TRAFFIC CAPACITY

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This report on traffic capacity of highways is based upon data obtained during the summer of 1930 as the result of a cooperative undertaking between the U S Bureau of Public Roads, the State Roads Commission of Maryland, and the University of Maryland The traffic study was made under the direction of A N Johnson, Dean of the College of Engineering, University of Maryland, and two observers, J H Deckman and G E Taylor of the University of Maryland Observations were made from June 26 to September 1, 1930

The object of the investigation was to determine the relative capacity of two-lane, three-lane and four-lane roadways

The observations were purposely limited to straight stretches of road as free as possible from interfering influences of cross road traffic, or other disturbing conditions.

DEFINITION OF TRAFFIC CAPACITY

It was first necessary to develop a definition for traffic capacity for the purpose of this study We can visualize a road carrying but a few vehicles, and agree there is no congestion But as the number of vehicles increases, there will be reached a point at which some vehicles will be delayed because they are immediately unable to pass other slower moving vehicles Such a point indicates the beginning of congestion, or what may be called "working capacity" or "free-moving capacity" of the highway

As the volume of traffic increases beyond the free-moving or working capacity, the number of vehicles passing in a given time will still increase, but they will move with more and more restrictions, and the individual driver will have less and less freedom of action The number of vehicles may increase until a point is reached where the total volume is at the maximum, which may be called the "ultimate capacity" of the highway This stage would immediately precede that of incipient stagnation, when the number of vehicles on the highway becomes so great as seriously to interfere with their movement, and the number passing a given point during a given time begins to decrease

The observations made and recorded in the traffic study here discussed were for the purpose of establishing the point where congestion begins, or what has been defined as the free-moving or working capacity of the highway, whether of two three, or four traffic lanes

The instructions to the observers in this particular were substantially as follows· "Congestion is considered to occur on a road when the number of vehicles reaches a total great enough to fill the road and make

turning out impracticable, this condition to last a sufficient length of time to be noticeable, the minimum amount of time being one minute.

"When congestion occurs, reduction of speed will be noticed, along with the tendency for drivers to crowd one another"

To test the judgment of the observers, the station that was first occupied was again occupied at the close of the work, the traffic at the time being about the same as on the first day. The reports were similar, indicating that the picture in the observer's mind of congested condition, as here defined, was fairly well fixed

METHOD OF MAKING TRAFFIC COUNTS

It was first necessary to find sections of road over which there was expected a sufficient amount of traffic to develop congestion as herein defined As this was not always easily done, it was necessary to undertake many counts where the traffic proved to be not of sufficient volume to give any indication of congestion

The observers traveled from point to point in an automobile and sat in the car at one side of the road when making the count The tally sheets were arranged to show the direction and volume of traffic for each five-minute interval, classified as automobiles, trucks, or busses If the traffic during a particular five-minute period was running freely, it was so indicated on the margin of the tally sheet If there was a suggestion of congestion that extended for a minute or more, it was entered accordingly Remarks as to the approximate speed, condition of the weather, the road width, lane markings, character of the road surfaces, and the location of the road were also noted

Each observer kept a tally sheet of the traffic in but one direction In case of three-lane roads, two tally sheets were kept by each observer, and likewise for four-lane roads The tally sheets were later summarized to show the amount of traffic in each direction, as well as the total for both directions, and the totals for the three classifications automobiles, trucks and busses

Usually the observers used counters for the automobile traffic and pencil marks for recording the trucks and busses The traffic counts were taken between the hours of 3 and 8 in the afternoon, extending generally over a period of four hours, the intention being to take observations through a peak load Observations were made in this manner at fifty-one stations, scattered between Washington and Boston as follows Maryland, 21, Pennsylvania, 6, New Jersey, 11, New York, 2, Connecticut, 6, Massachusetts, 4, Virginia, 1 Traffic counts were made at 31 points on two lane roads, at 10 points on three-lane roads, and at 10 points on four-lane roads.

There was not enough traffic to give any indication of congestion on any of the four-lane roads observed, the maximum hourly rate re-

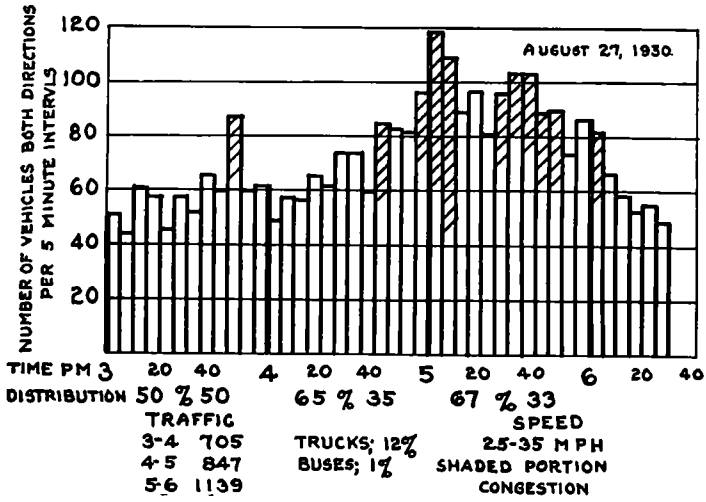

Figure 1. Traffic on 2 Lane Road, Washington-Baltimore Boulevard, Md., U. S. No. 1, 100 Yards South of East Branch, Anacostia River

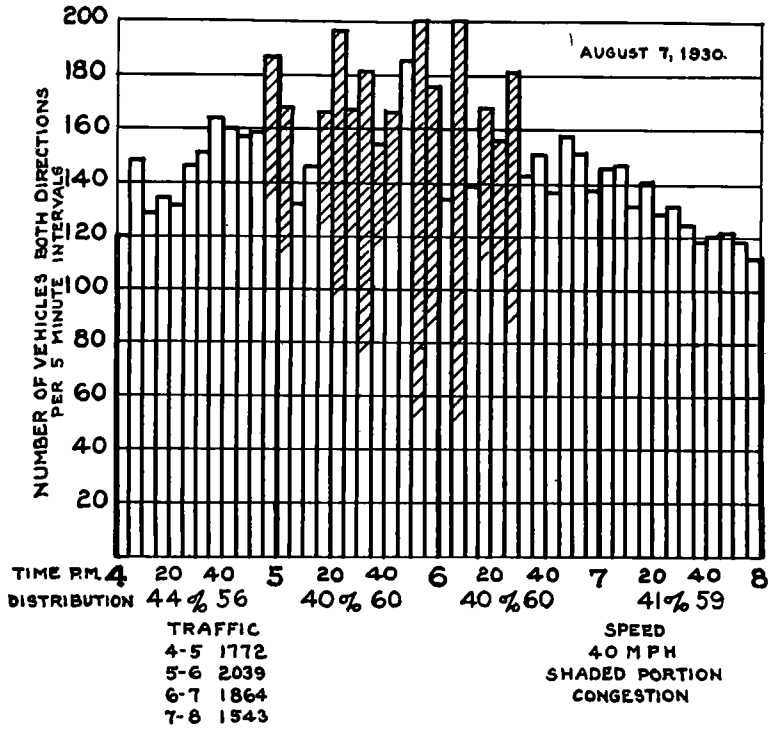

Figure 2. Traffic on 3 Lane Road, U. S No. 9, New Jersey, 1 Mile West of South Amboy

corded being 3228 vehicles What the working capacity of a four-lane road may be is, therefore, at present, a matter of conjecture only

METHOD OF ANALYSIS

As a first step, and as a means to get a picture of conditions at each observation point, the total number of vehicles for both directions was platted for successive five-minute intervals, the number of vehicles for the interval being platted as an ordinate If, during any particular

TABLE I

ANALYSIS OF TRAFFIC ON 2-LANE ROADS

Based on all traffic counts for 5-minute intervals on 2-lane roads

Number of vehicles per 5 minutes	Rate per hour	Per cent of time congested under all conditions	Per cent of time congested—maximum per cent of traffic one way			
			50–60 per cent	60–70 per cent	70–80 per cent	80–100 per cent
50–70	600–840	0	0	0	0	0
70–90	840–1,080	8	6	13	13	0
90–110	1,080–1,320	33	42	43	53	0
110–130	1,320–1,560	73	78	100	67	80

TABLE II

ANALYSIS OF TRAFFIC ON 3-LANE ROADS

Based on all traffic counts for 5-minute intervals on 3-lane roads

Number of vehicles per 5 minutes	Rate per hour	Per cent of time congested under all conditions	Per cent of time congested—maximum per cent of traffic one way			
			50–60 per cent	60–70 per cent	70–80 per cent	80–100 per cent
70–100	840–1,200	0	0	0	0	0
100–130	1,200–1,560	10	20	4	0	0
130–160	1,560–1,920	21	33	18	40	0
160–190	1,920–2,280	53	71	90	100	0
190–220	2,280–2,640	80	100	100	100	40

five-minute interval, congestion occurred such was indicated by cross hatching the ordinate for the relative portion of the five minutes during which congestion occurred A glance at Figures 1 and 2 will make this clear

Tables I and II are the results of analysis of the data arranged for all of the two-lane roads by five-minute intervals from the least to the greatest, a similar arrangement being made for the three and four-lane roads

RESULTS OBTAINED

The results obtained are shown in concise form in the accompanying tables, Table I being an analysis of the traffic on two-lane roads, and Table II an analysis of traffic on three-lane roads In general, it will be noted that on the two-lane roads there is no serious amount of congestion up to a traffic rate of about 1000 per hour, but the demarcation between the amount of congestion when less than 1000 per hour and when over 1000 per hour is better defined in the case of three-lane roads where the demarcation is not so sharp

On three-lane roads there is little congestion up to 1600 per hour, and between 1600 and 1900 congestion occurred during only 21 per cent of the time

Tables I and II show the division of traffic as to relative amount in each direction, and the per cent of time that congestion occurred accordingly It should be borne in mind, however, that the values shown do not rest upon a sufficient number of observations to be conclusive This also accounts for some discrepancies that will be noticed But it is evident that these figures do disclose a general indication that must be close to the facts

Referring to Table I for the two-lane roads, it is noticed that when the traffic is 80 to 100 per cent in one direction congestion does not occur until vehicles are passing at a rate exceeding 1300 per hour, and that for three-lane roads nearly 2300 per hour is the rate before congestion occurs The influence on congestion of the distribution of traffic as to direction is apparently less marked on two-lane roads than on three-lane roads, for as the proportion of traffic in one direction increases the three-lane roads handle it with a decreasing amount of congestion

The Committee believes the application of these data to be of fundamental importance to any study of road economics Further investigation could well be made along the lines already started, so that a sufficient number of observations would be at hand to make possible more definite conclusions Many other features, such as intersections, could be studied in similar fashion to learn their influence on traffic capacity.

CONCLUSIONS

The following conclusions are drawn from the data presented Using the term "congestion" as defined, the two-lane road is practically free from congestion up to 1000 vehicles per hour

The three-lane road is practically free from congestion up to 1600 vehicles per hour, and is congested not to exceed one-fifth of the time up to 1900 vehicles per hour

With further increase in the number of vehicles per hour, congestion increases at a more rapid rate on a two-lane road than on a three-lane road

When four-fifths or more of the traffic is in one direction, the two-lane road is practically free from congestion up to 1300 vehicles per hour, and the three-lane road up to 2300 vehicles per hour

DISCUSSION

ON

REPORT ON TRAFFIC CAPACITY

DR J G MCKAY, *Director Cleveland Highway Research Bureau*· The question of how many traffic lanes should be provided for a completed project depends upon knowledge of the amount of traffic This is admittedly a difficult factor in the problem, but a very important one, not only from the financial standpoint but with respect to projects in which permanency of width is established by such items as fixed curves or drainage influences that are introduced in the design

The paper by Dean Johnson is a very interesting type of presentation of evidence which, I believe, should have been collected in researches beginning some years ago, because we will all admit that in planning the widths we are guessing, and have been for some time There are two series of researches of this character which agree Dean Johnson's work gives around 1000 per maximum hour, which is 10,000 vehicles per 24-hour day, for the capacity of two lane roads Three years ago in the Cleveland region the Bureau of Public Roads estimated and established a maximum rate outside of the so-called suburban congestion areas of 10,000 for 20-foot roadway with a maximum capacity of 1000 per maximum hour

With respect to the three and four lane roadways, I agree with Dean Johnson that there is still considerable latitude I have seen the heaviest traffic, and have analyzed it four years in a row, on a structure in Cleveland that is carrying more vehicles per 24-hour day than any other bridge in the United States,—in excess of the Queensborough bridge in New York—in excess of the volume on Michigan Avenue in Chicago—operating three lanes in one direction at the peak hour and two at other times The maximum on the fastest lane, is 1250 per hour The inner lane is the median, the curb lane is the least The highest maximum per hour is 1250 vehicles per hour per lane on the heaviest traveled section of roadway in the United States, and perhaps in the world I find nowhere actual capacity per hour in excess of between 900 and 950 vehicles per maximum hour in one direction, with the theoretical accumulation ranging from 1500 to 2100

MR. A H BLANCHARD I trust the Committee will consider the problem controversial in nature relative to the 3-lane traffic from the

standpoint of essentially equal traffic flow in both directions Who has the right of way on the middle lane under such conditions?

MR C N CONNER· Mr Chairman, I would like to ask Dean Johnson if any data were secured on single lane roads

DEAN JOHNSON They do not come into the traffic scheme at all

FINANCIAL RESPONSIBILITY OF MOTORISTS

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(Report presented by Wm G Eliot, 3rd, U S Bureau of Public Roads)

Fundamentally, the problem of financial responsibility for highway accidents is one of economic and social policy, and as such it is more closely related to questions like vehicle taxation, workmen's compensation or even installment buying than it is to the other agenda of this committee There appears, however, to be some correlation between financial irresponsibility and recklessness in driving At any rate, "compulsory insurance" has been frequently urged as a safety measure, especially when the legislation is designed to favor the motorist with a good driving record

Some fourteen States in this country, and two Canadian provinces, now have one or another form of automobile security legislation The common law recognizes the right of an individual innocently injured on the highway to recover damages from the person responsible for the accident But few of those who own or operate motor vehicles are able to meet large judgments against themselves Relatively few voluntarily protect themselves or the public by purchasing insurance, and experience has shown that these are usually the preferred risks One of the major problems in any scheme of "compulsory insurance" is to place the burden where it really belongs, and not to increase the cost of protection to those who would have carried insurance or have been otherwise responsible in the absence of legislation

Automobile security laws have been of two general types

(1) Those requiring insurance (or other acceptable security) from all car owners as a prerequisite to licensing and operation Massachusetts is the only State which has legislated on this basis A similar law becomes effective in England and Scotland next January 1.

(2) Those requiring evidence of financial responsibility only from motorists who have been involved in an accident, or who have committed a serious offense under the traffic laws All State security laws