ROAD DESIGN TO REDUCE MAINTENANCE COSTS

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More than twenty-five years ago, a distinguished historian wrote in an essay entitled "The Road":

"It is the Road which determines the sites of many cities and the growth and nourishment of all. It is the Road which controls the development of strategies and fixes the sites of battles. It is the Road which gives its frame-work to all economic development. It is the Road which is the channel of all trade and, what is more important, of all ideas. In its most humble function it is a necessary guide without which progress from place to place would be a ceaseless experiment; it is a sustenance without which organized society would be impossible; thus, and with those other characters I have mentioned, the Road moves and controls all history."

Since this essay was written, the rapid growth of the many state road systems in this Country, including our own road system here in Kentucky, and the increased use of these roads, have brought about specialization in the field of highway engineering. In fact, we may be, like some other professions, over specializing. I am convinced that we are no longer, by experience and in service training, developing highway engineers. Instead, we are developing highway design engineers, highway construction engineers, highway maintenance engineers and others, each a specialist within his own field but without the broad experience of all phases of highway engineering.

Having spent most of the past fifteen years in highway maintenance, I am, no doubt, catalogued now as a highway maintenance engineer and your Program Committee has assigned to me, a maintenance engineer, the subject of Road Design to Reduce Maintenance Costs. A discussion of road design by a maintenance engineer may involve the risk of having this discussion viewed by some with a feeling similar to the feeling expressed by a young army selectee in a story I ran across a few days ago. According to this story, the Lieutenant was having considerable difficulty taking the selectees assigned to him and changing them into soldiers. One day, when his patience had been worn almost to the limit, the Lieutenant singled out a young recruit who had been a rather particular problem and said: "Hey, you there, what kind of a soldier do you think you are?" The young recruit replied: "Sir, I am not a soldier, I am a misplaced civilian."

In spite of the risk involved, I am glad to have this opportunity to appear before this group and to discuss this question from the stand-
point of the problems encountered on maintenance resulting directly, or indirectly, from road design. I want to discuss this question very frankly. Road design, as used here, will cover all of the road facilities, including bridges.

Before getting into the design question, however, I think it might be well to discuss briefly highway maintenance and highway maintenance costs. I think, first, we might look for an answer to this question: What is highway maintenance? You can find any number of definitions of highway maintenance. I recently asked this question of several outstanding highway engineers across the Country and obtained many different answers. Perhaps the most widely used definition of highway maintenance is the definition found in the agreement between the Bureau of Public Roads and the respective state highway departments, which agreement provides that the roads constructed with Federal Aid will be maintained by the states. The definition as used by the Bureau is:

"The preserving and keeping of each type of roadway, roadside, structure and facility as nearly as possible in its original condition as constructed or as subsequently improved, and the operation of the highway facilities and services to provide satisfactory and safe highway transportation."

You will note that the first part of this definition provides for "keeping the roadway facilities in their original condition", while the second part is to provide "satisfactory and safe highway transportation".

There can be, and frequently is, a vast difference between keeping the highway facility as it was constructed and providing satisfactory and safe highway transportation. Many times the highway, as constructed, even though it provided satisfactory and safe highway transportation at the time it was constructed, has become obsolete due to the increased demand placed upon it so that if it were possible to keep it in the condition which it was constructed, it would no longer provide satisfactory and safe highway transportation.

Maintaining the highway system of Kentucky carries the responsibility of the second part of the definition, that is the responsibility of providing "satisfactory and safe highway transportation". A vast percentage of the total mileage, however, is, by reason of deterioration and the greatly increased demands of highway transportation, entirely inadequate to serve present day needs. Maintenance on this portion of the system is costly, tremendously costly, and these costs create a drain on highway user revenue that, if permitted to continue, can eventually cause new highway construction to be discontinued. This
must not be permitted to happen, and it can be prevented if, and perhaps only if, a compromise is reached between the replacement or reconditioning work that can be accomplished using current design standards and the amount of such work that it is possible to accomplish with available revenue.

Road design and road design standards, for the purpose of this discussion, can be divided into two general phases. The first phase is what we might term structural design or the design of the cross section of the road. In this phase, highway design engineers have done an outstanding job. They have studied soils, they have studied the load carrying qualities of construction materials and have produced a structural design, or we might say a two-dimension design, which provides adequate thickness of pavement to carry the desired loadings and adequate cross section. This structural design, or two-dimensional design, has received the attention of the best brains in the highway design field and has been worked out with marked success, in fact these designs have been so well done that they approach luxury, and maintenance engineers find no fault with this phase of road design except as it affects the second phase.

Road design engineers, generally; however, have overlooked the third dimension, the length of the roadway, except to establish standards of horizontal and vertical alignment, and this leads to the second phase of road design. This second phase of road design, which we might call design of a system of highways, is the problem that vitally concerns the maintenance engineer, and equally affects the user of the road system. Too often the road designer is given the problem of designing a section of road that may be 1.0 mile, 5.0 miles or 10.0 miles in length and is given design standards governing the cross section, the alignment, sight distances and other minimum requirements. These adopted design standards are all too often followed with little thought being given to how this section of road will fit into the present overall road system or the overall system as it may be improved within the reasonable future. No compromise is considered between the adopted design standard and the reduced cost that could be effected by saving some of the existing facilities, nor is a compromise considered between the adopted design standard and the design standard used on adjacent sections of the same road, even though the adjacent sections may be expected to serve for many years to come. The designer devotes his entire thinking to the problem of designing a road, the length of which has been assigned to him, so as to provide for the allowable weight and volume of traffic, the sight distances, the right of way widths, shoulder widths and ditch widths, all of which are set up in established standards.
The maintenance engineer must be concerned with the maintenance of a system of roads, and the replacement or reconditioning of one section, be it 5.0 miles long or 10.0 miles long, is only a link in a vast system that, in this State, consists of some 14,000 miles of roads that blankets an area of some 40,000 square miles and serves some three million Kentuckians and their visitors from other states.

Established highway improvement standards, which are now in use, have been set so high in relation to the funds that have been made available to bring about these improvements that the present highway system in this State, as well as the systems of other states throughout the Country, is deteriorating at a rate far in excess of replacement or reconditioning. Our road system is less capable today of providing the services demanded of it than it was twelve to fifteen years ago. It was estimated in a report to Congress in January, 1950, that, based on current design standards, it would cost 41 billion dollars to put the Nation's highways and streets in condition to serve the needs at that time. At the same time, it was estimated that 1.7 billion dollars worth of new highways were built in 1949. This 1949 improvement brought the Nation's highways, as a system, up to a standard approximately equal to the requirements of 1933. In other words, in 1949 the Nation's highway system was sixteen years behind the needs. If the 1949 rate of construction could be continued, and that is doubtful, then by 1973 we would have a system of highways equal to the needs of 1949. Then the Nation's highway system would be twenty-four years behind the needs instead of 16 years, as was the case in 1949.

In the development of a highway system, such as our own here in Kentucky, where the cost of improving the system, based on current design standards, is so far beyond any available revenue and so far beyond any hope of securing revenue, there are, of course, differences of opinion as to where the improvement should be made first. There are those who argue, and have argued for years, that a so-called system of main roads, or trunk line roads, should be improved first and when these main roads are completed, the feeder roads could be improved. On the other hand, there are those who argue that where there is an existing road, even though it is sub-standard, it should be made to serve until road improvements are made to serve the people who do not now have useable roads. These two lines of thought may represent the extremes and perhaps it would be wise to follow a course somewhere between these two extremes. However, it is evident that you can no more have a main road serving the people without a feeder system than you can have a river without tributary streams. Neither
can you have a feeder or secondary road system that will serve the people without main or trunk highways to provide for the concentrated traffic collected on the feeder system.

The so-called revenue producing roads, the roads that carry heavy volumes of traffic, are revenue producing, more because of the system of feeder roads collecting traffic for them, than because of the standard of improvement of the main road. It is not only the improvement or replacement of an existing road system that brings about growth in highway transportation, the expansion of such a road system to bring these services to more people has played a major role in this growth. This is evidenced by the ever growing use of the motor powered vehicle.

Automobiles outnumbered horses on farms in 1950 for the first time in History.

More than one-third of the coal produced in the State in 1949 was hauled over the highway system. Of the forty-seven counties producing coal in Kentucky, only twenty-one have mines served by railroads. In one of Kentucky’s largest coal producing counties there are seventeen railroad mines and 1235 truck mines. In this county in 1949, nearly three fourths (over five million tons) of coal produced moved over the highways. Other raw materials and manufactured goods move over the highways to serve every Kentucky citizen regardless of where in the State he may live.

Highway engineers who are still serving the people of this State as employees of the Department of Highways have seen, during their tenure of service, greater expansion and growth in highway transportation than had taken place in the history of our State prior to that time. The lack of earlier development was not, however, due to a lack of interest in roads.

Kentucky has always been interested in roads. A Road Commission was created in the first year of the history of the State and the first state road was built during the first five years of the State’s history.

This interest in roads has by no means declined. In the last few years our State has increased its efforts to expand the system of highways to serve more people. This expansion would have been financially impossible if design standards had not been changed. Design standards were changed, however, for this so-called rural secondary system and, in comparison to the design standards used for the main roads, they are extremely low. These roads are being added to the State maintained system and at the same time, improvement on the so-called main highways is being done under established design.
standards, which, again by comparison, are very high and approach the luxury in road design. Because of the fact that there are not sufficient funds to replace or recondition the main roads of the State according to the currently used design standards, there remains a vast mileage of roads within the system that is entirely inadequate. These roads have become so deteriorated under the increased demands that they can no longer adequately serve the needs. These roads, however, must be kept in service and their maintenance places a tremendously heavy financial responsibility upon the Division of Maintenance. The maintenance of some of these roads has reached the point where per mile maintenance costs are four to five times as much as is expended on an average mileage basis for the system as a whole. Many of these roads will not show a decreased maintenance cost until or unless major reconditioning work can be done. In fact, maintenance costs for these roads is expected to increase.

The State maintained system of highways is a huge plant that represents one of the State's major assets, which has a value today of perhaps well over a billion dollars and the system must be kept, as nearly as is possible, in a condition to provide satisfactory and safe highway transportation, even though such maintenance expenditures continue to reduce the amount of funds available for new construction.

It is my belief that highway users are not willing, nor, in my opinion, are they able to provide the funds necessary to replace or recondition a major portion of this system of roads, if such replacement is to be done according to present day design standards. Replacement or reconditioning of the present system, if done on current design standards, must be limited, for financial reasons, to more or less widely separated sections throughout the system. It is little comfort to the highway user to find that his highway department has improved a short section of one of the main roads to an ultra modern standard, approaching the luxury class, if at the same time he finds that he is forced to travel many, many miles of obsolete sections on the same road in order to enjoy these few short sections of so-called modern highway. The user will, I believe, feel that he would have been much better served if the funds made available to the Highway Department were expended in such a way as to reasonably improve a greater percent of the total mileage of the road system.

Design for replacement or reconditioning must then, I believe, be done using a design standard that is a reasonable compromise between what design engineers would like to have and what highway users are willing to pay for. Road designers must take into consideration the amount of work that can be accomplished with available funds in
order to give the best service on the entire system of roads to the greatest number of people. A designer must consider most carefully the facilities that are already in place and use any of these existing facilities that can be made to fit into the complete design, even though it may require a compromise design below the currently adopted standard. He must also consider the amount of service that can be rendered to highway users as a whole resulting from so-called refinements in his design, such as the construction of parking lanes, sidewalks and other facilities that materially increase the cost of construction; and if such cost is not justified by reason of the service it will render to all the highway users, compared with what service could be rendered by like expenditures on other links of the road system, then such refinements should not be included in the design.

There are other important features of road design that materially affect satisfactory and safe, particularly safe, operation of the highways, such as the layout of intersections and the width of median strips separating divided highways, all of which are most important and should receive most careful consideration by the road designer; however, this paper is limited to a discussion of design to reduce maintenance costs and I will not undertake to discuss these safety features.

The road designer might do well, in the preparation of roadway plans and in considering the adopted design standards, to examine his plans carefully before they are marked completed and see if he can truly give an affirmative answer to the following questions:

1. Is the proposed improvement the most needed improvement on the system, or is it the most needed expansion of the system?

2. Does the improvement, as designed, fit into the remainder of the road system, and particularly does it fit into the adjacent sections of the system, when no improvement is considered possible for these adjacent sections within a reasonable length of time?

3. Does the proposed improvement make use of all of the existing facilities that are useable in an effort to hold improvement costs to a minimum, thereby allowing the improvement of other sections of the system where improvement is so greatly needed?

4. Is the proposed improvement so designed that it can be safely operated?

5. Does the design include added features of refinement, on which the expense of construction can not be justified considering the needed improvements on the system as a whole?
I said near the beginning that I wanted to discuss this question frankly. These are the frank views of one maintenance engineer who is charged with the responsibility of maintaining a system of highways that is rapidly expanding and on which the traffic demands are ever increasing and with much of the present system entirely inadequate to serve present needs. This also is an appeal to road design engineers to give more study to the design of a highway system along with their study of cross sectional design of one particular road. It is an appeal to road designers to alter their design standards so as to permit the use of available funds in such a way as to render the greatest amount of service to the greatest number of highway users. It is an appeal for improvement of a greater mileage of the system, even if the improvement is done on lower design standards, because I believe that maintenance costs can be reduced only by replacing or reconditioning the obsolete and overloaded portions of the road system.

**DISCUSSION**

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It is a pleasure to be on the program to discuss Mr. Johnson’s excellent paper on the subject “Road Design to Reduce Maintenance Costs”. After spending several years on maintenance, I can appreciate the present day serious problem of maintaining our great system of highways and streets, especially when a large percentage of the mileage was never constructed to withstand the punishment it is now receiving from heavy and fast traffic. The powerful position the United States occupies today was gained by the superb production of industry supplemented by unequaled systems of communication.

We are now living from the fat of our highway system. Cities, counties and states are falling behind rapidly in the construction and maintenance of adequate highway facilities. People want the benefits derived from the use of heavy trucks, the luxury and time saved by fast automobiles, a well connected road system built to modern standards, but they are unwilling to pay the cost. It is well known that many persons will do without some of the more necessary things in life in order to buy an automobile. If our highway departments were doing as well as the motor companies financially, the scales would be better balanced between the vehicle use and the road condition.

Mr. Johnson pointed out that the field of highway engineering is becoming more and more specialized as the department grows. The