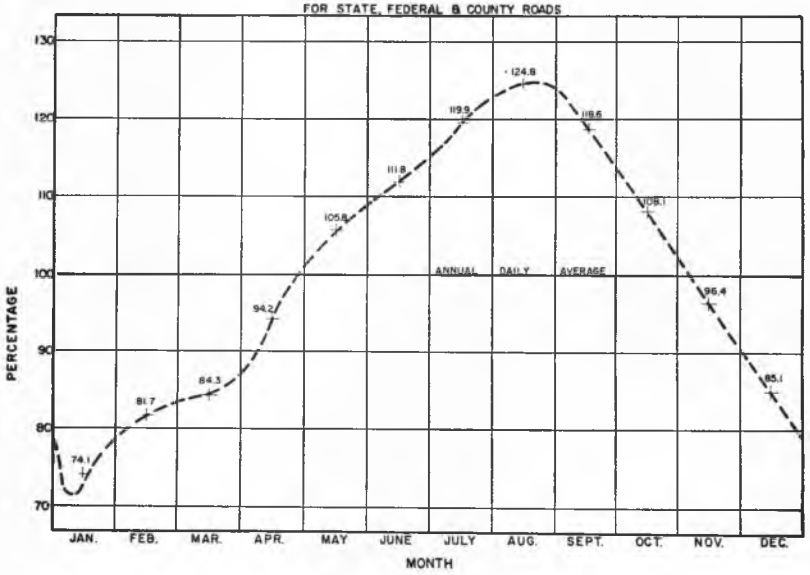

Fig. 1. Seasonal traffic volume variation expressed as a percentage of the average annual daily volume.

what we find. Figure 1 illustrates the average daily traffic volumes throughout the year as percentages of the annual average daily traffic. These data are taken from the records of 21 Indiana State Highway Department permanent counters installed on state and federal highways in all parts of the state and reflect the average volumes from 1946 through 1953.

The low volume (about 72 per cent of the annual daily average) occurs around January 5. After that date traffic volumes increase at a non-uniform rate until attaining a peak about August 30 (about 125 per cent). From that time until the low point they decrease at a re-

markably constant rate. Average traffic volumes occur around May 1 and November 5. Variations from the seasonal variations indicated by this curve occur on major holidays, such as Christmas and Fourth of July, and during periods of severe weather, such as a heavy snow or a prolonged icy spell. Special events, such as a college football game or a state fair, will also result in larger variations on the highways in the immediate vicinity of the event.

Seasonal traffic volume variations on county roads are similar to those for state highways and the data of Figure 1 may be used as an estimate for all rural roads. The seasonal variation in urban areas follows a similar pattern, with high and low points at the same season of the year, but with less variation from the average daily traffic. Very little data are available on this variation in Indiana at this date, but it is planned to include this study in future researches on the subject. The data which we have indicate, however, that the volume variation on city streets varies between 90 and 110 per cent of the annual daily average.

Daily Variation

The second cyclic variation is from day to day within a week. In the field of highway planning the unit of volume is also often taken as the number of vehicles per average week-day, Monday through Friday. The traffic patterns on these five days are often extremely similar and comparable, whereas the patterns of Saturday and Sunday are usually completely different. The purposes of week-day travel are considered more essential and the traffic more deserving of relief than that of week-end travel. Planning for new facilities, except for roads in recreational areas, is therefore on the basis of average week-day travel.

This week-day pattern reflects the travel for work and business and is also very similar from week to week. The averages shown in Figure 2 are averages for locations throughout the state and are for locations near or in cities. Variations are different for state or federal routes, county roads, and urban streets. For state roads Friday traffic is more than 10 per cent above average, with the other four days being slightly below average. Tuesday has the lowest traffic volumes and Monday has more travel than any day except Friday.

On the other hand, the volumes on county roads are almost average on Friday and slightly above average on Wednesday and Thursday. Tuesday again is the low volume day of the week. On city streets, traffic is about 8 per cent above average on Fridays, slightly above on Mondays, and also hits its low point on Tuesdays.

Local business practices may cause a shift in the average variations shown here. Closing of the businesses in a business district during a

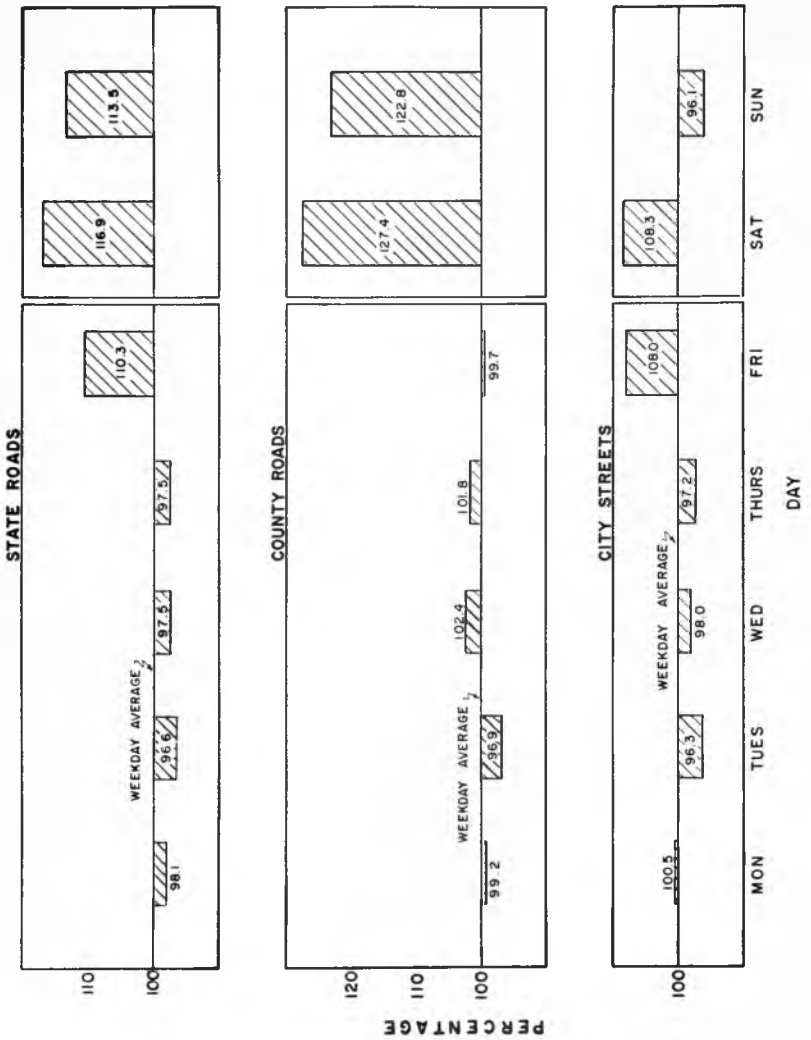

Fig. 2. Average volumes of traffic for each week day expressed as a percentage of the average week day volume.

portion of a day may produce a lower volume on that day, or shopping on some particular night may cause a higher volume for that day, especially on city streets. The effect on state or county roads of such commercial practices, however, is not as great on traffic volumes as might be expected.

Saturday volumes are the highest of the week and are especially noticeable on county roads (127.4 per cent of average week-day traffic).

This probably reflects the farm tendency of going to town on Saturday. A smaller variation is noticeable on city streets, actually not much different than Friday. Sunday volumes average slightly less than Saturday's for all roads, and for city streets are actually less than during the average week-day. In fact, the volumes on some city streets are much less on Sundays—for example, streets in the business districts and industrial areas of cities. Traffic in the vicinity of parks and other recreational areas is, on the other hand, usually above average.

Average week-day traffic averaged to be about 96 per cent of the average daily traffic for state highways, 93 per cent for county roads, and 99 per cent for city streets. The utilization of these percentages and the seasonal variation chart (Figure 1) will permit an estimation of the annual average daily traffic from counts made during any five week-days of the year or will permit an estimation of the average week-day traffic for any season of the year if the annual daily traffic volume for a location is known. Knowledge of both of these volumes is necessary for the planner who wishes to make wise decisions.

Hourly Variations

The third cyclic volume variation is from hour to hour and is related to the hours conventionally used for work, sleep, and play. The hourly variations on Saturdays and Sundays are not as repetitive as on week-days and are affected considerably by weather and local events. Hourly variations during the week-days are, however, quite similar and are shown in Figure 3 for state roads, county roads, and city streets. All values given are the percentages of the average week-day volume that are made during each hour of the day. Little difference exists in the variation pattern of state routes, county roads, and city streets, although county roads experience more hours (1 to 5 a. m.) of almost zero volume than do state routes and city streets. Local events and unusual happenings may, of course, cause large variations in these patterns on certain routes.

The peak hour of traffic flow is 4 to 5 p. m., when 7.8 per cent of the daily volume traverses the state routes, 9.0 per cent the county roads, and 8.4 per cent the city streets. Approximately 50 per cent of the total daily traffic use the highways during the eight hours from 9 a. m. to 1 p. m. and 2 to 6 p. m., while less than 7.5 per cent use the highways between midnight and 6 a. m. The low point of traffic movement is from 3 to 5 a. m. for roads of any type.

For design purposes, the 30th highest hourly volume during the year for a facility is often required. Experience has shown that this will be slightly higher than the average peak-hour week-day volume, since

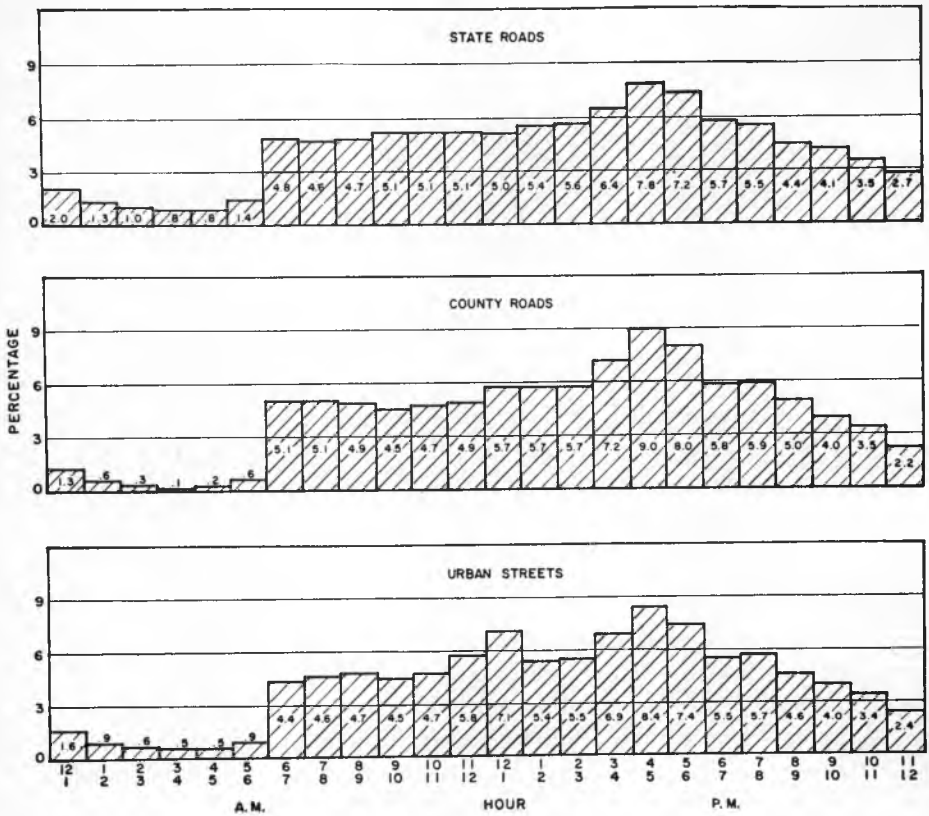

Fig. 3. Percentage of average daily traffic that travels during each hour of the day.

maximum volumes may be obtained during week-end hours. Studies by other investigators have shown that the 30th highest hourly volume can be quite accurately estimated by taking 15 per cent of the average daily traffic volume for rural highways. Our continuing studies here in the Project will include a study of this factor.

TRAFFIC VOLUME INCREASES

More important than cyclic volume variations to the highway planner is the matter of traffic volume increase. This not only affects present roads and streets, but greatly influences the size and type of new facilities. Highways have a life span of many years and improvement is difficult and expensive unless proper plans and arrangements have been previously provided. The normal life of a modern highway is at least 25 years; consequently, the planning for any new facility should consider the traffic volumes for 25 years in the future.

The actual amount and type of future traffic is governed by innumerable factors, many of which are difficult to estimate with any degree of accuracy. Some, such as wars and depressions, are impossible to predict. These primarily act as temporary deterrents to traffic increases, however, and are counterbalanced by larger increases in the immediate years following such calamities.

Traffic volumes have been predicted for many years and always have had one great similarity—they have been too conservative. Estimates of volumes for future years have actually been attained in one-half the estimated time or less. All of the predictors labored under the belief that actual traffic use would gradually reach some upper level in the years directly ahead. Actually, however, traffic use has increased quite steadily. Indiana has recorded volume counts for a number of years on 21 permanent counters located in various parts of the state. An analysis of the increases at these counters reveals that from 1946-1953 the increase has been remarkably steady. The chart in Figure 4 is

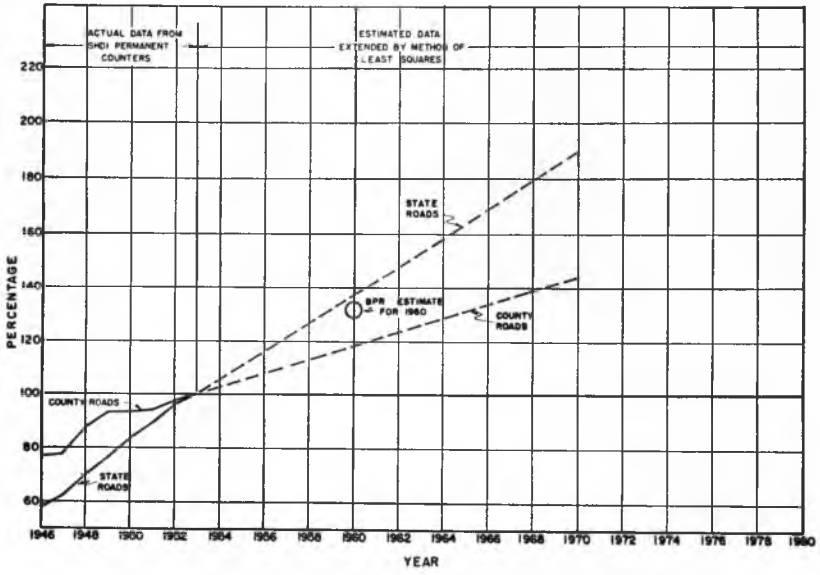

Fig. 4. Actual and estimated traffic volumes 1946-1970 expressed as percentage of 1953 average daily volume.

constructed on a percentage basis, with the average daily volume at all 21 counters in 1953 being the base volume. Volumes for all other years are then shown as percentages of 1953 volumes.

If the data from 1946-1953 is extended into the future under the assumption that traffic in the future will increase in the manner which

it has since 1946, we find that the apparent best-fitting line is a straight line. This line when extended for the next few years gives an estimation of the volumes for the future. In this chart the line has been extended to 1970, where we note a 90 per cent increase over 1953 volumes estimated by that date.

Bureau of Public Roads researchers estimated several years ago that traffic volumes would increase by an average of about 4 per cent each year until 1960. Using 1953 volumes and compounding the 4 per cent figure until 1960 gives an estimate for 1960 traffic volumes only slightly less than that indicated by the extension of the 1946-1953 data.

The increases which we have been discussing are for rural primary highways. The increases on county roads have been about one-half the increases on state roads and are shown by the bottom line on the chart. Information on volume increases in urban areas is not complete for Indiana cities, but indications are that the major thoroughfares have shown increases comparable to primary rural highways, while local city streets have been more comparable to county roads.

Under all methods of extension, however, we note huge volume increases of traffic for the years ahead. What will our congestion problem be with a 50 per cent increase in travel? Or a 100 per cent increase? In both cases the roads that we are building today will be major carriers of these volumes. Will they be found adequate? Can we honestly believe that the capacity of present highways and streets can be increased to meet these demands through better operational procedures? It would appear that considerable major construction and planning remains to be done.

TYPE OF VEHICLE CHARACTERISTICS

In planning, information is also needed on the type of traffic that uses highway facilities. Vehicles are usually classified as passenger cars, light trucks, medium trucks, heavy trucks, and buses. The traffic stream is composed of all these types and the amount of each type is subject to variations due to type and location of road or land use along the road. Variations on a particular road, however, are remarkably repetitive and variations among roads carrying similar traffic are only slightly more variable.

For general planning use, Figure 5 has been prepared. This chart presents the average percentage of each type of vehicle found on numerous highways in Indiana for rural state routes, county roads, and city streets. Passenger cars constitute the bulk of the traffic stream—approximately 80 per cent of the total volume on all rural roads. Almost equal volumes of light, medium and heavy trucks are found on state routes,

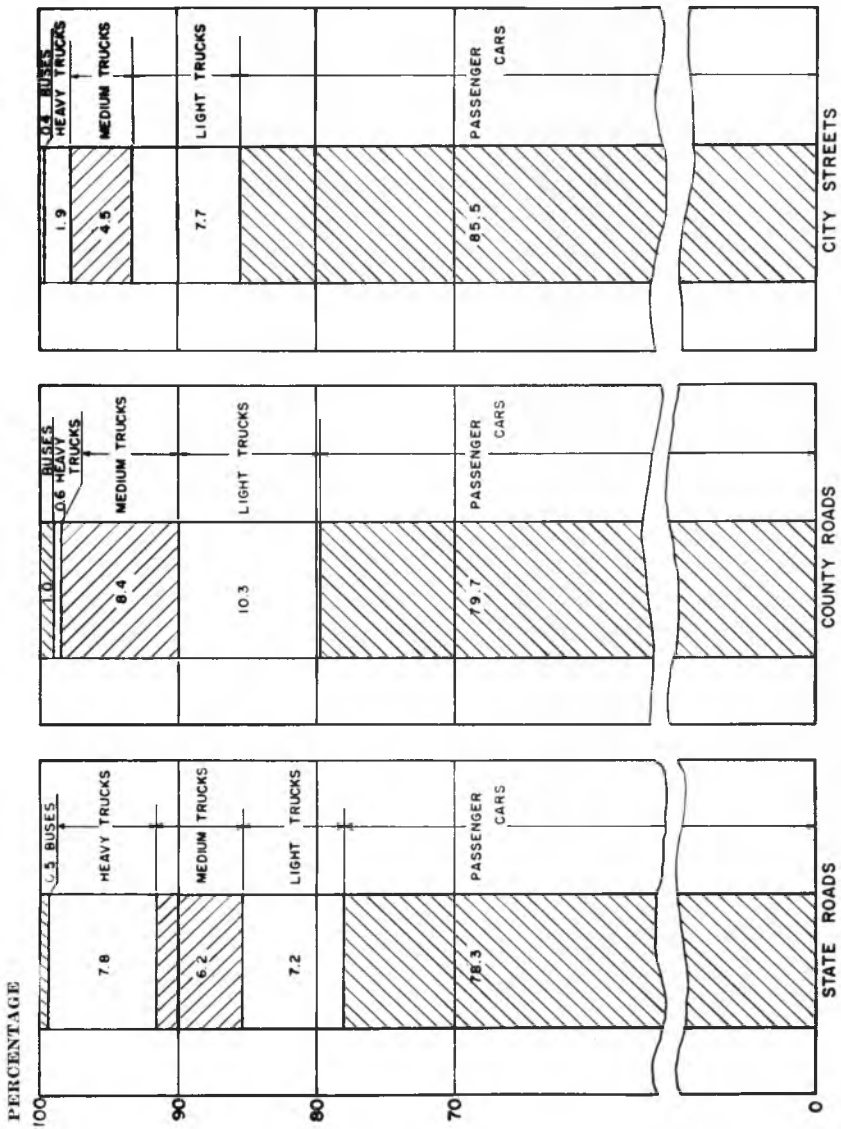

Fig. 5. Percentage of average daily traffic volumes by each vehicle type.

about 7 per cent each, while less than 1 per cent of the traffic is composed of buses. On county roads, truck traffic is composed of light (10 per cent) and medium (8 per cent) trucks and almost no heavy trucks. On city streets, 85 per cent of the volume is composed of passenger cars

with about 8 per cent light trucks, 4 per cent medium trucks, and 2 per cent heavy trucks. The absence of heavy trucks on city streets is the result of the general congestion and difficulty of movement on city streets and the fact that most heavy trucks are engaged in long trips. The percentage of heavy trucks will, of course, be higher on streets which serve as through routes and will approximate the percentage for state roads.

Travel by various types of vehicles also varies by the hour of the day. A significant variation is the number of heavy trucks on the highways during the night hours. In fact, over 50 per cent of the volume between 2 to 5 a. m. is composed of heavy trucks. In actual numbers the volume of heavy truck flow is almost constant for the full 24 hours, while the flow of other vehicle types varies throughout the day. Light and medium trucks are most active during the business day.

DIRECTION OF MOVEMENT CHARACTERISTICS

Another characteristic of traffic flow that has a bearing on the operational characteristics of highways is the unbalance which exists in the directional flow of traffic. This factor has special significance in capacity determinations and in one-way street operation. It is also of interest in the planning of origin-destination studies and the subsequent assignment of interviewers to the proper direction.

Over a full 24 hours, traffic will divide itself equally as to direction of flow, but certain purposes of travel during certain hours result in unbalanced flows during these hours. Figure 6 shows the average percentage of traffic inbound toward the city on state and county roads and that inbound toward the central business district on city streets. Data are shown for all hours for these three types of facilities except for the 10 p.m. to 6 a.m. hours on county roads. Volumes on these roads are so small during these hours that extremely variable results occur.

Especially significant are the directional volumes from 6 to 7 a.m. During this hour over 70 per cent of all traffic is bound toward the city, incidently, for work purposes. On city streets this directional movement is over 60 per cent in one direction and bound towards the industrial areas of the city.

As a general rule the data indicates slightly more inbound traffic during the morning hours and more outbound traffic during the late afternoon hours. Of special interest is the directional variation during the peak hour of 4 to 5 p.m. On state roads about 40 per cent is inbound, while on county roads and city streets the inbound traffic constitutes 45 per cent of the hourly traffic.

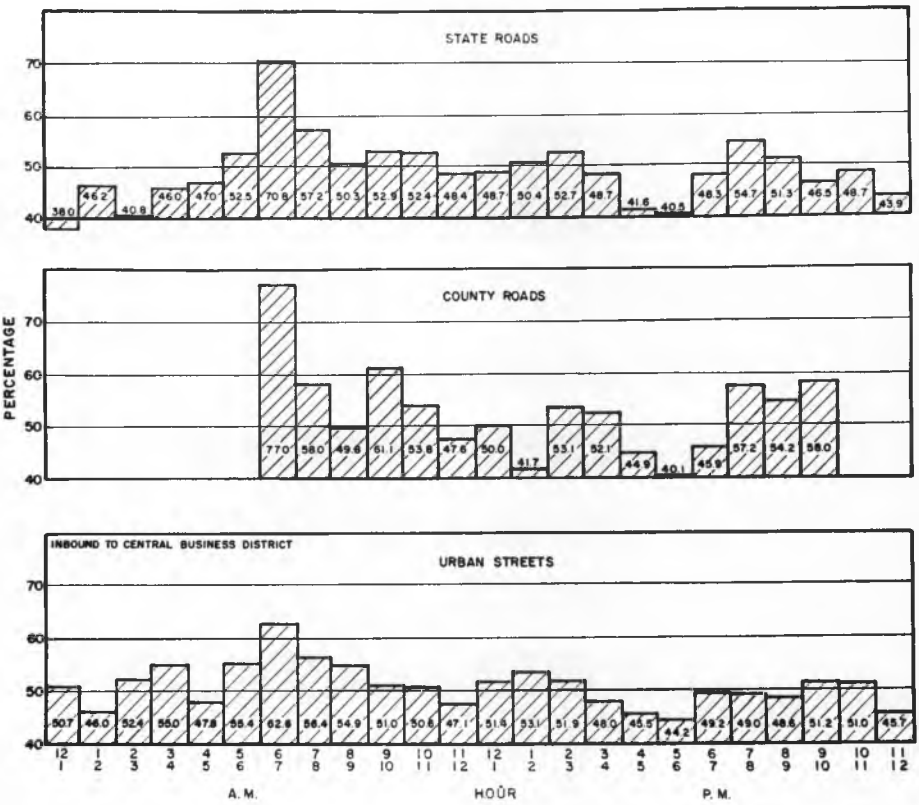

Fig. 6. Percentage of each average hourly traffic volume that is inbound to city.

For roads and streets in the vicinity of large industrial areas the directional movement may be more pronounced than for the facilities indicated here. For planning purposes, however, a 60 to 40 split of directional movement for state roads and a 55 to 45 split for county roads and city streets for the peak hour appears to be reasonable.

TRIP TYPES

A question which always faces the highway planner is the type of trip that will use a planned facility. The results of the origin-destination surveys at the seven widely scattered cities in Indiana indicated that the percentage of approaching traffic bound beyond the city conformed to the proportions determined by the Bureau of Public Roads several years ago. A chart prepared by them which shows the proportion of through traffic as a function of the size of city is shown

in Figure 7. The light areas are the proportion of approaching traffic bound through the city, the dark areas the proportion bound for the

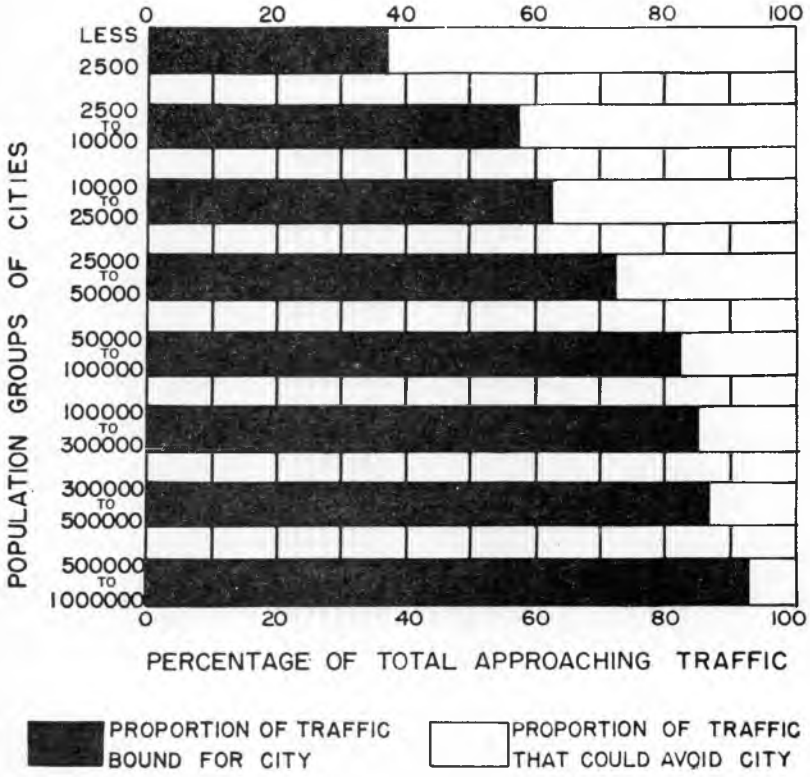

Fig. 7. Proportion of traffic approaching cities which is bound for or beyond the city.

city. For cities of less than 2,500 the through percentage of total approaching traffic is about 62 per cent while for cities between 300,000 and 500,000 it is only about 12 per cent.

The presence of a major interstate highway through the city will result in slightly higher proportions of through traffic but even major roads like U.S. 40 through Richmond resulted in only about 4 per cent more of the approaching traffic being through traffic than is estimated by this chart. For planning purposes it is quite adequate.

PURPOSE OF STOP BY THROUGH TRIPS

Although the percentage of total approaching traffic that is bound through a city varies with the size of the city, the percentage of that through traffic which stops in the city is almost a constant one.

The information collected in the seven cities included data on purposes of stop by through motorists. The summarization of this information is shown in Figure 8. An average of only 15 per cent of all through

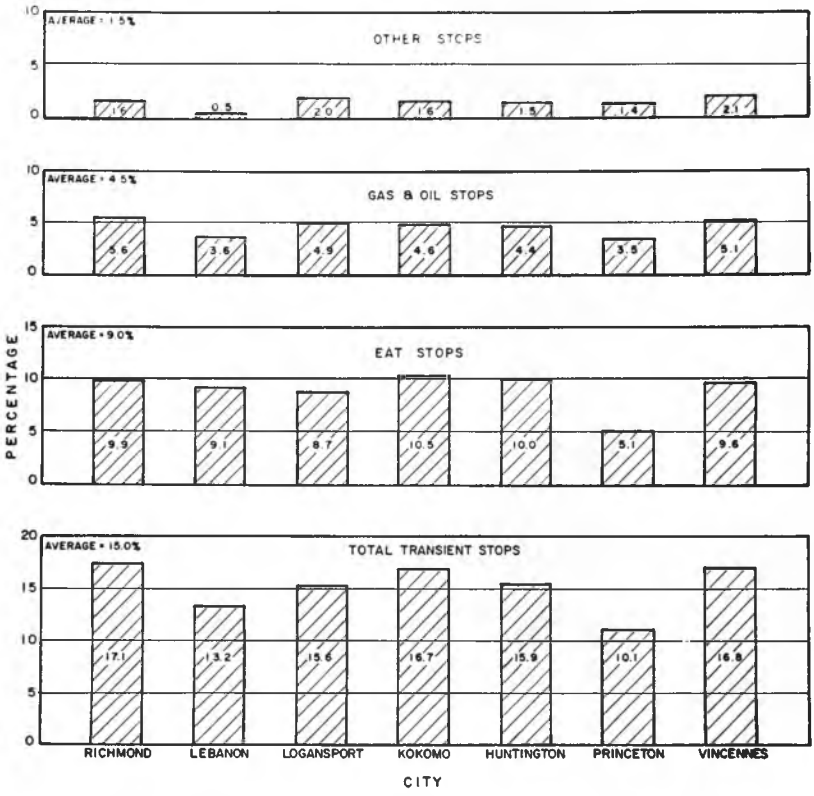

Fig. 8. Percentage of total thru trips that stop for transient purposes.

trips stopped in these cities for transient purposes and none of these cities had a by-pass when the survey was performed. Transient purposes are those purposes which could have been satisfied along the highway but not necessarily in any particular city. These are the stops which might be removed from a city if a by-pass were built. However, as reported at last year's Road School, approximately 45 per cent of these motorists make the stop in the downtown area of the city even after a by-pass has been constructed.

Of these 15 per cent, approximately 9 percent are for eat purposes and 4.5 per cent for gas and oil purposes. Only 1.5 per cent are for all other purposes. Note that the percentages for each of the seven cities are quite similar even though they vary in size from 7,000 to

40,000 in population. The eat purposes at Princeton are less than for the other cities, however, perhaps because this city is considerably smaller than the others.

PURPOSE OF TRIP

It is generally accepted that the motor vehicle is a major factor in the economy of this country and that a majority of the trips made by motorists are for necessary purposes. To test this hypothesis motorists in our various surveys were queried as to the purpose of their trip and each purpose was listed in one of two categories—social purposes or work purposes. All necessary purposes, such as shopping, work, business, medical, etc., were classed as work and all unnecessary ones, such as social, recreational, vacation, etc., were classed as social purposes. This classification is not intended to leave the impression that recreation and vacation are not necessary but rather that the specific

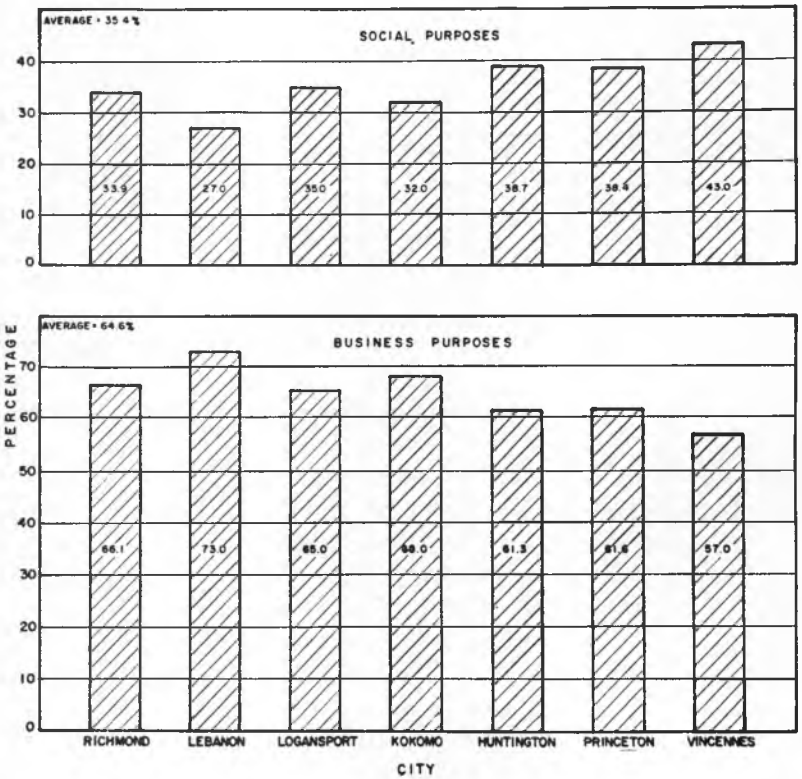

Fig. 9. Percentage of total trips by passenger cars that are made for social and business purposes.

trip of these motorists could be modified or temporarily eliminated without producing an important effect on their lives.

The purpose of trip for motorists driving passenger cars in the seven cities is shown in Figure 9. The average in these cities is approximately 65 per cent for work and 35 per cent for social purposes with the variation from city to city being quite small. These results are for trips during the average week-day and reflect the dependence that we have on the motor vehicle. The purposes of trips for trucks are not included in these tabulations as they are almost totally work purposes.

PASSENGERS PER CAR

Although the American motorist demands a passenger car that will comfortably seat six individuals, he seldom makes use of this capacity. The average number of passengers in passenger cars for the seven cities is shown in Figure 10. For all purposes of trip an average

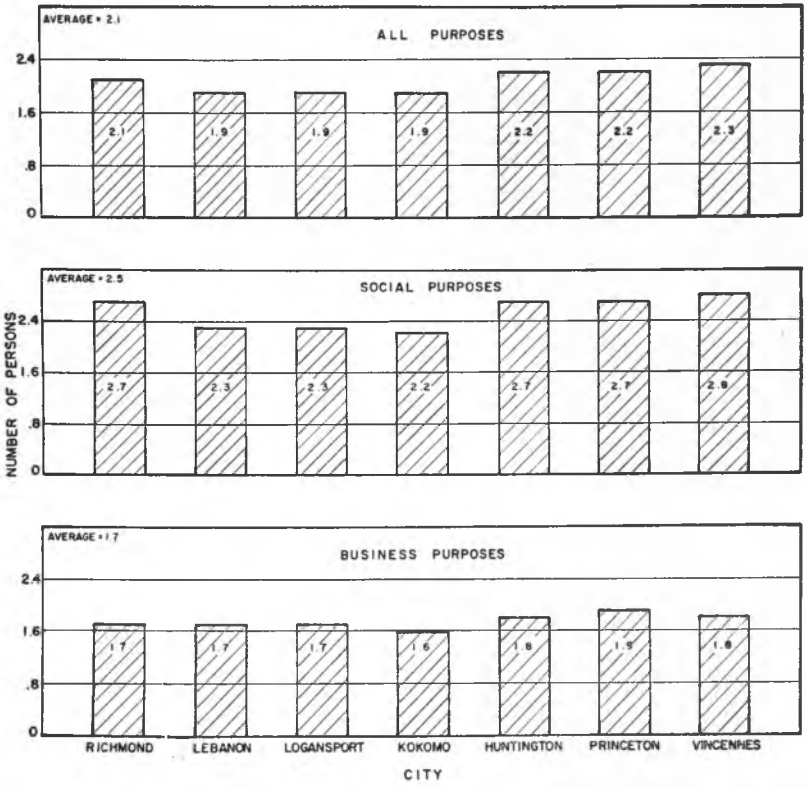

Fig. 10, Average number of passengers per passenger car.

of slightly more than two persons are in each passenger car. For trips to and from work, the average number of persons per automobile trip is 1.74 while for social purposes the average is 2.52. This information is useful in determining the number of parking spaces required for industries, theatres, and other establishments and indicates possible encouragement for share-a-ride campaigns among industrial workers.

LOCATION OF REGISTRATION

As further evidence of the great preponderance of local trips made on the highways of an area, the location of registration of each motor vehicle was determined by noting the license plate that was carried. A tabulation of the percentage of the total vehicles using the highways near the seven cities and registered in Indiana is shown in Figure 11. These percentages are of course affected by the nearness of the city to the state border—witness Richmond, Princeton, and

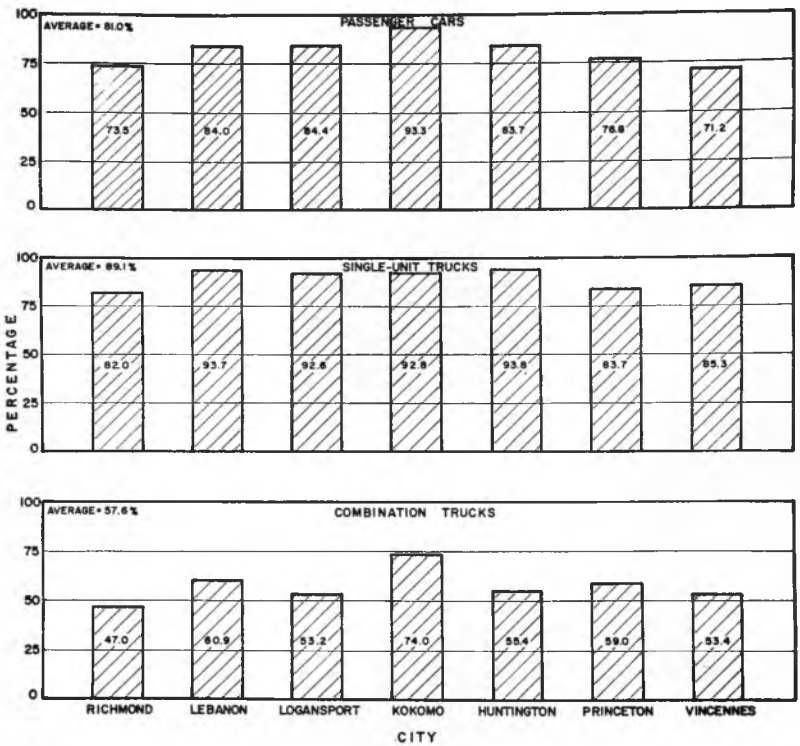

Fig. 11. Location of vehicle registration expressed as the percentage of observed Indiana registrants among the total vehicle volumes of each vehicle type.

Vincennes—but the great majority of passenger cars and light and medium trucks using our Indiana highways are registered in Indiana. For heavy trucks, this is not so. At several cities about one-half were not registered in Indiana but in some other state, and at all cities a large percentage (an average of over 40 per cent) are registered outside of Indiana.

SPEEDS

The Project has maintained an unbroken record of speed trends since 1939 and has reported these trends at periodic intervals throughout the years. Figure 12 summarizes the average speeds on main Indiana rural highways since 1942. The most significant pattern is

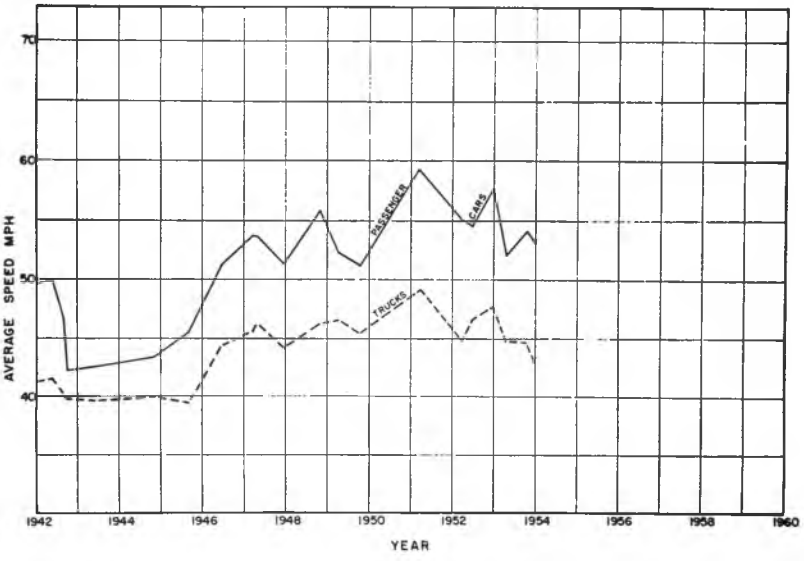

Fig. 12. Average speeds on rural Indiana highways 1942-1954.

the increasing trend from 1945 to 1951 and the reduction in speeds since 1951. This recent reduction may be the result of increasing volumes of traffic at the sites tested, of the recent 65 mile speed limit law, a combination of these, or some other reasons. A study of these recent declining average speeds is underway and will be the subject of a future report. The average speed at the six locations used for our speed studies—undeveloped rural locations on long tangents—was about 53 m.p.h. for passenger cars and 43 m.p.h. for trucks at the beginning of 1954.

CONCLUSION

In conclusion our studies over the past several years have produced considerable information regarding the characteristics of travel on our Indiana highways. This information is especially valuable to the highway planner and to those engaged in the performance of traffic studies or the operation of highway facilities. The solution of the highway traffic problem must of necessity be based on factual and basic data concerning the characteristics of motor vehicle travel. Only with facts can we begin to understand the problem with which we are confronted and only with facts can we wisely plan an efficient, economical, and safe solution. The few characteristics presented in this paper are offered as a contribution to a better understanding of the complex problem of motor vehicle travel.

ACKNOWLEDGEMENTS

The author wishes to express his appreciation to those who have assisted in any way with this study. Special mention is due the personnel of the Metropolitan Area Traffic Survey Unit and the Statewide Highway Planning Survey Unit of the State Highway Department of Indiana for providing a great amount of the data. The assistance of Messrs. John Baerwald and David Rosenfield of the Joint Highway Research Project Staff in the collection and tabulation of portions of the data is gratefully acknowledged and the help of various draftsmen and clerical personnel is appreciated.

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