

Research and Local Road Development

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Purdue has not only led the way in spreading the gospel of better highway construction methods through its academic program and through regular meetings such as this one, but also set the pattern for service to the state highway department through its Joint Highway Research Project that is now being followed in many other states. And the influence of Purdue is being felt throughout the nation and beyond its borders as Purdue graduates find their way into positions of trust and responsibility. It is likely that no other single institution has had as much impact on highway development and highway transportation as this University.

PROGRESS ON THE FEDERAL-AID HIGHWAY PROGRAM

As a representative of the Bureau of Public Roads I am glad to be able to report most satisfactory progress on our federal-aid highway program. The 1956 Federal-Aid Highway Act set us on our course, and the 1958 Act reaffirmed the intent of Congress to authorize a highway program adequate for the needs of the federal-aid system.

The results are now being felt and seen everywhere, as the "Grand Plan" is fast coming into being. In 1956, when the act was passed federal-aid funds were used in the amount of less than \$800 million; in 1959 it is estimated that the amount will approach \$2- $\frac{3}{4}$ billion. With these expenditures, matched in appropriate ratio by the states, the program is well on schedule. At the end of February 1959, federal-aid funds for the Interstate System had been obligated by the states in a total amount equaling all the apportionments still available for the years prior to fiscal 1959, and 88 per cent of the 1959 funds, with fiscal year 1959 but two-thirds gone.

Despite the emphasis on the Interstate System, application of other federal-aid funds has not lagged. At the end of February federal-aid primary, secondary, and urban funds, called the ABC funds, had been obligated for the country as a whole to the extent of 79 per cent of the 1959 apportionments, again with a third of the year still remaining.

The two and a half years since the passage of the 1956 Act have seen truly remarkable accomplishment. The report of progress recently sent to Congress, as required by the 1956 Act, shows that over 1,500 miles on the Interstate System financed with Interstate funds were completed and opened to traffic since June 1956. This mileage, added to that completed to acceptable standards as toll or free road prior to passage of the 1956 Act or since, gives a total of 4,700 miles now open to traffic. This of course is what the public sees and in large part constitutes its measure of our progress.

Of more real significance, however, is the progress in the many stages of effort required prior to opening a road to traffic, stages all too familiar to the engineer, but generally overlooked or not understood by the highway user. In these earlier stages the record of the last two and a half years is most impressive. Work is actually in progress or completed on some phase, either construction, acquisition of right-of-way, or plan preparation, on over 28,000 miles of the 41,000-mile Interstate System. The assembly line is operating and the various components are being fed in to emerge as a steady flow of 1975-model highways. All that is needed is the assurance of funds to keep the line moving at the pace necessary to supply the increasing demands of the American economy and way of life.

Highway transportation has become woven into our daily lives so gradually and so easily that unless we stand back and take a deliberate look at it, we perhaps do not appreciate its real significance. The motor vehicle takes us to and from work, on shopping trips, to and from the doctor and the dentist, to school and to the psychiatrist. It takes us on vacations, to the drive-ins, even lets us drive just to be driving. And the motor truck is equally interwoven into the commercial and industrial aspects of daily living.

Highway transportation is more than a part of our economic and social structure; it characterizes a way of life. Like it or not, we are utterly dependent on it for our very existence, and may expect to be no less so within the predictable future.

The growth of highway transportation and our increasing dependence on it are supported by ample statistical evidence. Motor vehicle travel became a full-fledged force in our economy at about the beginning of the great depression of the 1930's. By then its use had changed from one of sport to transport. In the quarter century since 1932 total highway travel increased three times and transportation of goods by truck increased at double that rate.

We have now become sufficiently accustomed to these rates of increase to accept them without too much reservation. But in the past

it took more courage and willingness to withstand ridicule than most of us possessed to predict that such rates of increase, then generally thought fantastic, would continue. What was not appreciated until fairly recently, is that the growth of highway transportation in our generation is no isolated phenomenon. Rather its growth has almost exactly paralleled the growth of our economy and is a part of it. In fact, in recent years it has been growing at an even faster rate. Highway travel has become so firmly enmeshed in our economy that it has grown with it and must continue to do so. And unless we can make adequate provision for its growth in the future, the economy and prosperity of the nation may be expected to suffer. It's that simple.

With that background, the Bureau of Public Roads now with little hesitation forecasts that by 1975 our 225 million people will travel well over a trillion miles in more than a hundred million vehicles. To reach this level of travel will involve an increase of some 80 per cent above present values, a modest rate in light of trends of the past.

NEED FOR FURTHER FUNDS

So with this clear evidence of need for more and better highways to support our growing nation, and with the needed roads coming steadily forth from the production line, we find ourselves facing the possibility of being brought up short because of the item mentioned earlier—funds.

In the 1956 Act Congress provided that certain highway user taxes would be appropriated to the Highway Trust Fund, and that all federal-aid highway expenditures would be paid from the fund. The amount to go into the fund was calculated during its lifetime, which extended to 1972, to equal the amount needed to complete the Interstate System and carry on a sizeable regular federal-aid program. The Congress in its original consideration of this bill recognized that there would be a period midway in the program in which the annual receipts would not equal the authorized annual expenditures, and so it provided for repayable advances from other funds. When the act was finally passed, however, it also contained a provision, known as the Byrd amendment, requiring that, despite the amounts authorized, the apportionments to the states for any year be limited to the amount of expenditures that could be defrayed from the Trust Fund when the states requested reimbursement for work accomplished. This provision was suspended by the 1958 Act for the fiscal years 1959 and 1960, however, and the Secretary of Commerce was directed to apportion all the funds authorized for those years.

Now we are faced with a situation in which Congress must take some further action if the Interstate program is to be continued. The report to Congress, mentioned earlier, describes the present situation as follows:

“As for the Interstate System, because of the provisions of section 209(g) of the Highway Revenue Act of 1956 it will be necessary, unless additional funds are made available, to completely forego any apportionment of Interstate funds during the calendar year 1959 (for the fiscal year 1961), and the apportionment during the calendar year 1960 (for the fiscal year 1962) would amount to only \$500 million. Thereafter, Interstate apportionments would amount to about \$1.7 or \$1.8 billion annually, or about three-fourths of the amount which was authorized as an annual rate by section 108(b) of the Federal-Aid Highway Act of 1956.”

How or whether federal funds for carrying on the Interstate program are provided, of course, remains to be seen. There is widespread expression of views, however, that the programs cannot be allowed to lag, as emphasized by the remarks of Congressional leaders at the AASHO meeting in San Francisco, so it would appear that the consideration of the problem that is beginning in Congress will be centered around the question how, rather than whether.

Beyond the immediate concern over federal-aid funds, however, is another and potentially more serious problem, that of the states and local units of government in stepping up to the increasing demands that must be set outside the federal-aid program. In 1955 and 1956 a great amount of support by national organizations and others was effectively directed toward the objective of stepping up federal aid for highway construction. The success of this effort and the increasing pace of activity on the Interstate System have perhaps led many to lose sight of the responsibilities remaining outside the area of federal aid.

The 1956 Act introduced a new concept in federal highway aid. For the first time the federal government accepted the responsibility for sharing—and in large measure, 90 per cent—the cost of completing an entire *system* of highways within a definite period. Theretofore it had only aided the states on a 50-50 basis in completing *projects* on the federal-aid systems, but without any intent, expressed or implied, to assume 50 per cent of the cost of completing the construction of an entire system in a specific number of years. States have traditionally accepted the responsibility for constructing and maintaining their state systems, often coextensive with the federal-aid primary system, but usually more extensive. In carrying out this responsibility they have been aided on many projects by federal participation, but always in the

past states have financed many projects on the state systems wholly from state funds, even though the routes may have been included in the federal-aid system, and the projects therefore legally eligible for federal participation had funds been available. In addition, of course, cities and counties, sometimes with state aid and sometimes independently, have carried on extensive improvement programs on roads and streets off the state system.

Now, with the increased federal funds, many states are finding themselves hard pressed even to match federal aid. This situation, of course, has serious implications with respect to the portions of the state systems that cannot be reached in the federal-aid program, and has perhaps more important, if somewhat subtle, implications of the states finding themselves in partnership with the federal government on *all* of their construction projects, with no latitude for wholly independent construction operations.

Over the years we have been able to say almost as a rule of thumb that federal aid amounted to about one-eighth of the capital outlay for highways. To show how this situation is changing, the Bureau's estimate of capital outlay for all roads and streets in 1959 is just over \$7 billion, of which approximately \$3 billion will be federal funds, over 40 per cent of the total. The federal government is fast becoming an equal partner, not just in projects, but in the total of highway construction. The earlier balance can be restored only by substantial increase in the responsibility to be accepted by state and local governments in the steadily rising cost of providing the highway transportation the nation requires.

The outlook thus seems to be one of increasing highway needs to be met with budgets of increasing stringency. And to get the most from the dollar in providing for the demands of the expanding economy we must turn increasingly to research to improve our science, technology, and administration.

IMPORTANCE OF RESEARCH

Sometimes one wonders whether we fully appreciate how many of today's practices stem from yesterday's research, and the importance of research today to develop the better practices needed for the tomorrow that is too soon another day.

Classification of soils, standards of optimum moisture and desired density, identification of soils through geophysical and serial photographic means, tests for quality and durability of asphalts, development of air-entraining cements, understanding of alkali-aggregate reaction—these

are all products of physical research. They are tools we use today, thanks to an earlier generation of researchers.

In other fields, standards of geometric design, bases for traffic and revenue forecasting, estimates of the physical and investment life of the highway plant by actuarial methods, methods for control of access, and many legal and administrative tools came through earlier research efforts. They are available because some individual or group had the vision, ability, patience, and encouragement to spend time and energy in this way.

So with this thought we come perhaps belatedly to the subject of this paper—research and local road development. Much is being done in research today that will have direct or indirect bearing on local road development and will undoubtedly have still more effect in the future.

AASHO ROAD RESEARCH PROJECT

Perhaps the first item to mention is the AASHO Road Test in your neighboring state of Illinois. It may be like carrying coals to Newcastle to describe that test here, because your Professor Woods is the chairman of its National Advisory Committee, several other Hoosiers are advising or aiding in various ways, and some of the more complex computations involved in the analyses will be conducted on Purdue's computer. But this test will be of direct interest to those responsible for local roads since many of the 836 test sections are designed to reflect traffic conditions and design practices characteristic of low-volume roads. Light-weight axle loops added in response to the requirement of the 1956 Federal-Aid Highway Act will be subjected to axle loads of 6,000 and 2,000 pounds and one loop will have no traffic of any sort, to determine simply the effects of the elements. Included in the tests are sections ranging from those on which tandem axles of 48,000 pounds roll over 12.5-inch cement slabs to sections literally of no load on almost no road.

But beyond the direct evidence of road surface and base behavior under the wide variety of loading, for direct application in design, is the expectation of the development of sound theories of design of both rigid and flexible pavement that will have broad future application.

Another research of interest in local road development is the study of culvert efficiency being conducted for the Bureau of Public Roads by the Bureau of Standards. This is perhaps particularly timely, remembering the recent mid-west floods. Here by full scale tests of culverts of as much as 30-inch diameter it has been found that by proper inlet design the capacity may be increased by nearly a third. This research is important also in the development of the theory of flow through short

pipes—a term, incidentally, more to the liking of the standards people than culverts—for it demonstrated earlier theory developed through model tests to be in substantial error. Design of inlets consistent with the theory and practicable of production are now being produced. A by-product of the study, fortunate or unfortunate, is the problem of handling at the outlet the much larger volume of water. So we now have another research project directed toward the prevention of scour. This research will have direct effect not only in improving the efficiency of highway drainage, but also in reducing its cost.

Soil stabilization is an area of great importance in local road development. A variety of methods are now in use, probably the most common being stabilization with Portland cement or lime. Many people have felt that, with the development of new synthetic materials and with constantly increasing kinds of by-products of new manufacturing processes, some better or cheaper stabilizing agent must sometime become available. In searching for such a material the Bureau has worked out cooperative agreements with 13 companies. Some are manufacturing chemists, who would like to produce an entirely new product. Others hope that some by-product of present manufacturing processes might prove suitable. Always of course the price comparison with Portland cement or lime is the nearly decisive factor as to acceptability.

We can just now say that a material supplied to us for laboratory test through this project offers sufficient promise to warrant full scale trial in the field. The Monsanto Chemical Company has provided a form of phosphoric acid that will soon be tried experimentally on a project in Georgia where specifications are now being prepared for a half-mile road test. We hope this may be a breakthrough, and that this and other chemicals may aid us in building better and cheaper roads in the years ahead.

IMPORTANCE OF MAINTENANCE

No item in the local road budget is more important than maintenance, and perhaps nowhere is there more room for improvement in efficiency. The Bureau of Public Roads has recently reached agreement with Iowa for an intensive study of maintenance practice in the field and a review of the administration of the maintenance function in the district and central offices. This will be an “operations research” type of study, one in which figuratively the microscope will be placed on every phase of the activity, although more literally the “microscope” will be a stop watch.

What is the most effective type of maintenance equipment for each phase of the work? Should heavy, expensive truck equipment needed for certain uses be used for others merely because it is available, or would it be cheaper in the long run to use lighter equipment, cheaper to operate and easier to load by hand, where that would suffice? What is the most effective size of crew for various operations? How far can we properly go in mechanization of certain functions?

These are but types of questions that the study will attempt to answer. Yet, many could be answered very simply if they were exposed by the microscope of careful scrutiny. In one state in which the Bureau participated in a maintenance cost study it was found that the large crew arrived on the job each morning and all sat around awaiting the heating of a tar kettle and melting of the tar. As a result of this observation one man subsequently was dispatched a half hour in advance to light the fire, so the crew could start work when it arrived. It should not have taken a study to come to such a decision, but the fact is that no one noticed this obvious loss of time until the whole area of maintenance practice was reviewed deliberately and in detail.

The Iowa study will produce results of much value generally and results that will be of particular significance in local road development where maintenance is relatively such a large item. Yet this is an area that is wide open to a do-it-yourself approach that I would like to touch on again a little later.

Counties, perhaps even more than most other jurisdictions, are beset with budgetary limitations, and consequently must make the best use of all available resources. Unfortunately the lack of funds makes it difficult to employ engineering and administrative personnel of the competence necessary to insure the most effective and efficient discharge of responsibility in the highway field.

STUDIES OF HIGHWAY ADMINISTRATION

In the area of administration the Bureau of Public Roads has joined with the Automotive Safety Foundation in supporting a study by the National Association of County Officials of county road management. This study will produce invaluable guides on the subject of county administration, guides which, because of the constant review by committees of the Association, will have the assurance of practicability.

In this same area of administration, a study started by Professor Stoner at Indiana University, financed by state and federal-aid highway funds, is exploring the application of cost accounting methods in county road administration. This is an area of widely recognized need, and the results will have widespread and immediate application.

There are, of course, countless other areas in which current research will be invaluable in local road development. Not only the construction and maintenance of the roads, but the selection of routes to be included in the various road systems and the degree of improvement necessary for various amounts and characteristics of traffic, are subjects that not only can be but have been researched. Yet despite the information that is available in printed form on many subjects, it is often surprising and discouraging to find how little is being used.

APPLYING RESULTS OF RESEARCH

Probably one reason is that many research reports are written in such technical language and cover either so intensively or extensively the subject in question that the average reader finds it difficult or impossible to learn exactly how the results can be applied to his particular problem. Such technical reports are necessary to advance our science and technology, and to provide the launching pads from which the same or other researchers hopefully fire their next research projects. But there is need also to reduce the findings of research to forms understandable and usable by the practicing engineer or administrator harassed as he is with everyday problems—always, of course, of the greatest urgency.

We in the Bureau of Public Roads are planning to assign a competent engineer to that specific job, so far as our own research product is concerned. It seems to me that here is a field for universities and experiment stations to do the same thing, so that the results of research can be brought promptly to the attention of the people who can and need to take advantage of them.

Two other current projects that are not particularly directed to local road development are in our view of much importance and I should like to mention them. The first should be, of course, of interest to city officials, for it relates to better use of existing streets.

Even with the completion of the Interstate System 80 per cent of the traffic then anticipated will be using other roads and streets. And with the rate of increase expected, the volume remaining on these other roads and streets will be greater than today's volume. In short, the Interstate program certainly will provide no more than enough additional capacity to take care of the increase, if that.

The project being carried out with the cooperation of the District of Columbia Department of Highways will determine how, by the application of all known techniques of traffic operation, legal restrictions, and minor design changes, a principal traffic artery can be upgraded to achieve the maximum traffic capacity. Unfortunately, few

arteries operate at near their potential, often because of lack of small amounts of money to make recognized operational improvements or because the possible improvements are not even recognized. We hope that we can demonstrate what can be done as encouragement to others to undertake similar studies. It is no longer a question, of whether we should have expressways or arterial streets. We need them both. One supplements, not supplants, the other.

The other project that we feel holds great potential is under way with Bureau support here at Purdue, under Professors Kossack and Quinn. This project recognizes the vehicle-road combination as a system, and hypothesizes that any improvement in the vehicle to make the ride better for cargo or passengers has a salutary effect also on the road, and vice versa. It may be that improvement in vehicle suspension would have a more beneficial effect on road performance than some degree of improvement in the road itself.

The work here at Purdue approaches the problem experimentally by vibrating a vehicle at various frequencies and amplitudes, and observing the effect on the various components of the vehicle and the interaction with the road as measured by the actual load imposed. The same problem is being studied at Cornell by a mathematical approach, the results of which would be verified by full scale tests, which is extremely complex. We have strong hopes that one or both approaches will yield basic information that may be directed toward extending the life of the road as well as increasing the comfort of the vehicle.

Research does not require long-haired specialists in the laboratory working with computers and other complex apparatus, although I should hasten to add that among those with whom I am acquainted here at Purdue, such hair as they have is cut pretty short. Research is not always big nor does it have to be broad in scope or expensive in operation to be research. It does require careful and competent people.

Research is carried out, whatever its scope, by carefully recording what happens, and then studying the record to learn what it means. The record does not always have to be studied with an electronic computer. A slide rule often will do. There are countless examples of research possibilities that go unnoticed, yet which in total could yield information of broad application and value.

For example, traffic engineers are constantly experimenting with new signs, changing their locations or messages, trying new ideas of channelization, and experimenting in many other phases of traffic

operation. It would be a simple matter to record the "before and after" conditions, and thereby to appraise the effect of the experiment in relation to the cost. Yet, how many do that? Or, having recorded the "before" with all good intentions, ever get around to observing the "after"?

The field of maintenance offers real opportunity for limited-scale practical research, which I described earlier as of the do-it-yourself variety. Seal coating is a common repetitive operation, usually following a routine and not always carefully controlled process. Yet, how many engineers make real effort to insure that they get the most for their money in these operations? Would a heavier application, for example, perhaps lengthen the time between repetitions more than enough to warrant the added initial expense? There are many variations of quantity and type of bitumen and aggregate that could be tried experimentally to insure the best job for the least money.

In nearly any day-by-day operation there is opportunity for improvement. Trying new ideas and carefully recording and interpreting their effect is research, just as much as a million-dollar project of traffic simulation. It differs only in scale. Anyone who can make a real improvement, documented by careful record, will never lack opportunity to describe his work in publication, to receive deserved recognition, and to have the satisfaction of aiding his fellow engineers as well.

Providing the highway that will be needed in the expanding economy of the nation's future is indeed a challenge—a challenge that will require our maximum of effort and the application of the best of our techniques. But in applying these techniques let us not forget that they are the product of yesterday's research and of the foresight of those who preceded us. And also let us not forget that we have a responsibility to leave to those who will follow in our footsteps, as they face the more complex problems that tomorrow will bring, a heritage of at least equal value. It is no small challenge.