DISCUSSION, REPORT OF COMMITTEE ON HIGHWAY TRAFFIC ANALYSIS

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There is probably no more important element to be considered in arriving at a proper solution of our highway problems than that of traffic analysis, it being the basis upon which must be formulated and worked out all the principles of economics which apply with such tremendous force to our highway operation in these days of heavy and increasing traffic, and it is essential that at least a proper traffic census be made and maintained before our highway problems can be considered intelligently. Highway transport surveys are useful and probably justify the time and cost incident to their being made, but, except in special cases, in my opinion, are not so absolutely essential as is the traffic census This statement regarding highway transport surveys is particularly true in those states and in those localities where the industrial development has already progressed to a considerable degree, accompanied by highway construction in reasonably direct routes at least approaching the necessities imposed, and where the results of such survey are desired in connection with the design and location of the highways concerned Highway transport surveys do, however, establish the basis for the determination of the economic value of a highway system which may be of great value in financing such system or for other reasons

The work, therefore, of the Committee on Highway Traffic Analysis is of the utmost importance and seems to be progressing along lines which are of great value The comments which I have to make are based on the work which is being done in the state of New Jersey The state of New Jersey for the past four years has been conducting a traffic survey of the state highway system of that state The results are obtained by counters who are kept continuously at work throughout the year, making counts at various points on the highway system It is, of course, desirable to count traffic over the full 24-hour period, and this has been done to an extent which has enabled us to determine the very definite relationship which exists on the average between traffic flowing at the various periods throughout the 24 hours.

In order to reduce the expense of this work and at the same time cover as much territory as possible, we have during the past year or two, in many instances, made counts over shorter periods, estimating the 24-hour traffic on the basis of the relationship above referred to, which exists between the various parts of the 24-hour period It has been very definitely determined, for instance, that the factor of 12 2 times the maximum hour traffic on any highway will equal approxi-

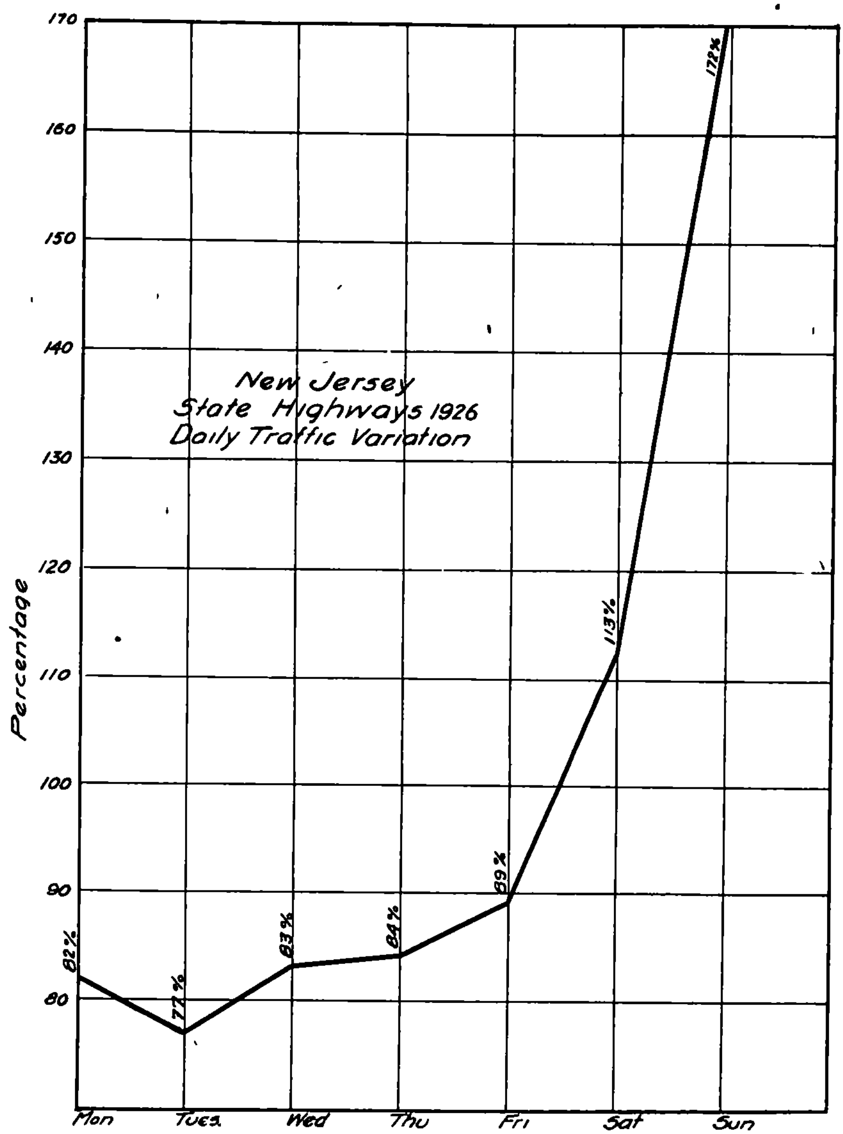

Figure 1

mately the 24-hour traffic on that highway Likewise, the traffic for the several days of the week while extremely variable as between these days, yet week for week bears a reasonably constant ratio, or, at least, this is true with one ratio for the summer months and another for the winter, this condition being shown on Figure 1 Again during the months of the year the same condition seems to apply, the result being shown on Figure 2. We find these relations extremely useful

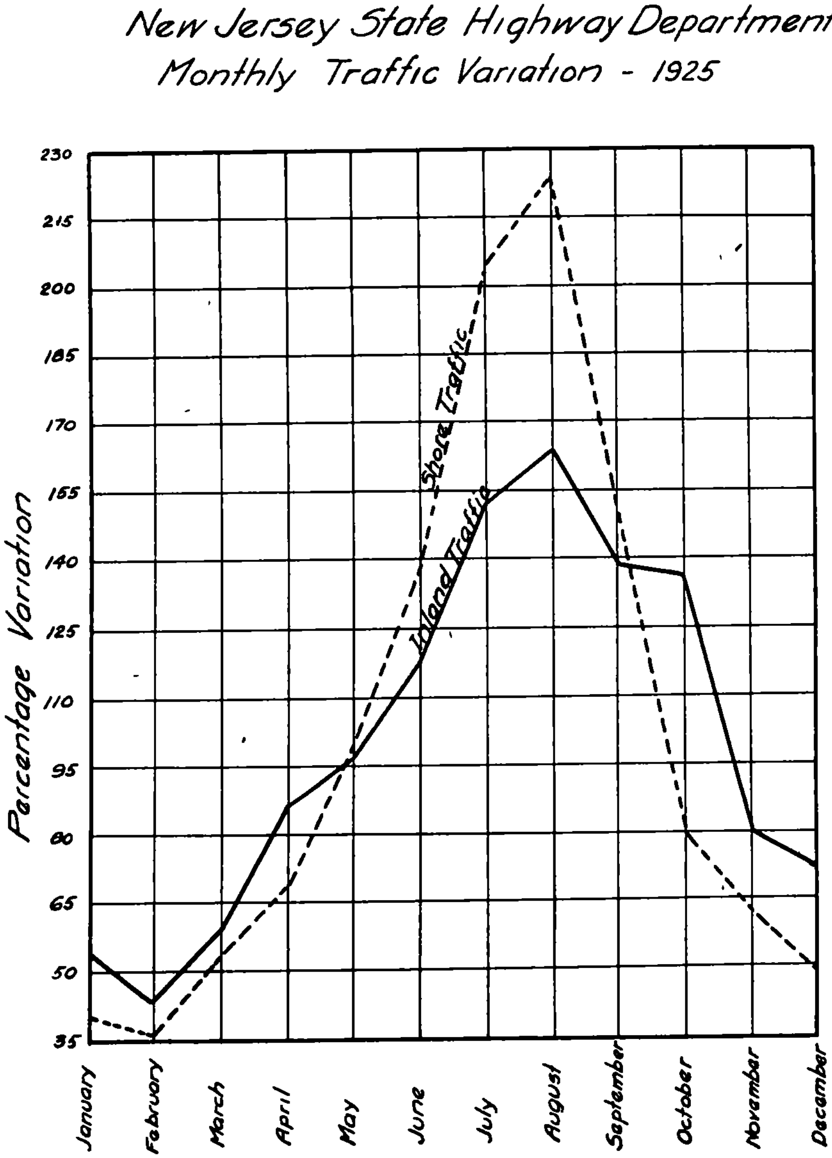

Figure 2

in checking up our traffic counts and in arriving at approximate figures for traffic on roads where actual counts have not been taken covering the period in question.

Existing volume of traffic on any highway must be the basis for the prediction as to probable future traffic on that highway In 1923, approximately four years ago, on the basis of the then existing traffic

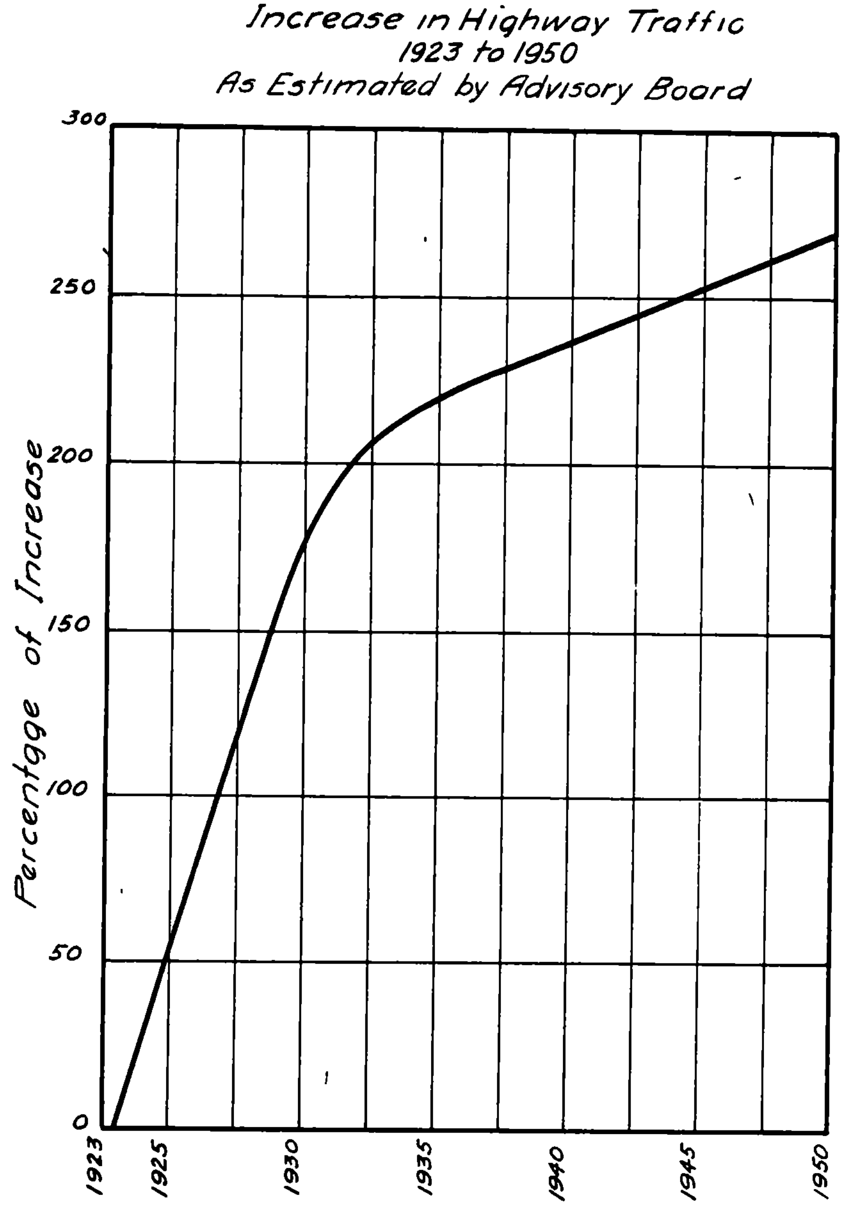

Figure 3

and after careful study of existing and probable future conditions, a prediction was made as to the probable increase in traffic on New Jersey highways up to the year 1950 This prediction in percentages of increase year by year is shown by Figure 3. The three factors on which the increase in traffic was based were: 1 The increase in population. 2 Increase in motor-vehicle ownership 3 A factor representing the use of the automobile as compared with the registration. At that time it did not appear that the use of the automobile varied directly as the registration, but fell somewhere between the square

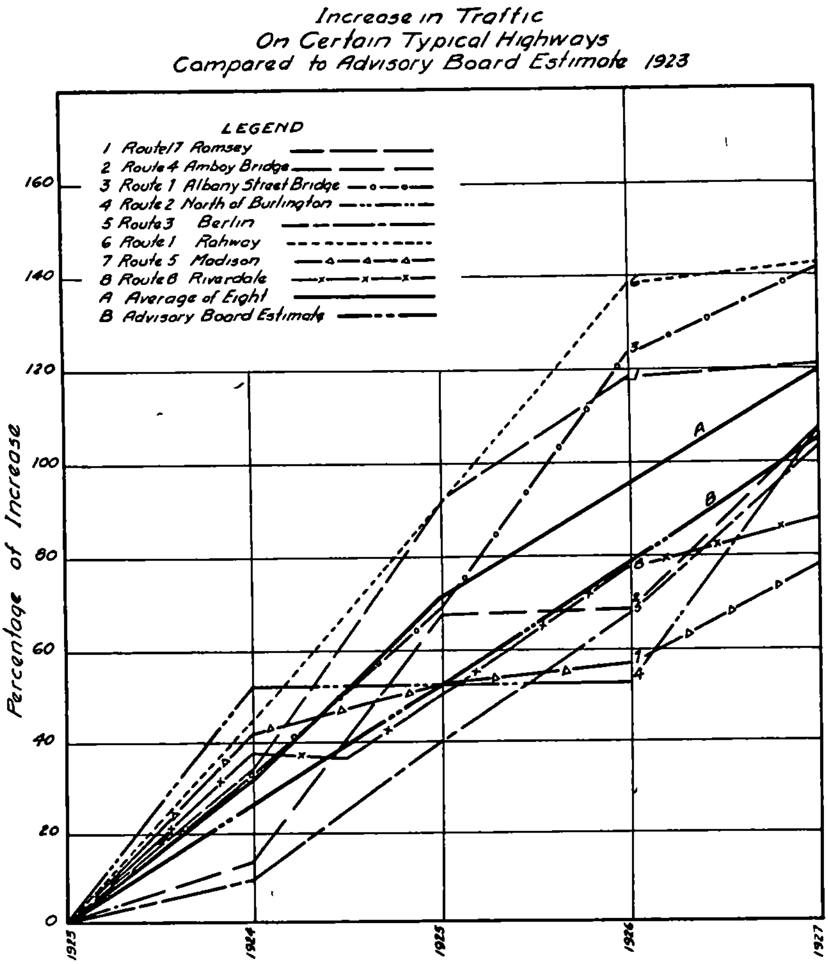

Figure 4

root of the number of registrations and the first power. In order to be conservative, however, the curve as drawn is based on the use of the automobile, varying directly as the registration. During the succeeding years an effort has been made to check up this curve with actual conditions, and on an estimate involving the balance of 1927 the actual increase is shown in comparison with the predicted increase on Figure 4. It is to be noted that traffic in New Jersey has increased considerably faster than was predicted four years ago, in the face of the fact that the increase in population and the increase in automobile registrations have not varied materially from the assumptions made, which necessitates the only conclusion possible—that is, that the use of the automobile is increasing faster than the registration. This is borne out in many ways, notably by the increased gasoline consumption per automobile, and in New Jersey, due to its peculiar geographical position, it is undoubtedly also due in a considerable degree to the number of foreign cars using its highways

In discussing "the maximum capacity of a single traffic lane," we are dealing with a subject which, while interesting, is at the same

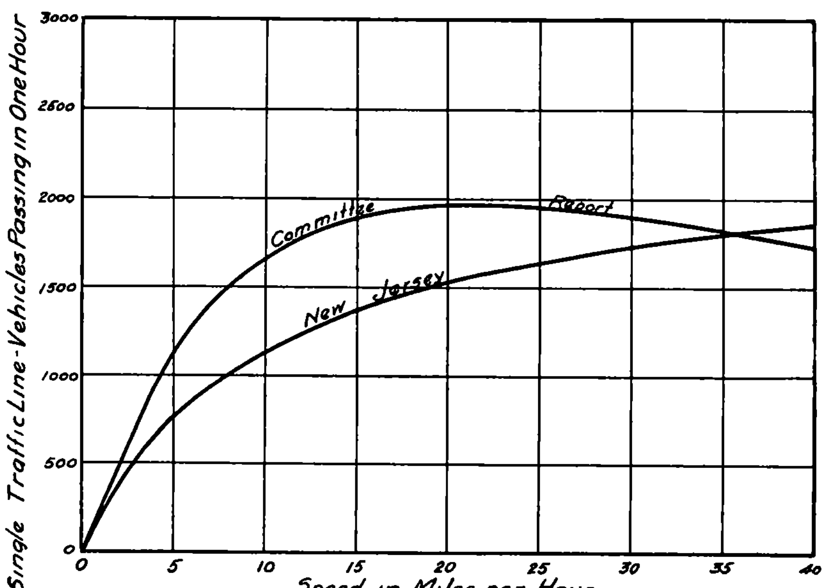

Figure 5. Capacity of Single Traffic Lane as Estimated by New Jersey Highway Department

time unsatisfactory in that a scientific analysis of the question must of necessity be based on assumptions Among these assumptions is the extremely uncertain one that all drivers of automobiles are able, experienced and attentive to the conditions under which they are driving, for the maximum capacity of a traffic lane at any given speed is dependent entirely upon the spacing of the cars. Again, to be of any comparative value, the conditions surrounding the traffic lanes as regard obstructions to traffic in the way of intersecting streets, gradients, curves, etc, must be the same It is assumed that the committee has had under consideration a traffic lane free from any such obstructions, and under these conditions the capacities arrived at by the New Jersey State Highway Department are shown plotted on Figure 5 with the curve recommended by the committee. The assumption in the case of the New Jersey curve is that the interval between vehicles is one of both time and distance, namely, one and one-half seconds plus five feet, and the further assumption that the average length of the vehicle shall be 20 feet These assumptions produce the formula $n = \frac{p}{0\ 025\ p + 25}$ in which n is the number of cars per minute and p the rate of speed in feet per minute. Further difference in the curves is that, according to the New Jersey assumption, the capacity continues to increase with an increase of speed, but with a constantly decreasing ratio, whereas, according to the calculations of the committee, the capacity falls off at the higher speeds, the curves crossing at about a speed of 35 miles per hour As above stated, while such calculations are of interest, they really form very little basis of judgment as to capacities under conditions ordinarily encountered, where by reason of intersecting streets and other obstructions to the free flow of traffic, the theoretical capacities drop materially. The capacities indicated by the curves, however, have the great advantage of indicating the economic value of the removal of such obstructions

The following are some of the obstructions to the free flow of traffic which may well be given consideration:

1. Grade crossing of streets.
2. Grade crossing of railroad tracks
3. Grade crossing of street railways
4. Drawbridges
5. Snow in streets
6. Improper traffic signals
7. Roadway in bad repair

The seriousness of an obstruction caused by the crossing of traffic at intersecting streets depends on the density of traffic at that point. It has been computed by the State Highway Department in one specific instance under investigation that the capacity of a highway would be increased 35 per cent by the elimination of a single street crossing at grade. In this particular instance the highway under consideration is expected to carry some 18,000,000 vehicles each year, while the traffic on the cross highway was reasonably heavy. Calculations indicate that the loss in efficiency as a traffic carrier of the main highway amounted to more than $2,500,000, and the loss of time to the users of the two highways when capitalized amounted to an equal amount, or a total loss of more than $5,000,000 This expenditure, of course, is only justified in the elimination of a grade crossing under these conditions, if such grade crossing is the only similar obstruction to the free movement of traffic over a considerable distance of the highway, and this figure would not be applicable to the elimination of each of several grade crossings occurring in close proximity to each other The same calculation being carried out to include, say, five grade crossings within a reasonable distance of each other, would result in a total justified expenditure of about $6,000,000

In the same way the situation existing at the grade crossing of a highway and the tracks of a railroad company may be analyzed, the economic value of the element of delay often justifying the elimination of a crossing, independent of the great element of danger which exists at such points

Drawbridges over navigable streams are often a cause of serious delay to traffic on highways Such delays can often be economically reduced, either by raising the bridge high enough above the waterway to clear all or a large part of the river traffic, or, in extreme cases, by the substitution of a tunnel for the bridge In either of the above cases, however, there must be balanced against the saving in delay due to bridge openings the additional construction cost and the transportation cost to the users of the highway, due to the additional rise and fall which may be involved

Parked vehicles are an obstruction to traffic, even when they are parked at considerable distances apart The effect of parked vehicles is to reduce the effective capacity by one or two lanes of traffic, and a proper solution of the parking problem on congested streets needs serious consideration

Slow-moving vehicles and trolley cars are not necessarily an obstruction to the continuous flow of traffic, but they do impede the speed thereof, and thereby reduce the capacity of the highway.

The point which I wish to bring out in citing the above instances is that, on congested roadways, obstructions of any kind are costly, first, in that they decrease the capacity of the roadway, and thereby decrease the value of the money invested in its construction, and, secondly, they increase the cost of transportation for the users of the highway When traffic is light, these losses may be immaterial, but when traffic approaches the capacity of the highway, particularly on a highway of large capacity, the losses become astonishingly large, which, unfortunately, is not generally appreciated

Under the heading "Effect of Curves, Steep Hills, Narrow Bridges, Road Under Repairs, Cross Roads, School Zones, etc., on Carrying Capacity" in the report it is stated that, each stop causes loss of time, which may be expressed as one-half of the time of braking to stop, all of the standstill time, starting time and one-half of the time required to accelerate to traveled speed It seems to me that actually the problem is somewhat more complicated for the reason that the period of stoppage is not uniform for all cars affected, it being the maximum for the car nearest the point where the stop is made and reducing over a long line of cars to a point where a car stops for an instant only and immediately starts, or even farther down the line where a car simply slows up and immediately goes ahead again. The analysis of the situation as made by the New Jersey State Highway Department results in the formula:

Let a = period of stopping of traffic, in minutes,
p = normal rate of speed, in feet per minute,
d = average distance from center to center of cars, when running at normal rate of speed, in feet,
t = minimum distance from center to center of cars, when running at normal rate of speed, in feet,

then the total time lost by a single stoppage will be expressed by

$$\frac{a^2 p}{2(d-t)} \text{ car minutes}$$

Regulation of traffic by improper devices is a growing menace Safety at highway intersections is, of course, to be desired, and it is inexcusable to fail to properly provide for it, but such provision should not entail an undue delay to those using the highway, a condition which is almost universally imposed where automatic regulating devices are used This situation again lends itself to analysis on an economic basis, and such analysis would often justify the substitution of manual control at these points

Another matter of utmost importance which is brought out in the report is that which concerns the by-passing of through traffic by centers of population. I have recently made a study of the conditions existing in seven of the medium-sized towns in New Jersey where the state highway passes through the congested streets of the town The method followed in making investigations was to place traffic counters at approximately two miles each side of the center of population and at the point of congestion, at the same time determining the movement of speed of traffic between the two exterior counters by driving an automobile back and forth between these points. From the traffic counts obtained it was possible to separate the through and local traffic, and from the time of travel between the two points as noted the rate of movement of this traffic was determined The total car minutes applying to the through traffic were compared with the total car minutes which would obtain with the same volume of traffic if traveling on a highway around the town where a reasonable rate of speed could be maintained, with the result that the capitalized value of the total car minutes lost in passing through the towns varied from $500,000 in the case of Bridgeton, where the movement of through traffic amounted to a maximum of 4000 vehicles in 24 hours to $2,700,000 in the case of New Brunswick, where the maximum traffic amounted to 12,000 vehicles in 24 hours. In each of the seven cases the construction of a by-passing highway was economically justifiable

In my opinion, one of the most serious problems facing us at the present time is the use to capacity of our highways If some method could be devised whereby traffic would be required to confine itself to its own traffic lane, except when overtaking and passing another vehicle, the capacities of our highways would be very much increased. Under existing conditions my observation is that a highway having a capacity for four traffic lanes has not over 150 per cent carrying capacity of a highway having two traffic lanes Proper regulation of traffic would increase this capacity, but not, in my judgment, to a point where four traffic lanes would carry twice the traffic of a road having two traffic lanes, and the difficulty multiplies as additional lanes are added, so that I am of the opinion that where the volume of traffic is such that more than four traffic lines are required, it should not be provided by widening the existing road, but by building a parallel highway In most cases a highway providing for four new traffic lanes must in reality be of sufficient width to accommodate six lanes for the reason that even an occasional parked vehicle on either side occupies two exterior lanes to an extent such that it cannot be freely used for the movement of traffic