use than the ease with which their use can be managed efficiently. A good deal of emphasis has been laid on the fact that really efficient operation can be maintained on jobs on which power shovels and elevating graders are used only as the tooling of successive operations is kept in balance. There is no such problem where these scrapers are used. The single unit handles the successive operations of digging, hauling, and distributing; therefore, there is no operation that can get out of balance. All that is required of the management is, then, to see that the unit is in the hands of a good operator, that it keeps moving at the right speed, and that it works in the right place. There is nothing difficult in any of this.

In closing, let me say again that I have tried to give you a birds-eye view of efficiency as applied to handling earthwork rather than to give you an intensive statement of some phase of efficiency with formulae and the rules for their application. I have tried particularly to emphasize two things—that efficiency has many ramifications and that if the aspect of earthwork in which interest usually centers, the construction operations it involves, is to be handled efficiently, a great many problems must be considered and a proper solution of them reached before, and long before, a pound of dirt is moved. Efficiency, truly, is a very broad field. It quite as truly deserves constant consideration in all the various phases of highway work you gentlemen represent.

BEYOND THE TWO-LANE ROAD

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In considering the field of highway development beyond the two-lane road, our first concern is with the extent of that field, that is, what portion of our highway mileage will reach the stage where more than two-lane pavement is warranted.

There is considerable loose thinking by the layman on this subject. The average motorist is apt to be influenced by conditions at times of abnormal traffic. He will make a trip on Labor Day or some summer Sunday when every other motorist has the same idea. Finding some congestion on the particular road he chooses to travel, he decides that a wider pavement is needed. In fact, he goes farther than merely to decide it is needed; he assumes it will be provided as a matter of course. In Illinois we are not asked, “Will Route X be widened?” nearly so often as “When will Route X be widened?” And in 95 cases out of 100 the only honest answer is “Never.” Traffic congestion of short duration a few times a year does not justify the heavy expenditure for pavement widening.
Congestion must occur, or be reasonably anticipated, at frequent intervals for periods of fair duration to warrant the increasing of pavement capacity. The best gauge we have of this occurrence is the year-round average for daily traffic. We know that, on the normal highway, traffic density variations will tend to follow the same patterns, with certain months of the year, days of the week, and hours of the day showing proportionately greater traffic than others. Applying these known factors to the daily average for traffic, we can estimate with reasonable accuracy the periods when congestion will occur. My own observations lead me to conclude that average daily traffic must exceed 3,500 vehicles, 15 to 20 per cent of which are trucks, before more than two lanes are needed. The U. S. Bureau of Public Roads figures that a properly designed two-lane highway can carry 3,000 to 5,000 vehicles per day without serious congestion. The percentage of truck traffic, of course, influences the capacity: the higher the percentage of trucks, the lower the free-moving capacity of the highway.

LIMITED NEED OF MULTIPLE-LANE ROADS

On the rational basis of measuring the need for wider pavements by traffic densities, what percentage of our roads will be affected? In a recent report of the U. S. Bureau of Public Roads, Segregation of the Various Classes of Traffic on the Highway, Mr. R. E. Toms, Chief of the Division of Design, states: “There is now no evidence that more than 95 per cent of all roads in the state highway systems can or will need to be advanced beyond the stage of adequate two-lane improvement.” Please observe that Mr. Toms speaks in terms of the state highway systems only, which comprise about 15 per cent of the total highway mileage in the whole United States. In the average state, then, the problem of more than two-lane construction is confined to 5 per cent of its state highway mileage. The percentage will be somewhat larger in Illinois because of the presence of two large metropolitan areas, but even there we can expect that some 90 per cent of our state roads will not progress beyond the two-lane stage.

Inasmuch as my discussion will be concerned with such a small percentage of our roads, it might appear that the matter is of small importance in the field of highway development. However, a vast amount of traffic is concentrated on this relatively small mileage of road, and from the viewpoint of the number of people served by these roads, the topic is one of prime importance.

In assigning this subject to me, Professor Petty established a minimum limit to my discussion: that is, I am to start where the two-lane road leaves off. Unfortunately, he set no maximum limit, and I assume I am permitted to go on as far as my imagination will stretch. I assure you, however, that I will not approach the fantastic schemes of some of our best
dreamers who solve all of our highway transportation problems with utter disregard for cost. My mind is still of too practical a turn to waste much thought on theories entirely beyond the range of financial possibility. I promise not to paint any pictures of futuristic multi-level roadways. In fact, I shall confine my discussion largely to rural highways.

FORESIGHT NEEDED

The first step beyond the two-lane road does not immediately get beyond at all. What I have in mind is the highway whose initial improvement is by two-lane pavement, but where provision is made for additional lane construction in the future. This is a matter to which most states gave little thought when they first undertook improvement of their primary roads. They built pavements 16 to 20 feet wide with structures, roadbed, and right-of-way only wide enough to accommodate them. Now that the need for widening some of these has arisen, they find that they can salvage very little of the original construction. Adjacent property has been built up close to the right-of-way lines, with the result that acquisition of additional width of right of way has become difficult and expensive.

The only remedy for any difficulty which results from lack of foresight in the past is to employ proper foresight in the present and future. I think that is what we are all trying to do. Employment of proper foresight is not simple. It would be easy to design every two-lane road so that it could be converted to three, four, or more lanes in the future. However, to do so would require additional expenditures of funds—an expenditure which would be wasteful in what we have already decided would be 95 per cent of the cases. So, to conserve our limited highway funds, we must look into the future very carefully. In our zeal not to lean over backward, we must avoid losing all sense of balance in the other direction.

Forecasting traffic needs on a particular highway ten to thirty years hence is a task which requires our best judgment. However, it should be easier than it was twenty years ago to anticipate today's needs. Surely, we do not have anything near the rapid increase in number of automobiles to contend with. Initial improvement of the primary systems is virtually complete in most states in this section, and traffic has distributed itself naturally over these roads. We must recognize, however, that when we better the type of improvement of one road, whether by bettering the surface or alignment, by widening, or in other ways making it more attractive, it will draw some traffic from competing roads. Estimating the extent to which traffic would be readjusted in such event involves considerable guesswork at the present time. If some one here can give us a rational formula to apply, I am sure that contribution alone will make this short course well worthwhile to all of us.
Trying to forecast population changes can be another headache. Unless there is some visible indication to the contrary, we assume it will follow the trend of the past. But some new industry or other factor may knock our predictions entirely out of line. An oil boom in a rather sparsely settled farming area of Illinois shot up population almost overnight and has boosted traffic on all roads in that area away beyond previous records. We can not tell you even today how much permanence there is to this growth either in population or in traffic. So what chance was there for us to foresee it ten, or even five years ago? We must admit that there is, as based on present knowledge, considerable guesswork in this business of forecasting future traffic. It behooves us to give the maximum of intelligence to our guesses.

Assuming that we have solved the problem of reasonably expected future traffic, we know whether or not we must plan for future expansion in capacity, and how much. We establish our ultimate design now, and fit our right-of-way, roadbed, and structures to that. Where we are pretty certain of the need for the additional pavement lanes, we may acquire full width right-of-way at the start, grade the full-width roadway, and build structures wide enough for the added lanes. If we have some doubts, we will not get too far out on a limb. We will secure the width of right-of-way needed for the present, but by means of set-back ordinances, long-term options, or some other legal device, we will make it possible to secure the extra width, when and if needed, at minimum difficulty and expense. We may initially grade only that portion of the roadway needed for the two-lane pavement. We, likewise, may build structures to such width as is needed for the initial pavement, but we will use types of design which can be widened or we will plan on employing independent structures to carry the added lanes.

The design for the initial two-lane pavement must, of course, fit the ultimate plan so that it will be unnecessary to make expensive changes when the conversion is made. Careful treatment will be necessary at intersections, bridges, and railroad crossings. If the ultimate design is to be a dual-type four-lane pavement with center parkway, decision will need to be made whether the two pavements are to be carried over railroads and streams on single structures or independent structures. In case of a long crossing, it will probably be found best to use a single structure, bringing the pavements together, but probably separating them by median curbs. This is only one instance of the many items in the final design which must be determined before the initial two-lane pavement is built.

**SOME TYPICAL EXAMPLES**

I might mention a few examples of two-lane roads we are now building or planning to build in Illinois which have been
designed for future conversion to greater capacity. In one case we are building a two-lane pavement where we have only a 100-foot right-of-way. If it becomes necessary to add lanes later, we propose to convert this to a four-lane pavement divided by median curbs. It is undesirable in this case to build the first pavement off center of the right-of-way. We are, therefore, considering constructing the new pavement centered on the right-of-way, building two 11-foot concrete pavements, separated by a 4-foot bituminous strip down the center. This bituminous strip would be constructed flush with the inside edges of the pavement, so that vehicles could ride over it easily to pass cars ahead. If the pavement is widened in the future, we would add pavement lanes on the outside of those initially constructed. The bituminous strip in the center would then be removed and replaced with a median curb. Even if it never becomes necessary to widen this pavement, we would be interested in observing the effect which the center strip would have on traffic. I have had the thought in mind for some time that there might be wisdom in building a separating strip of this character on two-lane roads, and this construction will give the opportunity to test out this theory.

We have several roads now under construction where we are building two-lane pavements off center of wide rights-of-way and where we ultimately expect to build another two-lane separated from the first by a center parkway. In the usual cases we are acquiring a 160-foot width of right-of-way. However, we have one road near Chicago where we are now building a two-lane pavement on a 240-foot right-of-way. In this case, our plan is for a dual-type, four-lane pavement with center parkway for through traffic and for independent service drives to serve abutting property.

What I have said with respect to providing for future additions to two-lane roads applies with the same force to wider roads which may be expanded still further in the future. For instance, a road may be built of three-lane width with the intention of later converting it to a four-lane width. We have one case where we are designing a three-lane pavement and plan to employ a bituminous surfacing on the center lane. If the pavement is converted to a four-lane width, we intend to remove the center lane and replace it with a parkway.

THREE-LANE PAVEMENTS

The next logical step beyond the two-lane pavement is the three-lane construction. There has been a general tendency in the middle west to avoid this type of construction as hazardous. We have had some fear that there would be conflict between traffic moving in opposing directions for use of this center lane. It is interesting to note that there are many miles of three-lane roads in the east and that they have not proved particularly hazardous. A study of accident records in the State of
New Jersey, as reported in Mr. Toms' article which I have previously quoted, states that two-lane roadways showed an accident rate of 2.75 accidents per million vehicle miles traveled, three-lane roadways 3.53, and four-lane solid type pavement 3.61. It is to be expected that the greater density of traffic normally encountered on a three-lane road would result in a higher accident rate than on the two-lane. It is interesting to note that, contrary to general belief, four-lane highways of the undivided type were more hazardous than three-lane highways.

I am convinced that there is a definite place for the three-lane highway. If we are to ban this particular width, we must resign ourselves to the fact that many miles of two-lane highways now overcrowded to some extent will never get relief because of the greater cost which will be involved in four-lane construction.

While I favor the use of the three-lane pavement, I feel we must use it judiciously. I would be inclined to avoid its use in open country where traffic moves at high speeds, unless I could provide long sight-distance. I favor constructing the center lane, which would be used only for passing, of a material which would contrast with the two outer lanes, particularly as to color, and possibly in texture as well. In zones of potential hazard, I would replace the center lane with a dividing parkway, so as to prevent passing.

FOUR-LANE PAVEMENTS

We now pass to the four-lane pavement, and I call your attention first to the well-known fact that there are two general types of four-lane pavement—the solid type, and the divided or dual type. We have heard much discussion of the dual type and its merits over the last several years, and highway engineers generally have concentrated their efforts in four-lane construction on that particular type.

A couple of years ago a recognized authority on highway safety, in an address before the American Association of State Highway Officials, made the statement that he would like to see the division of four-lane roadways so strongly endorsed by the association that any highway engineer would be ashamed ever to build or remodel a four-lane highway without it. I hereby make a confession that according to this standard I should be held up to shame, for I believe there is a place for the solid four-lane pavement in our highway system. I do not question the fact that the divided pavement, from the standpoint of safety, is much superior to the solid, and I agree that this fact in itself is worth considerable extra cost per mile. However, I contend that there are places in the metropolitan areas—at least we have them in Illinois—where it is impossible to get a divided pavement at any cost within the range of reason. We are certainly making no contribution to traffic safety by letting
these roads remain at two- or three-lane width merely because we can't build four lanes and have them separated.

Another place where the dual type does not seem to fit in is in areas where the abutting property is highly developed. To provide ingress and egress for such property, frequent openings would be necessary in the dividing strip, so frequent, in fact, as to make the division of questionable value. If frequent openings are not provided in such cases, traffic to and from the property along the road will ride over the center strip with greater possibility of accidents than would be the case if there were no division whatever. I think we should not blindly accept the theory that the divided pavement is the safest under all conditions, but should recognize the fact that there are places and conditions where the dividing strip may result in greater danger.

I think we should also recognize the fact that the solid pavement is more flexible than the dual type. We have a peculiar but not unexpected situation on a number of highways radiating out from the city of Chicago. In the morning these highways carry a heavy load of inbound traffic, with almost none moving in the opposite direction. In the evening this is just reversed, with the heavy traffic outbound. This is caused, of course, by the large number of people living in the suburbs going to and from their work in the city. It is quite common to see two practically solid lanes of traffic moving in one direction, using the lane on the opposite side of the center lane for passing. Some authorities hold this up as an objection to the solid pavement, claiming that the third lane is being misused. That may be the case, but our accident records do not indicate that this is a serious fault. The fact is that there is such a little volume of opposing traffic at those particular times that it readily confines itself to the single outer lane. There can be no question that our solid four-lane pavements are carrying traffic which would equal the capacity of a six-lane divided roadway.

Assuming that I have convinced you that there is an occasional place where the solid type pavement is proper, I will remark briefly on one feature of design, i.e., pavement width. Under general conditions this width should not be less than 40 feet; preferably it should be more, so that the inner lanes may be wider than the outer lanes. There are probably a few cases in slow-moving traffic areas where a 36-foot width will be satisfactory, but then it should be taken only as a matter of necessity. We certainly have no business considering a pavement less than 36 feet wide as having four-lane capacity. If we are forced to a less width than that, we will have to be satisfied with three-lane marking.
MEDIAN CURBS

The dual-type pavement is of two general divisions. The first is that where some narrow form of separating device, such as a median curb, is used. This design is employed where there is not sufficient right-of-way width for a better separator, and frankly I feel that it is still somewhat in the experimental stage. Caution must be used in the design of the separator, or it in itself may become a greater hazard than that we are attempting to eliminate. I am inclined to lean toward the median curb as the best type of narrow separator. I feel that this curb should have a width of four feet and should have rolling edges rather than vertical faces, so that vehicles may pass over it with minimum danger in cases of emergency. The divider should be designed so as definitely to warn drivers encroaching on the neutral strip, but should not be an insurmountable obstacle. The curb should afford high visible contrast with the adjacent driving lanes.

Numerous schemes for narrow dividers other than a median curb are being experimented with, and it is possible that some better kind may be developed.

CENTER PARKWAY

The best form of dividing strip is the center parkway. The farther we can separate the opposing lanes of traffic the less possibility there is of friction between them. In addition, the center parkway reduces the danger caused by glare from approaching headlights. It also serves at intersections as an intermediate stopping zone between the two roadways for crossing and turning traffic.

We find that a parkway width of 30 feet is best suited to conditions in Illinois. This width provides a suitable waiting zone for cross traffic. It is also sufficient to permit vehicles desiring to make a U-turn to do so conveniently. It is a width susceptible to proper landscaping which can be effectively employed in screening against headlight glare. This landscaping also helps to overcome the tendency of some drivers to cut across the parkway rather than to drive to the nearest cross-over.

I favor the use of curbs adjacent to the center parkway, but I believe that these should be of low rolling type rather than with vertical faces.

MORE THAN FOUR LANES

The next step beyond the four-lane road will be six lanes. I believe that the cases where such construction will be needed, particularly in rural areas, will be quite rare. However, there will be cases where it is desirable to provide separate roadways to give service to abutting properties. These service drives should be separated from the through pavements and should
give access to the through pavements only at limited intervals. Where pavements pass through highly developed areas, I think such service drives will be necessary to overcome constant interference of traffic turning in and out of the property with through traffic. These service drives would not, of course, be improved to nearly as high type as the through pavements. In most cases a surfacing of gravel or crushed stone would be sufficient, and the design standards employed could be much below those which we would apply to a high-speed road.

STATE ROUTES THROUGH CITIES

Early in my talk I stated that I would confine my discussion largely to rural highways. I think it is appropriate to remark, however, that most all states have some critical problems to solve in cities. Our biggest problem in Illinois, of course, is in the city of Chicago. Numerous schemes have been proposed for bettering traffic facilities there, and, frankly, that is indeed a real problem. If the various governmental agencies involved had unlimited funds on which to draw, there is no question but what they could construct a system of super-highways, elevated or not, which could take traffic into and out of Chicago with dispatch. Various interests have proposed numerous schemes, but almost without exception they disregard the tremendous outlay of money for construction and property damage. However, it is a problem with which we have to cope in Illinois, and I assume that other states have situations which approach it. Earlier in my remarks I stated that while only a small percentage of our roads would ever justify more than two-lane construction, that small percentage of roads was highly important because of the large amount of traffic served. The same is true of our highway situation in Chicago. The mileage involved is an almost insignificant percentage of our primary road system; however, that limited mileage is of great importance to hundreds of thousands of highway users. It is natural, therefore, that the situation there should be of major concern to us, and we may expect the ultimate solution to be far removed from the two-lane highway, from which point I started this discussion.

BEYOND THE TWO-LANE ROAD

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I wish to compliment Mr. Surman on his very interesting and able presentation of the subject “Beyond the Two-Lane Road.” I have had the pleasure on another occasion of listening to Mr. Surman present a paper on design of divided-lane highways, and I wish to say I consider him one of the best