

thinking to his location, design, and type of road. He was circumscribed by many restrictions and regulations, political and otherwise, offering no encouragement to a long-range program. The 1930's were somewhat of a reversal. The depression brought many engineers by force of necessity into the highway field and, for a long period of time, in many states highway work was the principal livelihood for many engineers who had started out with other plans. The 1930's are gone, and at their end the engineer who was able to plan, design, construct, and maintain a modern roadway has become somewhat of a specialist. For the first time he is able to select his design speed and determine what classification his highway is to carry. He is able to provide right-of-way that will be sufficient for the life of the road. He has become a landscape engineer because the people are demanding beauty as well as utility along the roads.

It is with a note of encouragement, therefore, that we look into the future and seem to see the ever-increasing part that the engineer must play in the proper development of our national highway system and our Union. To occupy his proper sphere in the scheme of transportation on the highways, he must be taught something besides concrete, steel, soils, and things of that nature. He must take his place in the councils of men and speak up. He must be taught to lead and not always to follow. It is not too much to say that he must go into politics of the right kind. The future seems to offer opportunities, and it is believed that the highway engineer is on his way to greater service. Young men are being trained at Purdue, at Texas A. & M., and at other forward-looking colleges with this in view.

LOOKING TOWARD THE FUTURE OF INDIANA ROADS

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Highways, as a means of quick, convenient, and safe transportation for the majority of our population and for the movement of an increasing percentage of our farm and factory products are today entering upon a new stage of development—a stage which challenges the roadbuilding industry to meet the needs of the future as well as those of the present.

Never before in our history have the attention and the interest of the general public been centered more searchingly upon highways—their construction, their maintenance, their financing, and their uses. Neither has there been a more widespread realization of the importance of roads in our social and economic life, or—because of war conditions on other continents—a more general realization of the importance of roads as a phase of our national defense.

We who are engaged in the road-building industry—whether our task is the designing, the building, or only the administering of roads or streets—face a greater responsibility and a greater opportunity as a result of that increased public interest in roads. If we are not to fail in the responsibilities which are ours, and at the same time are to profit through the opportunities that increased public interest presents, our united, unselfish efforts must be given to the discharge of our obligations in the building, the maintaining, and the financing of roads.

If we, as the men responsible for the roads of Indiana today and during the coming generations, are to contribute our share to the welfare of these who will use the roads that we build, we must envision to the best of our ability the transportation needs of the near future and march, shoulder to shoulder, toward the accomplishment of that purpose.

Highway transportation today is too big, too fast-growing, and too vital to our daily life for a viewpoint bounded by corporation or county lines, or even state boundaries. No longer can we afford to invest the road dollar in roads or streets that go nowhere, or that cost more to maintain than they can earn through the traffic served. We have today, in the state highway system, miles of improved roads on which the traffic earning, measured by gasoline tax and license fees, is less than we are forced to spend to maintain those sections of highways. Undoubtedly there are other miles of county roads and city streets where the yardstick or earning capacity will show that the investment has been greater than the return.

This condition is not a reflection upon the men who designed and authorized the improvement of these roads and streets. They built to the best of their ability and to the extent to which they were able to forecast the future traffic needs, needs that may not have materialized.

We must face the fact that today, and more and more in the future, the job of the road-builder will be one of maintenance or reconstruction rather than new construction. We have today in Indiana some seventy-six thousand miles of state highways and county roads, including only a fractional part of the city-street mileage. I question whether there is a need now or in the immediate future for many miles of additional roads. The problem, as I see it, is the development and improvement of the mileage we now have rather than the addition of new mileage to Indiana's road system.

DEMANDS OF THE MOTORISTS

You in the counties and the cities, as well as we in the state highway system, know that the demands of the motorists for further improvement of the roads and streets over which they travel are increasing, that these demands include

services unthought of a decade ago. I can remember not so many years ago when breaking a road through the snow was an individual responsibility, and what an advance we felt had been made when breaking out the roads after a snowstorm became one of the services we received.

Today we know from experience that breaking a path through the snow is not enough; nor are the motorists satisfied to wait to have the roads cleared. It costs money to maintain an organization and the equipment necessary to meet these emergencies, and yet that is a service that must constantly be made more efficient to meet the expectations of the motorists.

There was a time when motorists were satisfied with almost any kind of sign along the roads to give them direction or information about the road ahead. Now we are expected to have all important marking along the roads done with reflectorized signs that provide night visibility almost equal to that obtained by daylight.

These are but two illustrations of the expensive services that motorists expect and are receiving today. There are dozens of others. I would not give the impression that the road-builders are opposed to performing these services; but I would impress upon the motorists at large that operation of a road system in the state, the county, or the city can only be as efficient and as modern as the funds provided will permit. We can and we have stretched the highway dollar to lengths that would have been impossible a generation ago, but there is a point beyond which we cannot go. If the motorists demand more, they must be willing to spend more.

UNFINISHED BUSINESS

Frequently we hear an intimation that now is the time to reduce the fees the Indiana motorist pays, and we are painted a picture of the tax load under which the motorist is operating his truck or automobile. Let us look at some statistics!

In 1938, the calendar year for which comparative figures are available, Indiana ranked ninth among the states in the number of motor-vehicle units registered. In that same year Indiana collected in gasoline tax and motor-vehicle taxes an average of \$35.12 per vehicle registered—less than ten cents a day. Indiana in 1938 was thirty-sixth in the per-vehicle tax collected by the various states, and the Indiana average was \$4.24 under the average for the United States.

There is another phase of highway financing with which we are concerned. Usually when the question of a reduction in the motoring taxes is raised there is a suggestion that the present road and street systems are sufficient, that there is nothing else to do except to preserve what we have. I point again, as I did from this platform a year ago, to the fact that while we may have all the mileage we need, the road system in

Indiana is far from complete as long as 95 per cent of the bridges on county roads and 60 per cent of the bridges on the state system have roadways of 20 feet or less, when 57 per cent of the bridges on the county roads and 17 per cent of the bridges on the state highways have a load-carrying capacity of five tons or less.

When there are more than seven thousand grade crossings on state and county roads and only seven hundred grade-separation structures and five hundred flasher-signal-protected crossings—can we say that our work is done? If we have 20 per cent of the state highway mileage and 71 per cent of the county road mileage on rights-of-way that are 16 feet or less in width, the road-builder's job is not finished.

FUTURE NEEDS

But we are concerned primarily at this time with the future of Indiana roads. It is a subject that is receiving attention in other states as well as our own, and for months the newspapers and other publications have frequently carried articles speculating on the highways that would carry the traffic in the future.

Possibly some of this speculation has been aroused by the proposals made in Congress, from time to time, that a series of super-highways crossing the nation from the Atlantic to the Pacific, and from north to south, should be constructed as a federal undertaking. Usually the proponents have urged such an undertaking as a means of creating employment, as having military importance in time of war, and as paying for construction and maintenance through the collection of tolls. That such self-financing highways on such a scale are hardly possible has been demonstrated by traffic studies and reports by the Public Roads Administration.

However, we cannot say today that such a system of super-highways is impossible, or condemn the idea as impracticable for the future. We are continually reminded of the scoffing that every major invention or construction project has received. Possibly you and I will see the day when such a super-highway will stretch across Indiana, carrying traffic at speeds of 100 or more miles an hour.

We know that elevated highways are being used today in some sections of the heavily-populated eastern states, that the road-builders found it more economical to raise the roads than to raise the funds the right-of-way for other construction methods would have cost. We do know that in Indiana we are extending the construction of dual-lane highways with separate traffic lanes for traffic moving in opposite directions. This type of construction is not what is meant when we speak of super-highways; and yet, to the road-builder of a generation ago, such dual-lane highways would have seemed super-highways.

Thus our attitude toward new developments in highways is largely a matter of experience and a realization of the existing needs. Thirty years ago there was no need for dual-lane highways in Indiana: bridges and roads with a sixteen-foot traveling surface were ample for the needs of the day, and a vehicle having a loaded weight of over five tons was almost inconceivable.

Without saying that super-highways are impossible in Indiana, I think that we can agree that they are unlikely in this state for years to come. At least we can be reasonably certain that such construction will be extremely limited, for there are few sections of highway in Indiana today where the traffic conditions would justify such an expenditure. Here again we must say "if," for our traffic studies reveal a constant growth in the use of the roads.

TRAFFIC GROWTH

When the first state-wide traffic study was made in Indiana, we were amazed by the revelation that there were more than ten million vehicular miles traveled daily on the state and county roads. In 1937 we completed a second traffic study and found that in four years the traffic flow had increased to forty per cent. In other words, whereas we had, in 1933, ten million vehicular miles daily, we had in 1937 a total of fourteen million vehicular miles daily over the state and county road systems.

From checks made recently, it is indicated that the traffic flow on the state system has increased approximately 7 per cent over previous figures; and it is probable that a corresponding increase has taken place on the county roads. In the face of these facts, who can say with any degree of confidence just what the traffic conditions will be in another ten or twenty years? Who can predict what the highway needs of another generation will be?

It was not so many years ago that men who were regarded as authorities in the field of motor vehicles and motor-vehicle transportation were pointing to the registration of automobiles and trucks with the assertion that we had reached, or were just about to reach, a saturation point. Needless to say, there is no evidence today that such a saturation point has been reached, and we can only anticipate a further increase in the number of vehicles on the roads and an increase in the vehicular mileage traveled daily.

PLANNING FOR THE FUTURE

Without assuming the role of a prophet or posing as an authority on highways and highway transportation in Indiana during the coming years, I have developed some thoughts on this subject that may be of interest.

In the first place it seems futile for any person or group of persons, regardless of their ability and their technical training, to assume that a road can be designed and built today that will serve all the transportation needs of a generation that may witness even more revolutionary developments in transportation than we have seen.

It seems to me that we who are now administering the roads and streets should be more concerned with laying a foundation for future highway systems than with speculation as to the form which that transportation may take. After all, even the best road we can build today has a normal useful life of only fifteen to twenty years under present traffic conditions. We can contribute most to the future roads of Indiana if we secure wide rights-of-way, even wider than we may require at the immediate time, for the right-of-way is the most permanent thing about a road.

In our construction, we can eliminate curves and grades that are already a hazard to traffic safety; in our maintenance we can develop more efficient methods of prolonging the life of a road that meets the existing traffic and safety needs; and we can increase and improve our services to the users of the roads in many ways.

If, then, we are to look into the future of roads in Indiana, we should expect to see among other things:

A system of roads and streets adequate for the traffic which they serve while contributing to the orderly, convenient, and safe movement of that traffic.

A primary state highway system carrying the major volume of traffic, both interstate and intrastate.

A system of county roads serving local, rural, and suburban traffic and acting as a secondary or feeder system to the state highways. And

A system of city streets designed and maintained for the special type of traffic they serve, a differentiation between business and residential areas with their widely separated problems.

But we should not stop with this vision of a more closely co-ordinated highway transportation system.

We should see, in looking into the future, a network of roads and streets improved and maintained as integral parts of a uniform transportation system—classified for construction and maintenance by the traffic they carry and the service they perform.

We should see a system of roads that has wide rights-of-way, that is not fenced with utility poles but has been made attractive through natural plantings and seeding.

We should see roads that have easy curves and grades, with ample sight distance, bridges with wide roadways, grade separations or other protections for the motorist at all rail-road crossings and at major highway intersections—in other

words, a system of roads and streets as free of traffic hazards as engineering skill and traffic regulations will permit.

It is one thing to picture what might be described as the ideal Indiana road of the future. It is not easy to reduce such an ideal to the practical basis from which we may hope to accomplish or achieve that ideal.

DEFINITE PROPOSALS

I felt that it would be unfair to this audience if I were merely to look into the future of Indiana roads without contributing what I could toward the practical attainment of such a road system.

I am therefore suggesting for your consideration as a means of making our administration of Indiana's highway transportation system more efficient and rendering a greater service to the motorists, the following proposals:

That we institute on a co-operative basis a broad, practical research program that will be concerned with all classes of roads and streets and will provide scientific, unbiased recommendations on road materials and their proper uses, on equipment, and on improved methods of construction, reconstruction, and maintenance.

That such findings as may result from such a research program shall automatically become the accepted means of developing a more efficient road system and administration in Indiana.

That present laws be amended, if necessary, to permit closer co-operation between the state, the counties, and the cities in solving their road and traffic engineering problems without encroaching upon or usurping the authority or responsibility of either the state, the counties, or the cities.

That as a means of localizing this co-operation and making it more effective in the solution of local or regional problems, county, city, and state road officials should develop a mutual understanding of problems through more frequent contacts by groups that might approximate the state highway districts or some other more advantageous geographical division of the state.

That some action be taken to prepare, as far as practicable, more standardized highway procedure, as, for example, the establishment of minimum width of rights-of-way for roads classified according to their present and potential traffic use, and that some program be initiated to secure such minimum rights-of-way where they do not now exist.

That we recognize the dependence of the state highways, the county roads, and the city streets, under present laws, upon funds derived from the gasoline tax and motor-vehicle fees for all construction, maintenance, and administration. I know that finances are as much a problem in the operation of the county roads and the city streets as in the operation of

the state highway system, and I feel that a primary step in any program to assure the future of Indiana roads should include a more thorough study of highway financing from the viewpoint of giving the motorist the best system of roads for what he is willing to pay.

There are many other suggestions that I might make as to the future of Indiana's roads, and doubtless there are many of you who could make valuable additions to those I have outlined. Possibly this discussion will inspire in some way the attainment of the common purpose that we all have—the best possible system of roads, now and in the future as well.

I realize that I could have stood before you this afternoon and sketched for the future of Indiana roads a vision of multiple-lane highways with all the refinements that an unrestrained fancy could conceive. But road-building is practical first, and we who are engaged in the building and maintaining of roads can not overlook our present problems or those of the immediate future.

PAVEMENT DESIGN

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For many years highway designers have endeavored to build more and better pavements at the lowest possible cost. Their efforts in that regard have been directed largely toward the structural design of the pavement, including such essentials as character and proportioning of aggregates, amount and distribution of wheel loads, pavement thickness, and the general economy of the structure. That properly is classed as structural design.

With increasing emphasis being placed on highway safety throughout the country, designers have undertaken, as their part, the development of basic data on which to modernize and develop design principles that will promote maximum safety of traffic, a greater utility of highways, that is, a better operating service. The fact has been established and is now generally accepted that there is no real economy in highway design until or unless roads can be traveled at reasonably fast speeds in comfort and safety. Designing for speed with safety is known by the new term "geometric design" because it has to do with the visible dimensions of the highway. Of particular interest in pavement design are width of pavement and number of lanes as related to traffic behavior.

The purpose of this paper is to summarize important facts and trends that have been developed in both the structural and geometric design of pavements and how these developments came about. To cover this rather wide field with rea-