Highway Shoulder Use Study Procedure Guide

• THIS GUIDE has been prepared by the Highway Research Board Committee on Shoulders and Medians to meet the need for standardized procedures in conducting shoulder use studies.

During its 1958 meeting, the Highway Research Board's Committee on Shoulders and Medians recognized a growing need for more complete factual information on driver stopping practices on highway shoulders. It was evident that such information was needed as a basis for sound policy recommendations regarding the prohibition of parking on highway shoulders and the extent that provision needs to be made for emergency and/or rest stops on freeways. To meet this need, a number of states at the recommendation of the Committee on Shoulders and Medians, initiated shoulder use studies during 1958 and several studies were completed by the end of the year.

In the course of reviewing these studies, the Committee on Shoulders and Medians found that, because of differences in study procedures and analytical methods, the shoulder use data from the several studies were not always on a comparable basis. As a result, a recommendation was made by the committee during its 1959 meeting that a shoulder use study guide be prepared and adopted, and that future studies be conducted in accordance with this guide so that the greatest utility and benefit could be obtained from the studies of the various states.

The purpose of this guide is to describe a method of making a shoulder use study which will provide uniform and reasonably accurate data on the use of highway shoulders for parking or stopping.

BACKGROUND

Parking on highway shoulders with its attendant hazard in entering and leaving the traveled lanes has long been recognized as a cause of accidents. With the ever-increasing mileage of high-speed multi-lane freeways on the highway systems of the nation, it has become evident that control of shoulder parking and provision for emergency and rest stops on such highways are necessary. In the past, shoulder parking restrictions have been applied to limited sections where specific parking hazards existed. However, it was considered neither desirable nor necessary to control parking continuously over the entire length of a highway. With the hundreds of miles of controlled-access highways now under construction or completed on the Interstate and other systems, there is an immediate need for current accurate information on which to base decisions for proper control of shoulder parking and planning of safety rest areas (1, 2).

This guide indicates the basic data to be collected, the methodology and procedures to be followed in collecting, assembling, and analyzing the data, and a suggested outline for a suitable report covering a shoulder use study. The guide is not intended to be all-inclusive or restrictive as far as the scope of shoulder use studies that may be undertaken. All specific problems or conditions that may be the subject of shoulder use studies cannot be covered in a guide of this type. It will be necessary for those conducting studies to supplement and adapt the procedures recommended herein to the specific study conditions at hand, bearing in mind the importance of maintaining uniformity of shoulder stop definitions and basic procedures to assure the comparability and reliability of shoulder use data reported in various studies.

As envisaged in this guide, a shoulder use study should be designed to provide all information necessary for establishing the shoulder parking characteristics of drivers on a selected section or sections of highway and under specified conditions (3). The essential procedural steps in the planning of such a study are as follows:

1. Selection of study site on highway section having the geometric design, traffic, and locational characteristics appropriate to the study objectives.
2. Observation and interviewing of drivers parking on shoulders in the selected study site over such periods of time as will establish, within reasonably accurate limits, the shoulder parking characteristics of drivers in terms of frequency and duration of shoulder stops, reasons for stopping, and related information.
3. Counting and classification of vehicle traffic on the study section during the shoulder use survey to establish accurately the relationship between shoulder stops and vehicle-miles of travel by vehicle types.
4. Tabulation and analysis of the shoulder use observation and traffic volume data, including the arithmetic tabulation and summarization of the data, the statistical analysis and presentation of data in the form of tables, charts, percentage distributions, averages, statistical tests of significance, and analytical interpretation of the data in narrative form.
5. Compilation and presentation of the data in narrative, tabular, and graphic form suitable for publication.

PRELIMINARY PLANNING AND GENERAL PROCEDURE

Before beginning the detailed planning of a shoulder use study, the objectives of the study should be decided on and clearly defined. The following is a list of the more important study objectives:

1. To establish the frequency, purpose, and duration of shoulder parking on certain types and classes of highways or highway systems.
2. To determine the effects of various shoulder parking controls as indicated by signing such as "No Parking," "No Parking on Highway Shoulders," and "Emergency Parking Only."
3. To determine the effect of roadside safety-rest areas on shoulder parking practices, and also information relating to the need for such rest areas and potential uses of them.
4. To determine the relationship between the frequency of shoulder stops and accidents involving a parked vehicle or one engaged in a maneuver leading to a stop or resuming travel after a stop.

In the design of a given study, of course, these objectives may be considered individually or in combination. Once the study objectives have been delineated, it then becomes necessary to choose as a study site a highway section or sections possessing the roadway and traffic characteristics appropriate to the study objectives. Such considerations include the extent of access control, distance between interchanges and population centers, shoulder width, character of abutting land, and others. Additional considerations may also be involved. For instance, if the study is concerned with the effect of shoulder parking control signing, it would be important that advance arrangements be made with the proper authorities for the installation or removal of signs in coordination with the shoulder use field observation schedule. In this connection, where studies are concerned with the effect of parking control signs or rest areas, newly constructed highways will afford a unique opportunity for before- and after-studies under controlled conditions.

The optimum plan for the collection of shoulder use field data would be one in which there were sufficient observers so situated that all drivers stopping on the highway shoulders would be observed and interviewed. From a practical standpoint, experience has shown that the number of observers and interviewers necessary to obtain 100 percent coverage would be excessive in relation to the probable degree of accuracy which would result. As an alternative to total coverage, it is recommended that a part of each study section be set up as a "control" section in which all stops are observed and recorded by fixed observer with mobile observers patrolling the entire section on a regular basis. The ratio of total stops in the "control" section to stops observed by the mobile observers in the "control" section provides a factor for expanding the observed shoulder stops to total stops in the study section.

Considering operational factors, it has been found from experience that study sections of from 4 to 8 mi in length are most suitable. If at all possible, a study section should be so located that an interchange is situated at or near each end, so that the mobile shoulder use observers will have a safe and easy means of changing their direction of travel. Another requirement to be considered is that of providing for a control section of at least 1 mi in length on which continuous observation can be made and on which there is available an advantageous position at which to station the classifier-observer to maintain this continuous surveillance.

As an aid to planning, it is desirable to procure a large-scale map (approximately 1 in. = 1 mi) of the area in which the study section or sections are located, including at least a 5-mi area on either side of the study section. Such a map was used in planning a shoulder use study on a 4-lane divided highway on Interstate 5 in Oregon (see Fig. 1). In this particular instance, the study section was 5.0 mi in length and so located that interchanges were conveniently available at either end to permit the mobile observers to change direction of travel in the course of patrolling the study area. A control section 2.0 mi in length was delineated at the north end of the full study section, and this was subject to continuous surveillance by the observer-classifier stationed at the vantage point offered by the Talbot Road Overcrossing near its midpoint.

There is no substitute for on-the-site observation of proposed study sties. It is important that the roadway in the "control" section be easily observed by the stationary observer. Excessive rise and fall or curvature of the roadway in the section will result in sight restriction, making impractical the complete observation of the control section. It is important to record the exact location of the various roadway features and any signs relating to them. Some of the more important features are parking regulations, safety rest areas, interchanges, crossroads, and special highway and roadside attractions. These signs and also the unmarked roadside features should be located on the map so that they may be considered in analyzing the survey data.

In summary, collecting field data for the shoulder use study involves the following:

1. Interview of drivers parking on shoulders during daylight hours by mobile observers in passenger cars patrolling the study sections in both travel directions.
2. Counting and classifying traffic in the study section during the shoulder use observation study period to obtain an accurate count of vehicle-miles by vehicle type. (Ordinarily one person acting as a combination traffic counter and classifier will suffice to secure accurate traffic data.)
3. Determining the number, type, and duration of shoulder stops occurring in a "control" section of 1 or more mi length under continuous observation during the survey. (This observation may normally be made by the vehicle classifier, mentioned at the same time he is counting traffic.)

COLLECTION OF FIELD DATA

Personnel Requirements

Personnel requirements for the field work of collecting traffic and shoulder use data will vary with the physical characteristics of the study section and the study purposes. Sufficient mobile observers will be required to patrol the highway section and interview drivers parking on highway shoulders to insure that the majority of all drivers stopping in the study section will be interviewed and reliable stop data will be obtained. Although no precise determination has been made, it is suggested that a sufficient number of mobile observers be assigned so that no part of the study section will be unobserved for an interval of more than 10 min (preferably less). In a specific instance, it was found that of the total stops known to have occurred on a 2-mi control section of 4-lane divided highway, approximately 65 percent were observed by two mobile observers traversing the section on a 15-min schedule. The mobile-observer coverage will, of course, be affected by the volume of stops and interview time both of which will vary on different highway study sections.

A stationary observer will be needed to record shoulder stops in the control section. This observer may also tabulate and classify traffic. One person will act as the super-

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SHOULDER USE STUDY

VICINITY MAP - STUDY SECTIONS

Ankeny Hill - South Jefferson Junction Section
Interstate Route 5, Highway No. 1 - M.P. 57.90-62.90

April, 1959

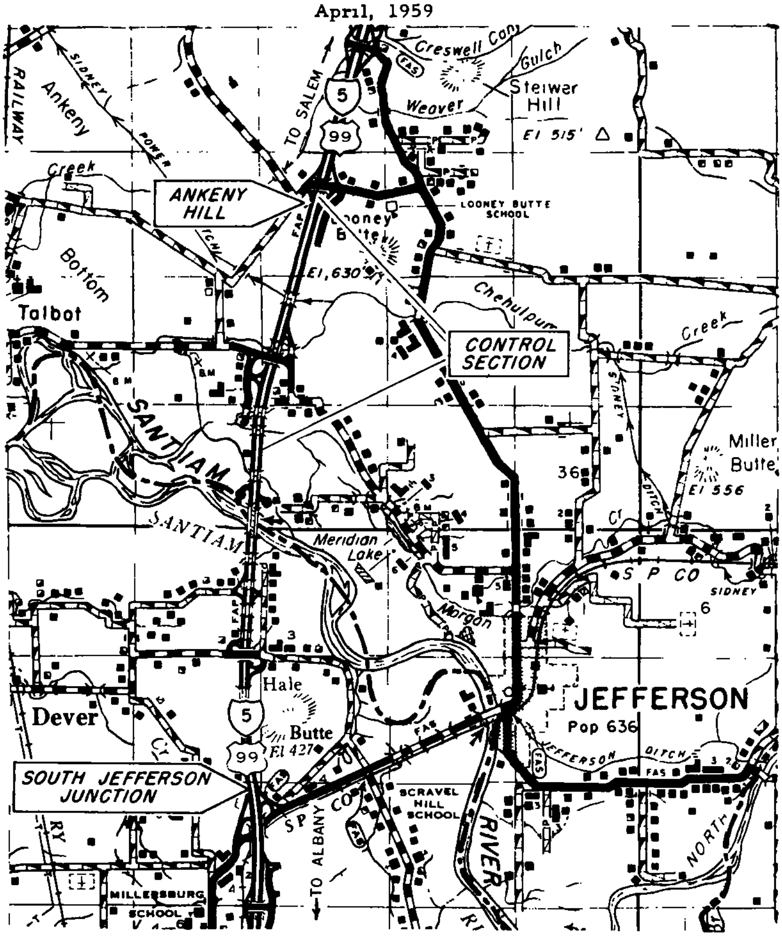


Figure 1.

visor of the field crew. The supervisor, in addition to his duties of coordinating the activities of the survey crew, will act as a relief man for the observers for lunch periods and other purposes. He will also review the data collected and be responsible for the completeness and accuracy of the data. In some instances, depending on the location and features of the survey section, it will be necessary for the supervisor to secure extra gasoline for the patrol cars, and record traffic data from mechanical traffic recorders. If the study section should include a safety rest area, an additional observer will be required to record stops and interview drivers parking in the rest area.

Equipment

The following equipment will ordinarily be required for the collection of the shoulder use field data:

1. Passenger Cars.—A passenger car will be used by each mobile observer in observing stops and interviewing drivers of vehicles parked on shoulders. An additional vehicle will be used in transporting the crew to work, and running errands necessary in the operation of the survey. It is preferable that the cars assigned the mobile observers for cruising the study section have two-way radio communications between them. However, this feature is not essential. In case radio equipment is not available, communication by pre-arranged auto light blinker or card signals may be provided.
2. The 6-bank Veeder Root counter or equivalent is desirable for use in counting traffic by vehicle type.
3. A clip board and pencils should be furnished each member of the survey team.
4. A time piece for each member of the survey team will be needed to coordinate operational schedules.
5. A tape for each mobile observer to measure the distance from the side of parked vehicles to the pavement edge.

Forms and Maps

A regional highway map, including the highway section under study, should be furnished the shoulder use study field supervisor, with the highway section and access routes to be used in reaching the study section identified so that there will be a minimum delay in reaching and no mistake in locating the section under study.

A large-scale map of the study section (preferably at least 1 in. = 1 mi scale) should be provided for laying out the routes of the mobile-observers and the placement of the traffic-observer, and for describing the exact limits of the study site and control section to the field crew (see Fig. 1).

Daily traffic classification count summary forms for entering and summarizing hourly traffic totals by day as counted by the classifier-observer (see Fig. 2).

STATE OF________
SHOULDER USE STUDY

DAILY TRAFFIC CLASSIFICATION COUNT SUMMARY

Highway No.________________

Study Section________________

Date________________

Day________________

Time Period		Northbound				Southbound			
		Pass. Cars (State)	Pass. Cars Out-of-State	Trucks & Buses	All Vehicles	Pass. Cars (State)	Pass. Cars Out-of-State	Trucks & Buses	All Vehicles
0600	0700	93	27	70	190	67	25	56	148
0700	0800	154	39	78	271	172	49	77	298
0800	0900	169	45	77	291	199	42	91	332
0900	1000	161	78	79	318	286	88	94	468
1000	1100	238	77	86	401	197	81	84	362
1100	1200	207	78	84	369	203	86	105	394
Total		1,022	344	474	1,840	1,124	371	507	2,002

Comments________________

(Data shown are for exemplary purposes only).

Figure 2.

STATE OF ________
SHOULDER USE STUDY

SHOULDER STOP INTERVIEW FORM

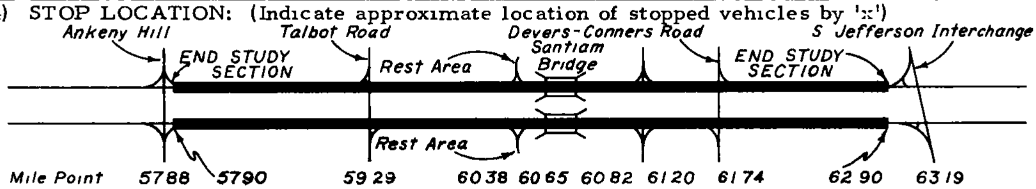
Highway No. ____________________ Observer ____________________
Date ____________________
Study Section ____________________ Day ____________________

(1) TIME. a. Observed ______
b. How long have you been here? ______
☐ a. m. c. How much longer will you stay? ______
☐ p. m.
d. Actual departure time, if observed ______

(2) STOP DURATION:
a. Departed ______
b. Stopped ______
c. Length of Stay ______
(Office Use Only)

(3) DIRECTION OF TRAVEL: ☐ Northbound ☐ Southbound

(4) STOP LOCATION: (Indicate approximate location of stopped vehicles by 'x')



Vehicle stopped:
On Median Shoulder ☐
On Outside Shoulder ☐

Distance parked from pavement edge _____ft. _____in.

(5) VEHICLE TYPE:
Passenger ☐
Truck and Bus ☐

(6) REGISTRATION:
State ☐
Out of State ☐
Unidentified ☐

(8) TRIP PURPOSE:
☐ Business
☐ Driving to or from work
☐ Vacation
☐ Recreation
☐ Social
☐ Shopping
☐ Other ________ (Explain)

(9) LAST STOP:
a. Time ______
b. Location ______
c. Estimated Elapsed Time ______

(7) IDENTIFICATION ______
______

(10) NUMBER OF OCCUPANTS ______

(11) TYPE AND PURPOSE OF STOP:

Voluntary

Rest and Leisure
- ☐ Rest or Sleep
- ☐ Checking Map
- ☐ Changing Drivers
- ☐ Eating in Vehicle
- ☐ Car Sickness
- ☐ Recreation (Picnic, Fishing, etc.
- ☐ Visiting
- ☐ Latrine
- ☐ Other ________ (Describe)

Business
- ☐ Discharging or Picking up Pass. (Bus Only)
- ☐ Inspecting Utilities
- ☐ Inspecting Farm and Crops
- ☐ Inspecting Industry
- ☐ Other ________ (Describe)

Other Voluntary
- ☐ Assisting Vehicle
- ☐ Checking Vehicle or Load
- ☐ Minor Mechanical Trouble
- ☐ Police Enforcement Stop
- ☐ Police Assist. Stop
- ☐ Stopped by Police
- ☐ Other ________ (Describe)

Involuntary
- ☐ Flat Tire
- ☐ Out of Gas
- ☐ Involved in an Accident
- ☐ Mechanical Failure
- ☐ Other ________ (Describe)

COMMENTS ____________________
(Sketch shown for exemplary purposes only)

Figure 3.

Shoulder use observation forms to record data on each observed shoulder stop and interview by the mobile observers (see Fig. 3). This same form will be used by the stationary classifier-observer to record observed shoulder stop data in the "control" section.

Schedule of Operations

Normally, shoulder use observations will be made during daylight hours. The hazards of nighttime interviewing and difficulties of counting and classifying traffic at night make it difficult to conduct the survey during hours of darkness. However, limited surveys of nighttime shoulder use may be made by a fixed observer covering short "control sections" in a similar manner to that described for the more extensive daytime study.

The observations should be representative of both morning and afternoon conditions and should preferably cover 12 continuous daylight hours; for example, 6:00 AM to 6:00 PM. It should be adequate to limit observations to weekday, daylight hours only. However, in the instance of study sections with unusually high usage by recreational weekend traffic, including recreational rest areas, it may be desirable to make a survey during the weekend.

It is necessary to establish definite mobile-observer trip and traffic counting schedules so that the interviews and traffic data collected will lend themselves to analysis and correlation. A morning trip and traffic-counting schedule for a 5-mi study section based on average mobile-observer speeds of 45 mph, is shown in Figure 4. A similar schedule would be provided for the 12:00 to 6:00 PM observations. This schedule would, of course, require modification to fit other study sections. The schedule assumes an 8-hr workday with 6 hr of observation time and 2 hr allocated for travel time and review of interviews and traffic counts.

Recording Traffic Volume and Classification Counts

Manual traffic classification counts will be made by the classifier-observer stationed at the observation vantage point in the control section. The hourly traffic counts should be entered on the daily traffic classification count summary (Fig. 2) at the times indicated by the shoulder use observation schedule. The traffic classifier-observer should continue his traffic counting during the entire shoulder use observation period, except when relieved of his duties by the supervisor or other relief man. It is important that the counts be as accurate as possible. The traffic classifier should synchronize his watch each day with the watches of the survey supervisor and mobile observers to maintain the coordination of traffic counts with shoulder use observations. The traffic classifier-observer may be seated in a parked automobile where the roadway visibility permits. However, to obtain an unobstructed view of the control section and reliably to count and classify traffic, it will often be necessary for the traffic classifier-observer to be stationed on an overhead crossing or median. In these instances where a car cannot be left parked safely, a folding chair and a beach-type umbrella is recommended for the comfort of the classifier-observer.

For study sections with interchanges or crossroads inside the section which have appreciable traffic off and on the highway under study, it may be necessary to supplement the manual traffic classification counts with mechanical recorder counts. On high-volume highways, any supplementary traffic counts that may be required should be made on the low-volume crossroads or interchange ramps, as experience has shown that automatic count variability on the "high line" will be so much as to add no accuracy to the original manual count.

Motorcycles, horse-drawn vehicles, highway maintenance equipment, tractors, graders and mowers, and other vehicles engaged in actual maintenance activity within the study section should be excluded from the traffic and shoulder stop counts.

Shoulder Stop Interviews

The reliability of the information presented in the shoulder use report will depend on the accuracy and completeness of the shoulder stop interview data. As the sources of

STATE OF__________
SHOULDER USE STUDY

SHOULDER USE OBSERVATION SCHEDULE
July 11, 13, 15 - A.M.

Highway No. ____________
Study Section____________

Time (A.M.)	Mobile-Observer #1	Mobile-Observer #2	Traffic Classifier-Observer
6:00	Lv. Ankeny Hill	Lv. S. Jefferson Jct.	Start Counts
6:12	Lv. S. Jefferson Jct.	Lv. Ankeny Hill	
6:24	Lv. Ankeny Hill	Lv. S. Jefferson Jct.	
6:36	Lv. S. Jefferson Jct.	Lv. Ankeny Hill	
6:48	Lv. Ankeny Hill	Lv. S. Jefferson Jct.	
7:00	Lv. S. Jefferson Jct.	Lv. Ankeny Hill	Post Hourly Totals
7:12	Lv. Ankeny Hill	Lv. S. Jefferson Jct.	
7:24	Lv. S. Jefferson Jct.	Lv. Ankeny Hill	
7:36	Lv. Ankeny Hill	Lv. S. Jefferson Jct.	
7:48	Lv. S. Jefferson Jct.	Lv. Ankeny Hill	
8:00	Lv. Ankeny Hill	Lv. S. Jefferson Jct.	Post Hourly Totals
8:12	Lv. S. Jefferson Jct.	Lv. Ankeny Hill	
8:24	Lv. Ankeny Hill 1/	Lv. S. Jefferson Jct.	
8:36	Lv. S. Jefferson Jct. 1/	Lv. Ankeny Hill	
8:48	Lv. Ankeny Hill	Lv. S. Jefferson Jct. 1/	
9:00	Lv. S. Jefferson Jct.	Lv. Ankeny Hill 1/	Post Hourly Totals
9:12	Lv. Ankeny Hill	Lv. S. Jefferson Jct.	1/
9:24	Lv. S. Jefferson Jct.	Lv. Ankeny Hill	1/
9:36	Lv. Ankeny Hill	Lv. S. Jefferson Jct.	
9:48	Lv. S. Jefferson Jct.	Lv. Ankeny Hill	
10:00	Lv. Ankeny Hill	Lv. S. Jefferson Jct.	Post Hourly Totals
10:12	Lv. S. Jefferson Jct.	Lv. Ankeny Hill	
10:24	Lv. Ankeny Hill	Lv. S. Jefferson Jct.	
10:36	Lv. S. Jefferson Jct.	Lv. Ankeny Hill	
10:48	Lv. Ankeny Hill	Lv. S. Jefferson Jct.	
11:00	Lv. S. Jefferson Jct.	Lv Ankeny Hill	Post Hourly Totals
11:12	Lv. Ankeny Hill	Lv. S. Jefferson Jct.	
11:24	Lv. S. Jefferson Jct.	Lv. Ankeny Hill	
11:36	Lv. Ankeny Hill	Lv. S. Jefferson Jct.	
11:48	Lv. S. Jefferson Jct.	Lv. Ankeny Hill	
12:00 (noon)	Arr. Ankeny Hill	Arr. S. Jefferson Jct.	Post Hourly Total

1/ Relief observer replaces regular observer for 24-minute rest periods.

(Data shown are for exemplary purposes only.)

Figure 4.

the data will be the interviewers and the drivers of the stopped vehicles, the success of the survey and the maintenance of favorable public relations will depend much on the manner in which the interviewer meets the public, explains the purpose of the survey, and asks the pertinent questions. The interviewer must present a neat appearance and be courteous and tactful regardless of the driver's attitude toward the survey.

It is important that the interviewers be instructed in advance of the actual work assignments as to the purpose of this survey, the over-all methodology of the survey, and their specific work assignments. Each interviewer should familiarize himself thoroughly with the survey procedures and discuss with the supervisor any points on which he may not be clear in advance of the beginning of the actual survey. It is recommended that the mobile-observers be given a "dry run" cruise of the study section, including trial interviews before the actual survey. A "dry run" should be followed by a review of the trial interview form, and appropriate instruction should be given to correct any deficiencies or answer any questions posed by the interviewer. The observers should be furnished with a supply of shoulder stop interview forms, a shoulder use observation schedule, a tape measure, a clip board, pencils, and scratch paper. It is strongly recommended that completed interview forms be reviewed by the survey supervisor during or at the end of the day on which they are obtained. If there are any corrections or deficiencies they should be discussed with the interviewers before the next day's work. Leaving the first review to a later date or to the office force is a poor practice. It becomes more difficult to recall details that may have been omitted on the form, and in many instances the persons who might be able to supply the correct information are not available for questioning.

The shoulder stop interview form (Fig. 3) should be prepared as completely as possible for each vehicle observed parking on the highway shoulder regardless of whether the driver of the vehicle is interviewed. In addition to the stops recorded by the mobile observers, the classifier-observer stationed in the control section should record all stops observed in the control section with as much detail as possible on shoulder stop interview forms. It is important that the classifer-observer record all stops in the control sections whether observed by the mobile-observers or not, as the ratio of total stops to stops observed by the mobile observers in the control section establishes an expansion factor used in estimating the total number of stops occurring in the study section.

The shoulder stop information should be recorded on the form as accurately as possible at the time of interview or immediately thereafter. Attempts to recall interview data at a later time leads to errors and incompleteness.

Entries

1. Time.—Indicate the time the vehicle stopping on the highway is observed by checking "AM" or "PM," and entering the time of day in the space opposite "observed" to the nearest minute. Enter the driver's answers to the questions "How long have you been here?" (1-b) and "How much longer will you stay?" (1-c) in minutes. If a driver is not interviewed, leave these spaces blank, or if he does not wish to cooperate in answering the questions, so indicate this fact under comments. If the actual time of departure is observed, enter the time in the space opposite "actual departure time" (1-d). If the vehicle is observed parking, it will be unnecessary to ask question 1-b, and a zero (0) should be entered in this space.

2. Stop Duration.—These entries are to be used in computing the estimated length of stop from the data shown in Entry 1, and will be completed in the office or by the survey supervisor. No entry is required here by the field observers.

3. Direction of Travel.—Indicate direction of travel (northbound, southbound, eastbound, westbound, as the case may be).

4. Stop Locations.—Indicate the approximate location of the vehicle stop by entering an X on the sketch. The sketch on the interview form should have a scale of about 1 in. = 1 mi, with major road crossings or other physical feature locations indicated by mile point. Reference by the mobile-observers to odometer mileage in relation to check points will aid in locating stops correctly. Notations as to stop location such as "0.4 mi N of Talbot Road" may be written in the margin.

Indicate the shoulder on which the vehicle parked (median or outside) by checking the appropriate box. Measure the distance from the edge of the pavement to the side of the vehicle nearest the traveled lane. Preferably the measurement should be made from the edge of the pavement as shown by the shoulder delineation stripe. If a shoulder stripe is not present, measure from the pavement edge as shown by the shoulder color or texture delineation. If no measurement is possible, as in the instance of a vehicle which moves away before an interview can be made, write "not measured" in the distance space.

5. Vehicle Type. —Indicate the type of vehicle parked by checking the box opposite the appropriate vehicle type. The passenger car classification should include taxis, passenger cars, and station wagons. Panels, pickups, trucks, specialized equipment (loaders, cranes, tractors, etc.) and buses will be under the truck and bus classification.

6. Registrations. —This entry refers to passenger cars only. Check whether the parked vehicle is currently registered in the state in which the study is being conducted or "out of state" as determined by the current license plate.

7. Identification. —Enter the last 3 digits of the license number of the vehicle so that the vehicle may be identified later in analyzing the data. If the license number is not visible, describe the car, for example, "yellow 1957 Chevrolet pickup." It may be advisable to assure the driver that this information is not being collected for law enforcement purposes in study sections where parking is regulated.

8. Trip Purpose. —Check the purpose of the trip as determined by the driver's answer to the question "for what purpose was this trip made?.......business, vacation, recreation, social, driving to work, shopping, or other."

9. Last Stop. — (a) Enter the location as determined from the question: "Where was your last stop?" The answer to this question should be specific enough so that the mileage from the last stop to the present stop may be readily estimated with the use of highway mileage maps.

(b) Enter the estimated time at which the last stop immediately preceding the observed stop occurred.

(c) The elapsed time between the observed and last stop will be computed in the office. No entry is necessary for the field observers.

10. Number of Occupants. —Enter the total number of occupants of the parked vehicle.

11. Type and Purpose of Stop. —Indicate the type and purpose of the stop by placing an X in the space provided opposite the item providing the best description of the type and purpose of the stop. Enter at the bottom of the questionnaire any supplementary information on the stop purpose or other comments that may clarify a questionable stop classification. A stop should be classified as "involuntary" if it results from immobility of the vehicle (including such things as a flat tire, burned-out bearing, etc.) which may or may not render the vehicle completely immobile, or if the continuation of the trip would cause obvious injury to the vehicle or its occupants, or if the motorist is involved in an accident. All other stops are to be considered "voluntary."

A business stop is defined as a stop in which the purpose is associated with a business activity off the highway. Stops associated with the checking of loads on trucks, which can in a certain sense be called business, are classified as "other voluntary" as are stops associated with police traffic enforcement. In Figure 3 there are 3 types of "other voluntary" stops associated with police action. When a policeman stops a motorist for enforcement purposes, the "police enforcement stop" category should be checked for the vehicle stop represented by the police car, and the "stopped by police" entry should be checked for the vehicle stop made by the motorist. In a similar way, if a policeman stops to assist a stranded motorist, the "police assistance stop" will be checked for the police car and one of the other appropriate stop classifications checked for the private vehicle. As with other multiple stops, a separate Shoulder Stop Interview Form should be used for each vehicle—police or otherwise.

In instances where a vehicle is observed, but resumes its trip before it can be interviewed, the stop is classified "voluntary—unknown," unless there is positive evidence to indicate otherwise. Such evidence might be in the form of an accident, the presence of a wrecker or service truck, or the observation that fuel was being poured in the gas tank.

SAMPLE CHARACTERISTICS—SIZE AND VARIABILITY

The determination of the sample size required to ensure that the data will have the required degree of accuracy is probably the most difficult problem encountered in any study. This is particularly true in a study such as this one on shoulder use in which the sample size is determined by the number of shoulder use observation periods, inasmuch as scheduling of men and equipment cannot always be done without considerable planning. It is desirable to keep the sampling period as small as possible, but large enough to ensure a reasonable measure of accuracy.

In the shoulder use study, the most important statistic to be considered in determining the sample size is the accuracy of the statistic measuring the relative frequency of shoulder usage—the vehicle-miles per stop average. It is recommended as a minimum requirement that the sample size be chosen to provide an accuracy in which the errors of the vehicle-miles per stop average for all vehicles, all stop types will be 20 percent or less 95 percent of the time. It is, of course, preferable that the errors will be less than 20 percent. However, experience has shown that the additional sampling necessary to improve the statistical accuracy of the data within the desired limits is not always practical.

The process of determining the sample size and statistical variability of the vehicle-miles per stop averages obtained from the sample data may be divided into four major steps:

1. Collection of data for determining an estimate of the variability of the vehicle-miles per stop average by conducting shoulder use observations for a number of days such that a number of fairly reliable vehicle-miles per stop averages (approximately 10) may be obtained for analysis.
2. Determination of the required sample size for the desired accuracy on the basis of the variability of the "sample" vehicle-mile per stop averages.
3. Collection of the shoulder use data for any additional observation periods required, to gain the desired sample accuracy as determined in step 2.
4. Computation of the reliability of the vehicle-miles per stop averages for the total study sample (combined data as obtained in steps 1 and 3). This will be expressed as a range within which the true value is to be found for a given confidence level.

A detailed discussion of statistical procedures, formulas, and methods of analyses to be used in determining the sample size and variability appears in the Appendix.

TABULATION AND ANALYSIS OF DATA

The services of a statistician and an assistant statistician or statistical clerk will usually be sufficient for the tabulation and analysis of the shoulder parking and traffic data collected during the survey. Ordinarily, the number of interviews and the amount of traffic data for the shoulder use study will not be sufficient to warrant machine processing. The following procedures assume the analysis and tabulation of the shoulder use data manually with the aid of adding machines and desk calculators.

It is recommended that the completed shoulder stop interview forms (Fig. 3) and daily traffic classification count summary forms (Fig. 2) for the first day or two of the survey be reviewed by the statistician in charge of the data analysis as soon as practical so that any deficiencies or necessary corrections can be discussed in conference with the field crew chief in order to reduce future errors and allow immediate correction and/or addition of missing data. This practice will correct any misinterpretation of instructions and result in improved data collection procedures for the duration of the survey.

Summary of Traffic Data and Computation of Vehicle-Miles

Figure 5 provides a detailed summary of traffic counts and vehicle-miles by direction

STATE OF __________
SHOULDER USE STUDY

DISTRIBUTION OF TRAFFIC AND VEHICLE MILES BY VEHICLE TYPE
AND DIRECTION OF TRAVEL

Highway No ______________
Study Section ______________

Study Section Length 5.0 (miles)

DATE	Northbound								Southbound								Total							
	Pass (State)		Pass (O.S.)		Bus & Truck		Total		Pass (State)		Pass (O.S.)		Bus & Truck		Total		Pass (State)		Pass (O.S.)		Bus & Truck		Total	
	Traffic	VM	Traffic	VM	Traffic	VM	Traffic	VM	Traffic	V.M	Traffic	V.M	Traffic	VM	Traffic	VM	Traffic	VM	Traffic	VM	Traffic	VM	Traffic	VM
7-20-59	1,022	5,110	344	1,720	474	2,370	1,840	9,200	1,124	5,620	371	1,855	507	2,535	2,002	10,010	2,146	10,730	715	3,575	981	4,905	3,842	19,210
7-21-59	1,004	5,020	347	1,735	479	2,395	1,830	9,150	1,040	5,200	356	1,780	487	2,435	1,883	9,415	2,044	10,220	703	3,515	966	4,830	3,713	18,565
7-22-59	1,228	6,140	393	1,965	505	2,525	2,126	10,630	1,180	5,900	377	1,885	485	2,425	2,042	10,210	2,408	12,040	770	3,850	990	4,950	4,168	20,840
7-23-59	1,095	5,475	343	1,715	450	2,250	1,888	9,440	1,186	5,930	371	1,855	489	2,445	2,046	10,230	2,281	11,405	714	3,570	939	4,695	3,934	19,670
7-24-59	1,195	5,975	386	1,930	429	2,395	2,060	10,300	1,244	6,220	401	2,005	499	2,495	2,144	10,720	2,439	12,195	787	3,935	978	4,890	4,204	21,020
7-27-59	1,188	5,940	352	1,760	447	2,235	1,987	9,935	1,188	5,940	352	1,760	446	2,230	1,986	9,930	2,376	11,880	704	3,520	893	4,465	3,973	19,865
7-28-59	1,056	5,280	371	1,855	497	2,485	1,924	9,620	1,099	5,495	386	1,930	518	2,590	2,003	10,015	2,155	10,775	757	3,785	1,015	5,075	3,927	19,635
7-29-59	1,139	5,795	416	2,080	516	2,580	2,091	10,455	1,194	5,570	399	1,995	495	2,475	2,008	10,040	2,273	11,365	815	4,075	1,011	5,055	4,099	20,495
7-30-59	1,174	5,870	356	1,780	478	2,390	2,008	10,040	1,221	6,105	371	1,855	497	2,485	2089	10,445	2,395	11,975	727	3,635	975	4,875	4,097	20,485
7-31-59	1,305	6,525	437	2,185	514	2,570	2,256	11,280	1,204	6,020	403	2,015	474	2,370	2,081	10,405	2,509	12,545	840	4,200	988	4,940	4,337	21,685
TOTAL	11,426	57,130	3,745	18,725	4,839	24,195	20,010	100,050	11,600	58,000	3,787	18,935	4,897	24,485	20,284	101,420	23,026	115,130	7,532	37,660	9,736	48,680	40,294	201,470

(Data shown are for exemplary purposes only)

Figure 5.

of travel and vehicle type. The traffic totals are transcribed from the daily traffic classification count form (Fig. 2) and multiplied by the study section length to obtain vehicle-mile totals by day and vehicle type.

Review of Shoulder Stop Interview Data

Although the initial review of shoulder stop interview data will have been accomplished by the field survey supervisor, it is important that a final review of the data be completed by the supervisor in charge of the analysis before the tabulated data are processed. Items that should be checked are as follows:

Item 2. Stop Duration. —The departure time (2-a) is computed by adding the minutes in answer to the question "How much longer will you stay?" (1-c) to the observed time (1-a). The observed departure time (1-d) will be used in place of the computed departure time when it has been recorded. The answers to these questions should be reviewed for reasonableness in relation to other observed stop times and the observer trip schedule.

The time when the vehicle first stopped (2-b) is computed by subtracting the number of minutes entered in answer to the question: "How long have you been here?" (1-b) from the observed time (1-a). If the actual time of stopping has been observed as evidenced by a 0 in item 2-b, no adjustment of the time observed is necessary.

In instances where a stop has been recorded although there is no interview, the initial stop or departure time will be in doubt. However, a reasonable estimate of the stop duration can be made by analysis of the trip schedule of the mobile observers in relation to the time the stopped vehicle is observed. The mobile observers will be traveling the study section at uniform time intervals and an estimate of the time of stopping can be determined by a log of the approximate travel time to various check points in the study section in relation to the time the stop was observed.

Item 3. Direction of Travel. —Verify the direction of travel by comparison with Item 4, Stop Location.

Items 4 through 10. —Check for completeness of entries and consistency with any comments. Item 7 provides a means of checking for possible duplicate stop observations.

Item 11. Type and Purpose of Stop. —Item 11 should be reviewed for consistency with stop definitions. Particular attention should be paid to the classification of borderline stop classifications in order to keep them consistent with the stop definitions.

Listing of Shoulder Stop Interview Data

On completion of review of the shoulder stop interview forms, the forms should be sorted by date and time of stop occurrence as determined by entry 2-b. The data should then be entered on the listing of observed vehicle shoulder stops by time of stop (Fig. 6). This form will serve as the data source for most of the analysis of the shoulder stop data, thus, it is important that the data transcription from the interview forms be thoroughly checked.

Procedure for Computing Number of Total Stops from Observed Stops

It is recognized that the total number of stops observed will be less than the total number of stops occurring in the entire study section by the number of short duration stops unobserved outside the control section.

The total number of stops occurring in the entire study section may be estimated from the observed stops by

$$T = \frac{T_f}{T_c} (T_m - T_c) + T_f \qquad (1)$$

STATE OF __________
SHOULDER USE STUDY

LISTING OF OBSERVED SHOULDER STOPS BY TIME OF STOP

HIGHWAY NUMBER __________

STUDY SECTION __________

Date	Time		Stay (Min)	Direction of Travel	Vehicle Type	Vehicle Reg	No of Occupants	Location of Stop			Trip Purpose	Last Stop Location	Time Between Stops	Type & Purpose of Stop
	Stopped	Departed						In Study Section	Shoulder	Dist fm Pave Edge				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)

Figure 6.

in which

T_m = total stops observed by mobile observers.
T_f = total stops in control section (observed by a fixed observer).
T_c = total stops observed in control section by mobile observers.

In Eq. 1, the ratio of the total control section stops to control section stops recorded by mobile observers, T_f/T_c, is multiplied by the number of observed stops outside the control section, $T_m - T_c$, to compute the total stops outside the control section. The total stops outside the control section are added to total stops in the control section, T_f, to obtain T the estimated total number of stops in the entire study section.

The expansion factor, F, to be applied to the observed stops in estimating the distribution of total stops from observed stops is

$$F = \frac{T}{T_o} \tag{2}$$

in which

T = total expanded number of stops in study section.
T_o = total observed stops ($T_m + T_f - T_c$).

It is possible that the stationary observer may miss one or two stops in the control section that may be observed by the mobile observers. These stops should be added to the total control section stops, as determined by the fixed observer in computing T_f.

An example of the computation of the expanded total of stops, T, and the expansion factor, F, is as follows: If T_m = 218, T_f = 56; T_c = 40; and T_o = 234; then by Eq. 1, T = 305.2 or rounded, 305; and by Eq. 2, F = 1.303.

The total number of observed stops, T_o, multiplied by the expansion factor F will equal the total number of expanded stops. In the hypothetical example (Fig. 7), the observed number of stops are multiplied by the expansion factor F and the product (rounded to the nearest unit) is shown in the next column.

Computation of Vehicle-Miles per Stop Average

The vehicle-miles per stop average is the measure of the frequency of shoulder stops relative to traffic volume. The equation for computing average vehicle-miles per stop is

$$VMS = \frac{VM}{T} \tag{3}$$

in which

VM = total vehicle-miles.
T = total number of stops (expanded).

It is important that the vehicle-miles figure (VM) be comparable to the stop total T in order that the VMS average will be independent of the vehicular composition of the traffic on the study section under study. For example, in computing the VMS average for passenger cars, only vehicle-miles for passenger cars should be used in the numerator, and only stops for passenger cars used in the denominator. Table 1 gives an example of the tabular data required for computing the VMS averages shown in Table 2. The stop totals are transcribed from the expanded stop totals shown in Figure 7 and the vehicle-mile totals are transcribed from the vehicle-miles summary, Figure 5. It is recommended that Tables like 1 and 2 be included in the published report. In the final table prepared for publication, the VMS averages should be rounded to the nearest 100 vehicle-mi.

TABLE 1

DISTRIBUTION OF VEHICLE-MILES BY VEHICLE TYPE AND EXPANDED NUMBER OF SHOULDER STOPS BY PURPOSE OF STOP AND VEHICLE TYPE

Vehicle Type	Vehicle-Miles	Voluntary Stops				Involuntary Stops	All Stops
		Rest and Leisure	Business	Other	Total		
Passenger:							
State	131,065	104	16	43	163	26	189
Out-of-state	39,555	26	1	3	30	5	35
Total	170,620	130	17	46	193	31	224
Truck or bus	30,840	29	8	34	71	10	81
All	201,470	159	25	80	264	41	305

Analysis Purpose of Trip Data. —It is recommended that the data obtained on trip purpose (Fig. 6, Col. 12) be tabulated and presented in a form similar to that shown in Table 3.

Purpose of Stop Data. —In addition to the analysis of shoulder stop frequency in terms of vehicle-miles per stop, it is recommended that a detailed analysis be made of the observed stops by type and purpose. Table 4 gives a suggested format for presentation of detailed data on the distribution of stops by type and purpose of stop. Table 5 gives hypothetical data on the percentage distribution of involuntary stops by vehicle type and reasons for stop. Figure 8 shows a graphic comparison of the percentages of shoulder stops by vehicle type and purpose. The data for these tables may be tabulated from the listing of observed vehicle shoulder stops by time of stop (see Fig. 6).

Time of Stopping. —An analysis of the time of day vehicles stopped on shoulders (Fig. 6, Col. 2) will supply an indication of the peak demand for safety-rest area parking spaces by time of day. A simple table giving the distribution of the number and percentage of stops by hour of occurrence and type of stop should provide the necessary analysis data.

Duration of Stop. —For purposes of analysis, the data on duration of stops (Fig. 6, Col. 4) may be arranged in a cumulative frequency distribution presented in the form of an ogive showing the cumulative percent of observed shoulder stops lasting less than a specified number of minutes (see Fig. 9).

TABLE 2

AVERAGE VEHICLE-MILES PER STOP BY VEHICLE TYPE AND PURPOSE OF STOP[a]

Vehicle Type	Voluntary Stops				Involuntary Stops	All Stops
	Rest and Leisure	Business	Other	Total Vol.		
Passenger:						
State	1,260	8,191	3,048	804	5,041	693
Out-of-state	1,521	39,555	13,185	1,318	7,911	1,130
Total	1,312	10,036	3,709	884	5,504	762
Truck or bus	1,063	3,855	907	434	3,084	381
All	1,269	8,059	2,518	763	4,914	661

[a]Data shown are for exemplary purposes only.

TABLE 3

PURPOSE OF TRIP AS GIVEN BY DRIVERS INTERVIEWED WHILE PARKING ON HIGHWAY SHOULDER

Trip Purpose	Passenger Vehicle				Trucks and Buses		All Vehicles	
	State		Out-of-State					
	No.	%	No.	%	No.	%	No.	%
Business								
Driving to or from work								
Vacation								
Recreation								
Social								
Shopping								
Other								
Total								

STATE OF__________
SHOULDER USE STUDY

WORKSHEET FOR COMPUTING DISTRIBUTION OF TOTAL SHOULDER STOPS FROM OBSERVED SHOULDER STOPS BY VEHICLE TYPE AND PURPOSE OF STOP

Highway No.__________ Study Period__________

Study Section__________ Expansion Factor 1.303

Purpose of Stop	Passenger Vehicles State (obs.)	State (exp.)	Out of State (obs.)	Out of State (exp.)	Trucks & Buses (obs.)	Trucks & Buses (exp.)	All Veh. (obs.)	All Veh. (exp.)
Voluntary	(125)	(163)	(23)	(30)	(54)	(71)	(202)	(264)
Rest or Leisure	80	104	20	26	22	29	122	159
Business	12	16	1	1	6	8	19	25
Other Voluntary	33	43	2	3	26	34	61	80
Involuntary	20	26	4	5	8	10	32	41
Total Observed	145		27		62		234	
Expanded Total		189		35		81		305

(Data shown are for exemplary purposes only.)

Figure 7.

TABLE 4

NUMBER OF OBSERVED SHOULDER STOPS CLASSIFIED BY TYPE AND PURPOSE OF STOP

Type	Purpose of Stop	Number	Percent of Total	Percent of Class
Involuntary	Flat tire			
	Out of gas			
	Mechanical failure			
	Involved in an accident			
	Other			
	Subtotal			
Voluntary	Rest and Leisure:			
	Rest or sleep			
	Checking map			
	Changing drivers			
	Eating in vehicle			
	Car sickness			
	Recreation			
	Visiting			
	Latrine			
	Other rest or leisure			
	Subtotal			
	Business:			
	Discharging or picking up passengers (buses only)			
	Inspecting utilities			
	Inspecting farm or crops			
	Inspecting industry			
	Other business			
	Subtotal			
	Other Voluntary:			
	Assisting another vehicle			
	Checking vehicle or load			
	Minor mechanical trouble			
	Police enforcement stop			
	Police assisting stop			
	Stopped by police			
	Unclassified			
	Subtotal			
	Total			

Last Stop Data. —Analysis of the data showing the last stop location provides an indication of the needed spacing of safety rest areas in terms of distance between stops in miles and travel time. The location of the last stop as recorded on the listing of observed shoulder stops by time of stop (Fig. 6, Col. 13) should be converted to the distance traveled in miles since last stop, using mileages on current highway maps.

For purposes of analysis, the data on elapsed time between stops (as tabulated in Fig. 6, Col. 14) may also be arranged in a cumulative frequency distribution and presented graphically in the form of an ogive chart.

Place of Stop. —The locations of shoulder stops within the study section will be of value in determining the effect of physical features of the highway, roadside attractions, and culture on stop frequency and location. Item 4 (stop location) of the shoulder use

TABLE 5

REASONS FOR INVOLUNTARY STOPS OF VEHICLES OBSERVED PARKING ON HIGHWAY SHOULDERS[a]

Reason	Passenger Vehicles		Trucks and Buses		All Vehicles	
	No	%	No.	%	No	%
Flat tire	11	46	3	38	14	44
Out of gas	4	17	2	25	6	19
Involved in accident	1	4		-	1	3
Mechanical failure	5	21	2	25	7	22
Other	3	12	1	12	4	12
Total	24	100	8	100	32	100

[a]Data shown are for exemplary purposes only

interview form furnished the data with which to plot a scatter diagram of the stop locations on a "blowup" map of the study section. Analysis of the scatter diagram will indicate whether there are significant tendencies for vehicle stops to occur at certain places.

On divided multi-lane highways it is not always possible or desirable for vehicles to cross traffic lanes in order to park on the outside shoulder during peak traffic hours or in emergencies. Analysis of the stop location data (Fig. 6, Col. 10) showing the location of stops by shoulder type (median or outside) in combination with the purpose of stop data (Fig. 6, Col. 15) will provide the information to determine the amount and type of median shoulder use as compared to the outside shoulder.

Vehicles parked on shoulders present a continuous hazard to traffic by the lateral displacement of vehicles on the traveled way and by the occupation of shoulder space that is needed by traffic for emergency escape movements in preventing accidents. Study has shown that vehicles parked at the pavement edge have the greatest effect on traffic on the adjacent lane and that lateral displacement of traffic decreases sharply as the distance between the parked vehicle and the pavement edge increases (5). Analysis of the Figure 6, Column 11 data will indicate the pattern of parked vehicle place-

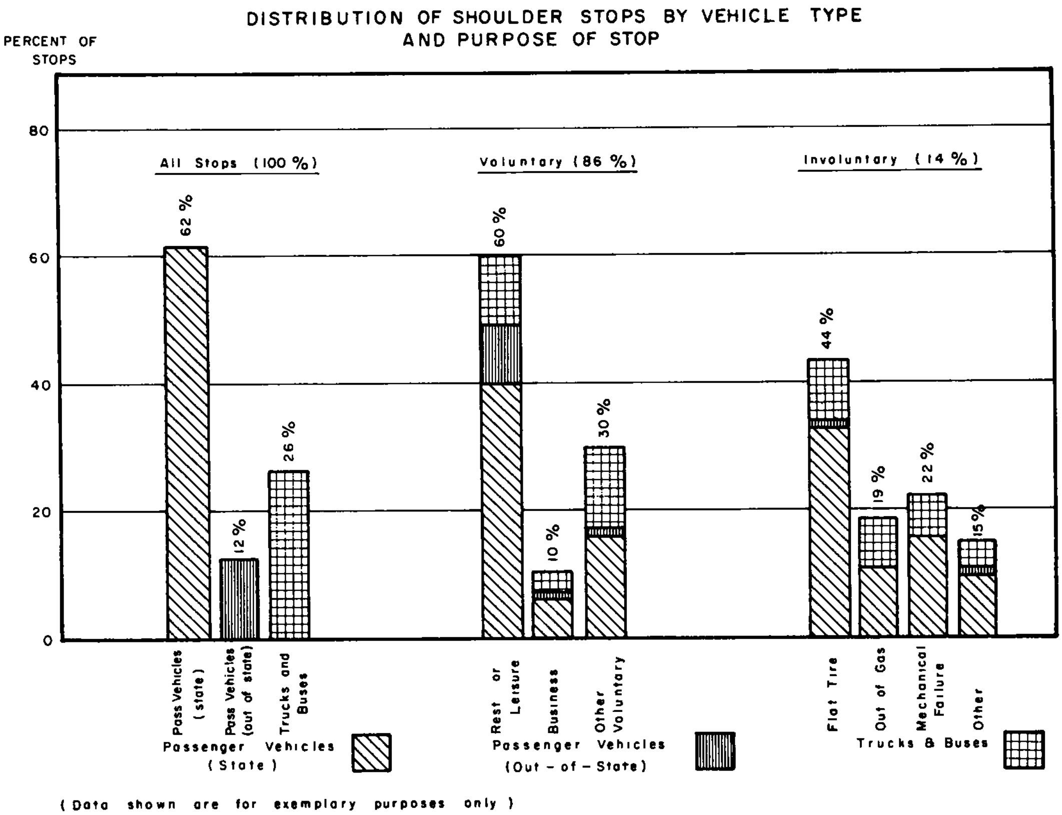


Figure 8.

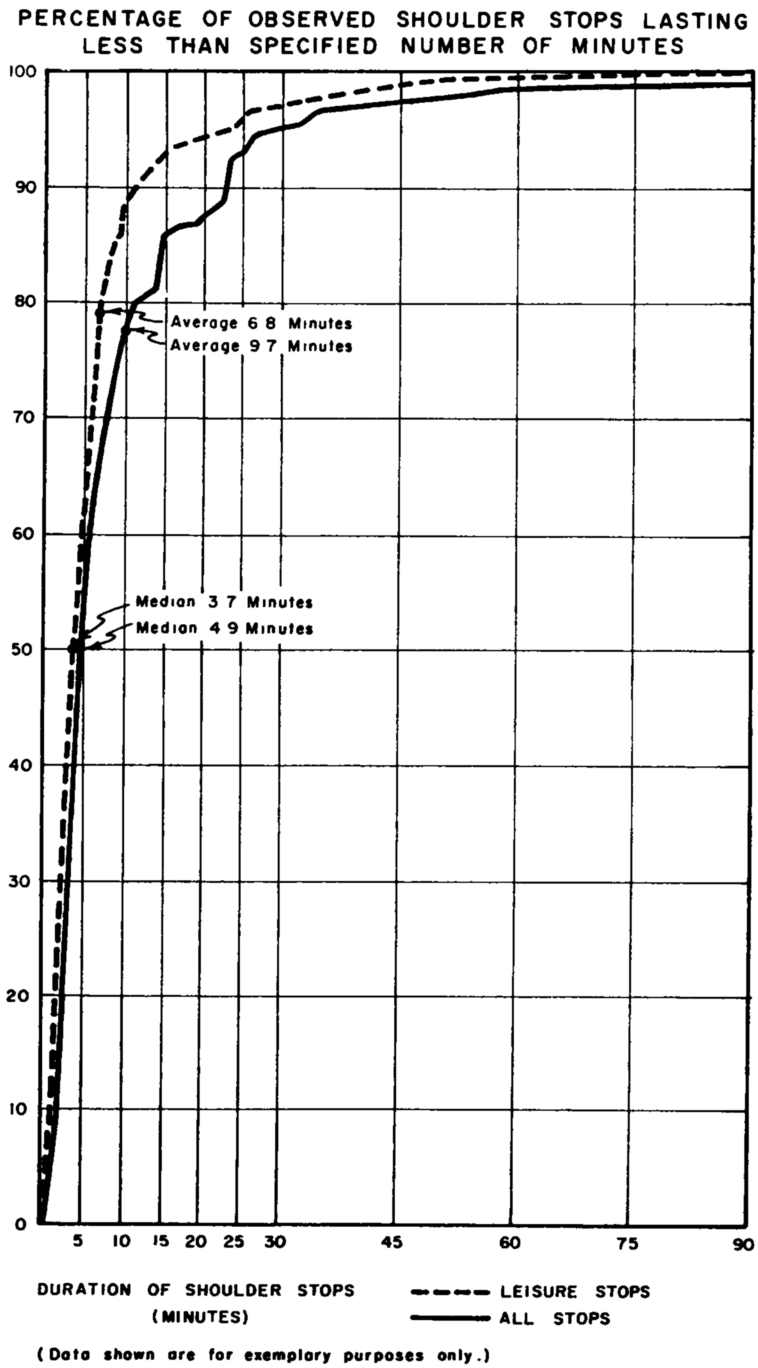

PERCENTAGE OF OBSERVED SHOULDER STOPS LASTING LESS THAN SPECIFIED NUMBER OF MINUTES
100
90
80
70
60
50
40
30
20
10
0
5
10
15
20
25
30
45
60
75
90
Average 6 8 Minutes
Average 9 7 Minutes
Median 3 7 Minutes
Median 4 9 Minutes
DURATION OF SHOULDER STOPS
(MINUTES)
LEISURE STOPS
ALL STOPS
(Data shown are for exemplary purposes only.)

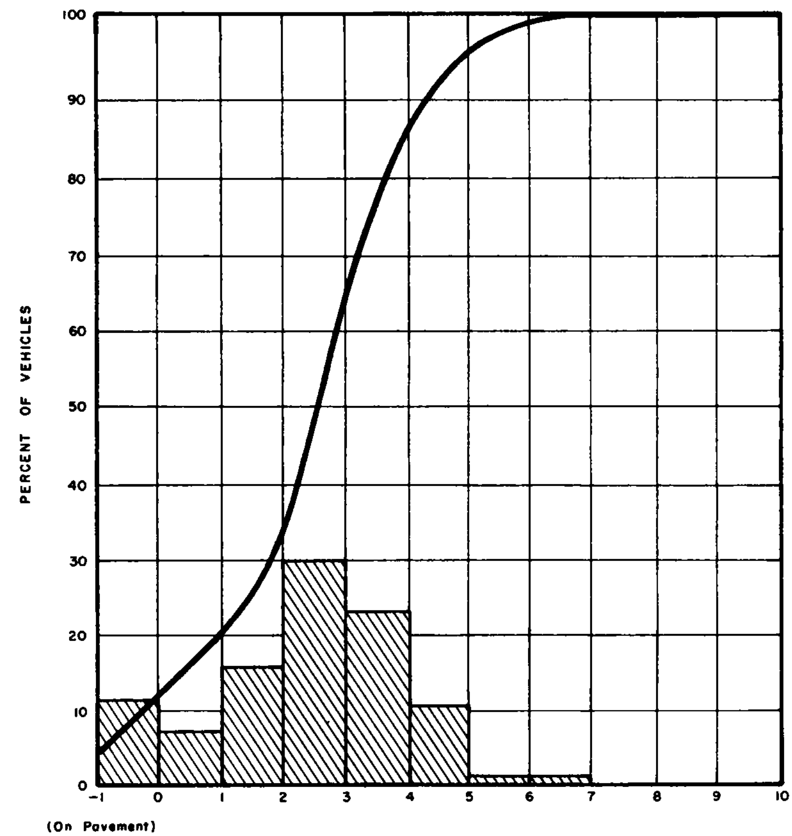
Figure 9.

ment on the shoulder for the section under study. It is suggested that the analysis include a cumulative frequency distribution table or chart showing the number and percent of stops by vehicle distance from the edge of the pavement in 1-ft intervals (see Fig. 10).

Accidents. — There are several different approaches to the problem of accident analysis in relation to shoulder usage. The type and extent of accident analysis is necessarily determined by the detail, accuracy, and reliability of the accident data available for analysis. The forms of analysis suggested assume that accurate, detailed, and complete accident history records are available for the shoulder use study sections. Otherwise, it is doubtful that an attempt at accident analysis is worthwhile. For purposes of this study, a shoulder use accident will be defined as one involving a parked vehicle, or one engaged in a maneuver leading to a stop or of resuming travel after a stop.

The first step in an accident analysis is the determination of the accident hazard resulting from shoulder use in relation to total accident hazard. Measures of the shoulder

PERCENTAGE DISTRIBUTION OF VEHICLES PARKED ON HIGHWAY SHOULDERS BY DISTANCE FROM PAVEMENT EDGE



Adapted from Figure 7, New York Shoulder Occupancy Study (4)

Figure 10.

usage accident hazard can be determined by computing the percentage of shoulder use accidents and by comparing the shoulder accident rates per million vehicle-miles with the total accident rate per million vehicle-miles.

One of the assumed benefits of providing safety-rest areas along highways and of controlling parking on the shoulder is the reduction of traffic hazards associated with shoulder use accidents. To ascertain more exactly these benefits in relation to accident experience, it would be in order to proceed in one of the following ways:

1. Calculate the percent of total accidents related to shoulder use for a study section having a rest area with an otherwise comparable highway section or sections without rest areas.
2. Calculate the percentage of shoulder use accidents on a before-after basis for a given study section that has controlled shoulder parking or safety rest areas.
3. Relate the percentage of shoulder use accidents for each of 10 or more highway sections with vehicle-miles per stop averages for each given section. If sections having low vehicle-miles per stop averages tend to have high "shoulder use" accident percentages, it would point to possible benefits from installing shoulder parking controls or safety-rest areas.

It is essential to have reliable accident data for all the above analyses. This implies that there should be at least 3 (preferably more) years of accident data available for the analyses. In the before-after proposal (2) this would mean 6 years of accident data. It would be necessary to examine the roadway conditions, traffic characteristics, etc., to insure that the rest area or the shoulder parking control was the only apparent difference between the before-after study periods. A need for reliable accident data and a long sample accident history period is particularly necessary because only a small part of the total accident experience on any given section is related to shoulder use. Figures from the New York shoulder occupancy study (4) reveal that accidents involving shoulder use involve roughly 1 to 7 percent of the total number of accidents on given study sections.

With regard to the proposal involving comparisons of accidents and stop frequency, it is also essential that long enough sampling periods of shoulder use be employed to provide reliable vehicle-miles per stop data. In this regard, the remarks concerned with the determination of sample size of the shoulder use study are relevant. If the sampling periods are inadequate, a ratio of vehicle-miles per shoulder stop will be excessively unstable and conclusions may not be reliable. If reliable ratios of vehicle-miles per stop are available for each of the 10 or more study sections, and the percents of shoulder use accidents are similarly consistent, a rank order correlation procedure may be applied. Results of this procedure would provide information as to the direction in magnitude of the relationship between actual parking usage and recorded shoulder parking accident experience.

An analysis of the correlation type would be applicable to highway sections which do not have rest areas or controlled shoulder parking. Thus, any roadway could be studied to ascertain the extent to which shoulder use could be used for establishing a priority system for construction of rest areas or control of shoulder parking.

An example of the application of the correlation analysis to the shoulder use vehicle-miles per stop and accident data of 8 hypothetical highway sections is shown in Table 6.

Before proceeding with the analysis, it should be remembered that a high percent of "shoulder-use" type accidents would be expected to occur when there are few vehicle-miles per stop (that is, relatively frequent shoulder stops).

$$\rho = 1 - \frac{6\,\Sigma\,D^2}{N\,(N^2-1)} \tag{4}$$

in which

$$N = 8 \text{ and } \rho = 1 - \frac{6 \cdot (28)}{8 \cdot (63)} = +\,0.67.$$

The interpretation of this large positive value is simply that sections with high shoulder-use accident frequencies have low vehicle-miles per stop averages.

TABLE 6

SHOULDER USE VEHICLE-MILES PER STOP AND ACCIDENT DATA FOR 8 HYPOTHETICAL HIGHWAYS

Study Site Identification	Vehicle-Miles Per Stop		Shoulder Use Accs.		Difference In Ranks	
	Average	Rank	Percent Tot. Acc.	Rank	(D)	$(D)^2$
A	2,800	6	3.0	4	2	4
B	1,700	3	1.5	7	4	16
C	1,400	2	6.0	1	1	1
D	1,900	4	3 5	3	1	1
E	4,700	8	2.0	6	2	4
F	3,500	7	0.5	8	1	1
G	900	1	5.5	2	1	1
H	2,400	5	2.5	5	0	0
$\sum D^2$						28

PREPARATION OF REPORT

The following suggestions and outline for content of the shoulder use report should not be considered as all-inclusive or restrictive in regard to the preparation of individual reports. The suggestions are intended to indicate the logical order of presentation and a minimum report content. The varied study conditions and objectives preclude other than the setting forth of basic report content, such that valid comparisons between data and findings of the various shoulder use studies may be made. The individual study objectives and data analyses will require additional report content, which must be determined by those analyzing the data and preparing each shoulder use report.

Suggested Report Outline

A. Introductory Pages
   1. Title page
   2. Preface
      a. Reason for report
      b. Purpose of study
      c. Acknowledgments
   3. Table of Contents
   4. List of tables and figures
   5. Introduction

B. Summary of Findings
   1. Statement of Effect of Control Conditions on Frequency of Shoulder Use (Comparison of vehicle-miles per stop averages under the controlled study conditions—for example, parking vs no parking, with or without rest areas, 2-lane vs 4-lane highways serving different types of traffic such as suburban vs intercity rural, or recreational rural).
   2. Statement of Average Relative Frequency of Shoulder Stops in Terms of Vehicle-Miles Per Stop for Major Types and Purpose of Stop Classifications, as disclosed in Table 2.
   3. Comparison of the Frequency of Stops by Vehicle Types, as disclosed in Tables 1 and 2.
   4. Statement of Distribution of Stops by Purpose, as disclosed in Tables 1 and 4.
   5. Comparison and Statement of Travel Time and Distance Between Stops by Vehicle Types and Stop Purpose, as disclosed in analysis of data from Cols. 13, 14 and 15, Figure 6.

6. Statement of Time Distribution of Shoulder Stops, as disclosed by analysis of data from Col. 2, Figure 6.
7. Statement of Average Duration of Shoulder Stops by Stop Type, as disclosed by Figure 9.
8. Statement of Distribution of Shoulder Stops by Type of Shoulder, as disclosed by analysis of data from Col. 10, Figure 6.
9. Statement of Shoulder Parking Hazard, as determined by analysis of data from Col. 11, Figure 6.
10. Statement of Contribution of Shoulder Accidents to Total Accident Hazard, based on accident reports and effect of "control" conditions on shoulder accidents, if such information can be obtained.

Scope of Study

A. Background and Purpose of Study.

B. Description of Highway Study Sections. Describe geometric design, physical features, ADT, vehicular composition of traffic, economic use of highway, surrounding areas, roadside attractions, and other features that may have a bearing on the types and amount of shoulder use. The descriptive material should include a picture of the study sections, a regional map on which the location of the study sections are indicated in relationship to major geographic places, and a large-scale sketch map (see Fig. 1) of the immediate study area.

C. Description of the Study Methodology.

Analysis

A. Types and Purpose of Stops. Discuss distribution and compare differences in the distribution of stops under the "control" (parking, no parking, with or without rest area) conditions of the study. Include tabular data on the number and distribution of stops as shown in Tables 1, 3 and 5. A percentage comparison of the distribution of shoulder stops by vehicle type may indicate significant relationships.

B. Frequency of Stops. Discuss and compare significant relationships of vehicle-miles per stop averages. Include tabular (rounded) data as shown in Table 2. Tables and graphs should be constructed to present comparisons of vehicle-miles per stop averages under the "control" conditions when such are study objectives. Significant differences in the frequency of stops by direction of travel will be of value.

C. Variability of Data. Analysis of the variability of the vehicle-miles per stop data as previously determined (see Appendix) should be discussed and the expected range of vehicle-miles per stop averages shown for the major stop categories.

D. Distance Since Last Stop. Discuss and present data on the average distance from the last stop in terms of mileages and travel times for state and out-of-state vehicles.

E. Length of Stop. Discuss the most significant relationships derived from the cumulative frequency distribution of stops by length and types. A suggested form of presentation is shown in Figure 9.

F. Time of Stop Occurrence. Discuss the distribution of the stops by time of day (volunatry and involuntary). A simple table or bar graph showing the distribution of stops by hour of day should be included.

G. Trip Purpose. The suggested table showing data on trip purpose is shown in Table 3. Accompanying narrative should point out the more interesting and important relationships. A comparison of the distribution of stops by trip purpose on different study sections may be helpful in explaining differences in observed shoulder stop frequencies.

H. Analysis of Accident Rates. Discuss the significant relationships between accidents (total and shoulder). If possible these data should be related to vehicle-miles per stop averages to determine if any significant relationship exists.

I. Place of Stop. Discuss any significant relationships between the placement of stops in the study section and the physical features of the highway and/or roadside attractions as developed from the scatter diagram of shoulder stops in the study section.

For divided highway study sections, discuss the findings of the analysis of stops classified by shoulder type (median or outside). The narrative should indicate significant differences in the types, duration and frequency of median shoulder stops in comparison to outside shoulder stops. Discuss the analysis of Col. 11, Figure 6, data showing the distance vehicles parked from the pavement edge in relation to probable accident hazard. A suggested basis for classifying shoulder stops by severity of hazard due to displacement of adjacent lane traffic is as follows:

Distance from Pavement Edge	Hazard
Less than 3 ft	Extreme hazard
3 to 6 ft	Moderate hazard
Over 6 ft	Minimum hazard

J. Occupancy. Compare the average occupancy of vehicles (All Stops, Voluntary and Involuntary Stops, and Rest and Leisure Stops).

Appendix

A. Table A-1, Table showing basic shoulder use data for each study section (see Table 7). The Service Type will describe the study section in terms of the normal type of service (usage) of the highway in which the study section(s) is located (for example, Interstate Intercity Primary, Intercity Secondary, Recreational Secondary, Local Market Road, etc.).

B. Figure A-1, Shoulder Stop Interview Form (see Fig. 3).

C. Table A-2, Accident History Summary of Study Sections (see Table 8).

D. Table A-3, Listing of Observed Shoulder Stops by Time of Stops (This table is optional, depending on the volume of stops observed and the length of the study period (see Fig. 6).)

COST OF CONDUCTING STUDIES

The cost of conducting shoulder use studies will vary considerably due to differences in the scope and purpose of the various studies that are made. Data collection costs will probably be the major cost item. The amount of data collection cost incurred will depend largely on the location and number of study sections and the number of hours it is necessary to make shoulder use observations in order to obtain statistically reliable stop data. Data tabulation costs, which include the coding and summarization of the survey data and the compilation of basic tables set forth in this guide, will depend not only on the amount of data collected but on the purposes and detail of analysis planned for the study. Planning, analysis, and reporting costs will be mainly independent of the volume of data collected.

Estimates based on New York (4) and Oregon experience in conducting shoulder use studies indicate that gross personnel costs for data collection will range from $1.00 to $2.00 per observation hour per study section mile. Travel expense for data collection is estimated at $0.70 to $1.35 per observation hour per study section mile. The lower travel cost figure is based on anticipated costs using public owned vehicles operating at $0.55 per mile on study sections where no per diem expense is involved. The upper cost estimate includes per diem allowance of $12.00 per day and a car mileage charge of $0.080 per mile.

Data tabulation costs for an adequate study are estimated at $500 to $1,000 depending on the volume of data collected and the scope of the study. Analytical and reporting costs for an acceptable study similar to that described by this guide are estimated at $1,000 to $1,200.

STATISTICAL ANALYSIS

Sample Size Determination

The usual method for determining sample size is based on the desired width of the confidence interval of the statistic in question. This width is usually expressed as a

TABLE 7

SHOULDER USE STUDY

BASIC DATA SUMMARY

Hwy Name or Route No	Location	No Lanes	Avg Daily Traffic	Section Length in Miles	Study Period and Total Hours	Service Type	VEHICLE MILES OF TRAVEL DURING STUDY PERIOD					NUMBER OF OBSERVED STOPS																				ALL STOPS	
												VOLUNTARY															INVOLUNTARY						
							Passenger Car			Truck & Bus	All Vehicles	Rest & Leisure					Business					Other					Passenger						
							(State)	(Out of State)	Total			Passenger State	O.S.	Total	Truck & Bus	All Veh	Passenger State	O.S.	Total	Truck & Bus	All Veh	Passenger State	O.S.	Total	Truck & Bus	All Veh.	State	O.S.	Total	Truck & Bus	All Veh	Observed	Total (Exp.)

TABLE 8

ACCIDENT HISTORY SUMMARY OF STUDY SECTIONS

STUDY SECTION DESCRIPTION					TOTAL ACCIDENT DATA										SHOULDER ACCIDENT DATA				
							All Acc		Fatal Acc		Pers Inj[1]		Prop Damage		All Acc		Fatal Acc		
Location	Lanes	Length (Miles)	ADT (1958)	Service Type	Study Period	Traffic M V M	No	Rate/ M V M	No	Rate/ 100 M V M	No	Rate/ M V M	No	Rate/ M V M	No	Rate/ M V M	No	Rate/ 100 M V M	Percent All Acc

1/ Includes only those accidents wherein one or more persons were injured   Does not include property damage accidents percentage of the statistic. For example, if it is desired to have the sample mean within a given percent of the population mean, it follows that

$$| C\overline{X} | = | \mu - \overline{X} | = t\,\sigma_m = \pm t\,\sigma/\sqrt{N-1} \qquad (5)$$

in which

N = sample size (number of observation periods) required
μ = population mean
$\overline{X}$ = sample mean (size n)
σ_m = standard deviation of the sample means
C = permitted error in the sampling as a decimal part of the mean (the 100 C is a percent of the mean)
σ = standard deviation of the sample (size)
t = value of t-distribution at specific level of confidence

This equation is solved for the sample size yielding,

$$N = 1 + \frac{t^2\sigma^2}{C^2\overline{X}^2} \qquad (6)$$

If the standard deviation of the population is known, t is the normal deviate as based on a near-normal distribution. If the standard deviation has to be estimated from the sample, the value for t is obtained from the t-distribution of the specified level of confidence.

The formula for the sample size as previously stated can be expressed in raw score form for easier computation:

$$N = 1 + \frac{t^2\,[n\Sigma X^2 - (\Sigma X)^2]}{C^2\,(\Sigma X)^2} \qquad (7)$$

A vehicle-miles-per-stop average X in Eq. 7 would be established from part or all of each day's shoulder use observations. Although it is desirable to increase n, precaution must be taken to prevent the introduction of bias into the study. One procedure for increasing the number of observations with a minimum of bias is to take each 12-hr day's data and divide them into two sets of representative observations. Because there is reason to believe that a significant difference does exist between AM and PM observations, it is proposed that the even numbered hours of observation be taken as one 6-hr sample period and the data of alternate hours be taken as another 6-hr sample period, providing two sets of observations from one day's study. This procedure does not unduly bias either set with data from any part of the day, but does yield two sets of data for assisting in the determination of a standard deviation.

From the standpoint of practical statistics, a sample of at least 10 representative observations should be made. It is doubtful if less than a 6-hr observation can be considered representative. If the foregoing procedure is employed for determining an observation, five 12-hr days of shoulder use observation would be employed in obtaining the field work. It is at this stage that further analysis could be made to determine whether further field work would be warranted.

Analysis of Sample Variability

This analysis of the data is carried out in two general parts: (a) an analysis on the frequency of stops, and (b) an anlysis on the vehicle-miles per stop.

The frequency of stops are analyzed to discover any gross inconsistencies in the data. Such inconsistencies could arise from the selection of the observation times, particularly if some abnormal use of the roadway is encountered or, as previously mentioned, if some sets of observations are for one part of the day and others from another. Such unwarranted observations could tend to produce large standard deviations in the subsequent analysis, making it difficult to interpret the data.

In analyzing the frequency of stops, an adjustment must be made to compensate for the difference in traffic volumes. The number or frequency of stops are analyzed by a simple chi-square (χ^2) test. The observed frequencies of stops, denoted by o are added together and proportionally distributed according to the traffic volumes of the study intervals to obtain the expected frequency of stops. The testing statistic is then given by

$$\chi^2 = \frac{(| o-e | -0.5)^2}{e} \qquad (8)$$

in which

o = observed frequency of stops.
e = expected frequency of stops.

If the calculated value of χ^2 is above the critical value as determined by the level of confidence desired, it follows that the frequency of stops is not proportionally distributed with respect to the volumes. If this occurs, the data should be scrutinized to determine the cause of the anomalies. The vehicle-miles per stop cannot be expected to yield consistent results unless the frequency of stops are themselves consistent. (If anomalies do arise in the frequency of stops, the sample data must be carefully investigated to ascertain the probable cause of such irregularities. Potential causes of irregularities could be among the following:

1. Climatic or weather variation;
2. Time variation in the hours of study (effective hours);
3. Seasonal variation;
4. Variation in roadway culture; and
5. Variation in the proportion of business, social, recreation, or commuting use.)

(No attempt is made to discuss all possibilities as each study may have its own unanticipated peculiarities. If a controllable cause for the irregularities in the frequencies can be found, the sampling should be continued with all attempts to control these factors.)

The stops and vehicle-miles for each time period in the study is then converted to a vehicle-miles per stop. Each of these vehicle-miles per stop is then considered as an element in the new population. The population arithmetic mean $\overline{X}$ and its standard deviation S is then calculated as follows:

$$\overline{X} = \frac{1}{N} \Sigma Z \qquad (9)$$

$$S = \frac{1}{N} \sqrt{N\Sigma X^2-(\Sigma X)^2} \qquad (10)$$

These statistics are now used for determining the confidence interval on the mean of the universe μ. The universe mean must satisfy the following inequality:

$$\overline{X} = \frac{tS}{\sqrt{N-1}} \leq \mu \leq \overline{X} + \frac{tS}{\sqrt{N-1}} \qquad (11)$$

where the level of confidence is specified in the value of the t-statistic. The values with equality yield the upper and lower bounds to the confidence interval.

The error as a percent of the mean at a given confidence level is given by 100 t S/ $\overline{X}$ $\sqrt{N-1}$. If this percentage is too large, it in general can be reduced by increasing the number of sample observations. Increasing the sample size by a factor of four can be expected to cut the confidence interval in half unless the estimate on the standard deviation is changed appreciably in the sampling.

If the data are to be tested against a theoretical population mean, $\mu.$, the following statistic is used:

$$Z = \frac{|\overline{X} - \mu.|}{S\sqrt{N-1}} \tag{12}$$

where $\overline{X}$, S, and N are defined as before. The statistic Z has a t-distribution with N-1 degrees of freedom. If the calculated value of Z is not less than or equal to the t-value as specified in the tables at the desired level of significance, the hypothetical value must be rejected.

Before comparing the data to a theoretical distribution, the decision must be made as to whether more sampling would be desired with the hope of refining the data.

Example of Computation of Sample Size and Variability

Table 9 gives basic data used in the sample size and variability computations.

If a χ^2 test is applied to the first 10 observations in the previous study, a calculated value of 14.453 is obtained which is less than the critical value of 16.919 at a confidence level of 95 percent (5 percent level of significance). From this information, there would be no reason to suspect any irregularities in the data, and hence one would proceed with the analysis or determination of sample size.

If it is assumed that the first 10 observations were made for the purpose of determining the sample size and if one wishes to establish with 95 percent confidence that the population mean is within 20 percent of the sample mean, the sample size estimate is given by

$$N = 1 + \frac{t^2S^2}{C^2\overline{X}^2} = 1 + \frac{t^2n^2S^2}{C^2(n\overline{X})^2} \tag{13}$$

where t = 2.262 at the 95 percent confidence level. Because $n\overline{X}$ = 18,600 and n^2S^2 = 55,640,000, Eq. 13 gives N = 1 + 20.59; hence, N = 22 would be the desired sample size.

After collecting the data to make a sample of 22 observations (24 observations were available from the New York Study), the data are again analyzed for consistency by the χ^2 test. Using the 24 tabulated frequencies of stops a χ^2 value of 23.092 is calculated which is considerably less than the critical value of 35.172 for 95 percent confidence. It follows that there is no reason to suspect any irregularities in the frequencies of stops.

Because no apparent anomalies exist in the frequencies of stops, the data are converted to vehicle-miles per stop and further analyzed. The arithmetic mean and standard deviation of the vehicle-miles per stop is calculated giving $\overline{X}$ = 2,050 by Eq. 9 and S = 1062.6 by Eq. 10. For the 23 degrees of freedom (N-1) had in the sample, t = 2.069. The mean of the universe then satisfies the inequality:

$$\overline{X} - \frac{tS}{\sqrt{N-1}} \leq \mu \leq \overline{X} + \frac{tS}{\sqrt{N-1}} \tag{14}$$

in which

$$\frac{tS}{\sqrt{N-1}} = \frac{(2.069)(1,062.6)}{\sqrt{23}} = 458.4$$

Rounding these values to the nearest 10 miles, the mean of the universe can be expected with 95 percent confidence to satisfy 1,590 < μ < 2,510. Any hypothetical mean within the interval of 1,590 to 2,510 could not be rejected on the basis of this sampling, even though the error as a percent of the mean is 22.36 percent.

It has probably been observed that the error obtained from the sample of 24 observations is greater than the error decided on with a sample size of 22. Sampling theory cannot guarantee the accuracy of the sampling and such discrepancies frequently arise. However, because no irregularities were apparent from the χ^2 testing on the frequency of stops, the analyst is not justified in deleting any observation from the analysis. For example, the analyst is not justified in removing the 18th observation which has an abnormally high number of vehicle-miles per stop and the omissions of which would reduce the standard deviation of the sample considerably.

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4. Billion, C.E., "Shoulder Occupancy on Rural Highways." HRB Proc., Vol. 38 (1959).

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TABLE 9

STOPS ON SHOULDERS AND VEHICLE-MILES TRAVELED ON 2-LANE HIGHWAYS, NEW YORK STATE[a]

Stops			Vehicle-Miles	Veh-Mi. /Stop
e_{10}	o	e_{24}		
7.10	8	6.47	11,075	1,800
6.07	11	5.53	9,467	900
15.97	15	14.56	24,905	1,700
9.03	4	8.23	14,076	3,500
13.40	13	12.21	20,886	1,600
7.35	6	6.70	11,464	1,900
9.03	5	8.23	14,076	2,800
9.32	17	8.49	14,525	900
12.84	9	11.71	20,023	2,200
8.88	11	8.09	13,845	1,300
	5	3.98	6,801	1,400
	3	3.23	5,532	1,800
	8	8.59	14,690	1,800
	7	4.90	8,346	1,200
	5	6.41	10,962	2,200
	3	6.00	10,266	3,400
	8	6.97	11,925	1,500
	3	10.47	17,909	6,000
	4	3.63	6,213	1,600
	7	7.01	11,985	1,700
	4	4.42	7,555	1,900
	4	2.49	4,257	1,100
	2	3.38	5,783	3,000
	2	2.31	3,959	2,000

[a]These observed stop and vehicle-miles totals were taken from New York State Highway Shoulder Occupancy Study (1958) Table 1A, (4), using data for all stops on 2-lane highways. Expected (e) stop totals are calculated values.