FEATURE ARTICLES

Better Use of Engineering Manpower in Maintenance

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The post-war population increase, an explosive nationwide transportation problem and a very ambitious highway construction program undertaken by this country have created an entirely new concept of highway engineering.

The highway engineer is going through a major readjustment period. A need for thorough understanding of problems and the application of scientific principles are replacing rather relaxed "rule-of-thumb" engineering practices. One of the problems which is virtually unexplored, and which may be the deciding factor in the success or failure of this vast highway construction program, is that of maintenance of highways. This article presents the problem and a concept of research which departs from the formal concept of research in engineering.

The maintenance engineer is faced with problems which can only be studied during the everyday operations. A well organized study of these everyday operations can produce answers to many problems, resulting in the most efficient use of manpower and machinery in maintenance.

The working of the human mind is one of the most amazing processes. This magnificent computer, the human brain, can control its own functions at will. Upon observing a certain act, a human being may put his brain into action to deduce significant facts, whatever form they may take. This process is called scientific investigation, reasoning, conclusion, or sometimes, discovery. It is equally amazing when this same magnificent machine shuts off the input end of its operation from the processing or computing end, and idles for a precious period of time that could be used in formulating useful reasoning, conclusions and discoveries.

It is just as interesting, although discouraging, to watch an engineer—particularly one experienced in the field of highways—ride over a poorly maintained highway, notice all the unsafe conditions, and yet never use his thinking abilities to reason why deficiencies exist, why maintenance is poorly and unsuccessfully performed on such roads, and what would be the best way to remedy the pitfalls of an increasing engineering problem—the maintenance of roadways.

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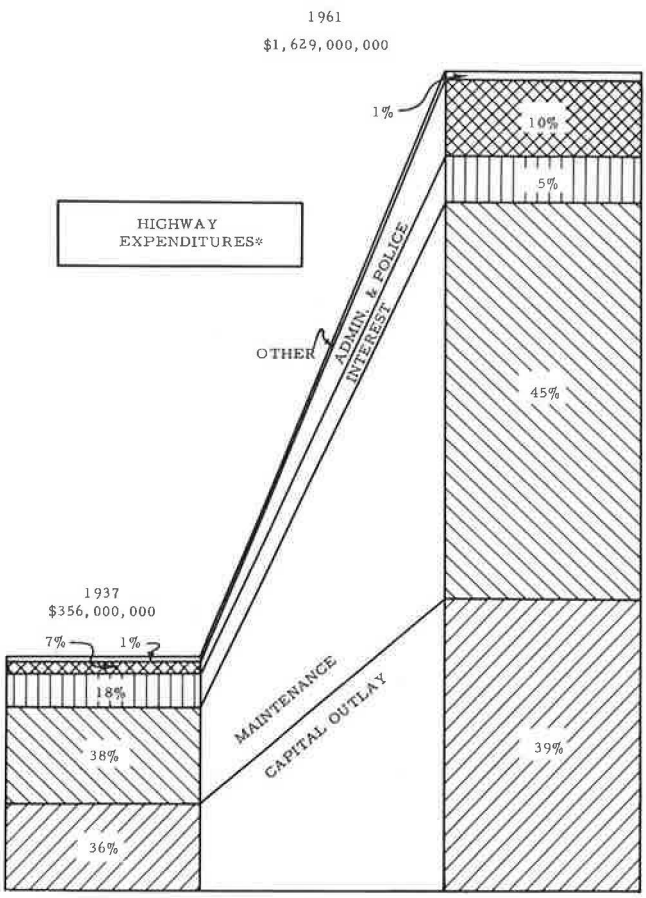
*Mr. Arman is a member of the Highway Research Board's Committee on Maintenance of Bituminous Pavements. The opinions and conclusions expressed or implied in this article are the author's and are not necessarily those of the Highway Research Board or the National Research Council.

Within the past decade new engineering fields have been created almost overnight. Some are very glamorous. Some, not so glamorous but just as important, are frequently more functional than the so-called glamorous fields.

With the advent of the Interstate program, a still unexplored and unsolved cluster of problems was created—specifically, how to properly and economically maintain these superhighways. The two innocently sounding adverbs "properly" and "economically" represent two highly complicated subdivisions of engineering. This nation is building a network of some of the finest highways ever constructed. These highways are truly engineering achievements; but, unless they are maintained, they may end up as ugly scars of soil, asphalt and concrete with no more function than the Great Wall of China.

As it is economically impossible to build highways which will not need maintenance, it is equally uneconomical to allow these highways to deteriorate for lack of proper maintenance engineering.

It is estimated that one-third of all highway funds are already being used for the maintenance of highways in the United States (Fig. 1). This percentage is



*For municipalities

From "Highway Statistics" U.S. Department of Commerce, Bureau of Public Roads

Figure 1.

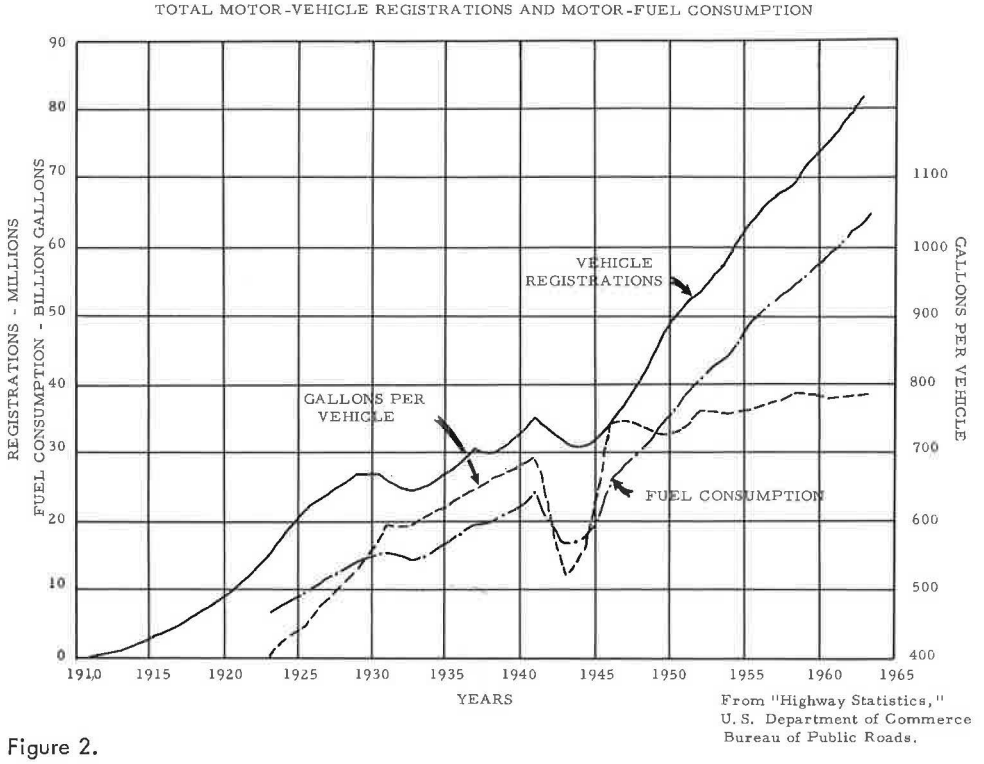


Figure 2.

expected to increase to one-half of the total funds when the majority of the Interstate System starts showing serious signs of distress within the next decade.

The highway engineering profession must face the facts that maintenance is another scientific phase of the engineering profession, that there is a lack of knowledge in the field of maintenance, and that the present hodge-podge must be corrected if the existence of the highways built today is desired for the future.

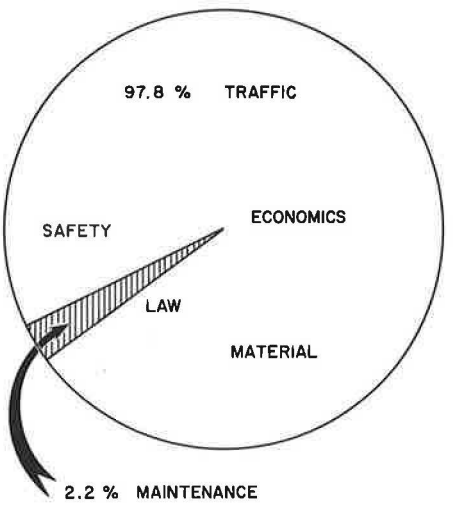


Figure 3. Distribution of highway research funds.

Motor vehicle registration has almost doubled since 1950 (Fig. 2)—so has the mileage of paved highways.

A considerable amount of research is being performed in traffic, safety, economics, law, and some materials fields. Highway Research In Progress, published by the Highway Research Information Service of the Highway Research Board, contains listings of approximately 3,500 research projects. Of these, only 78 are oriented toward maintenance, a mere 2.2 percent of the total (Fig. 3). Although 33.33 percent of the total highway effort is being spent on maintenance, only 2.2 percent of the research effort is being directed

toward this field—a grossly unbalanced situation. Three deductions could be made from the foregoing figures:

1. That the engineering profession is very well prepared to take care of maintenance problems, as availability of knowledge has reached its peak, making research unnecessary;
2. That the profession has a nonchalant attitude toward research and feels that the problem might go away if it is ignored; and
3. The most probable deduction, that the profession realizes the need, but not enough interest is being shown because of the lack of glamor in this type of research and a lack of desire on the part of some administrators to rock the boat.

Unfortunately, the highway engineer has not reached a peak in his knowledge. The problem will not go away if ignored, and the boat must be rocked! Furthermore, studies made in New Jersey, Virginia, Louisiana, and other states have proved that improvements are essential.

A systematic study of everyday operations and their results, combined with the outcome of well-planned research in that field, will produce invaluable results toward the betterment of maintenance operations from a material and/or operations standpoint.

The net meaning of all that has been said thus far can be summarized as follows: the maintenance engineer should assume an active role in research.

This is not to say that the maintenance engineer should devote all his time to research; however, in the operation of a maintenance section, research must be given the prime position. The maintenance engineer and his staff should take steps to assure that some of the research effort in the department is directed toward maintenance engineering and its problems.

Operational, personnel and material problems which arise daily should be evaluated, and those needing further study should be identified so as to be included in a research program. The study of everyday problems and their eventual solution through research should be made part of every overall maintenance program.

A qualified engineer should be assigned to direct special projects for the maintenance division. He could be an employee of the maintenance division or the research division of the department. Nevertheless, his job should be to initiate special studies in relation to day-to-day operation, to act as liaison between the department and researchers, and also, to up-date studies performed earlier. In maintenance, changing conditions should be taken into account any time the results of a past study are being used. This, in effect, will require that studies be up-dated periodically. The Louisiana Department of Highways' maintenance section follows this procedure by up-dating their "Formula for Allocation of Maintenance Funds" continuously, using data obtained in the field and fed into the computer (1).

Research directed toward solving a maintenance problem will make the job of the maintenance engineer easier, more pleasant, and highly economical. Research in maintenance may be directed in various directions. However, it should have a single aim—the delivery of an answer (or a useful product) to an existing or expected problem. This may involve a piece of simple hardware for grass cutting machines to cut hard-to-reach spots, an exotic chemical to aid in weed control, or perhaps a maintenance management study such as the one directed by the Ontario Department of Highways (2).

The collection of data for each of these subjects falls in a different category. Thus, one of the responsibilities of the special projects engineer would be to render a decision as to which is the best way to get a solution to a problem; that is, should it be done within the department or should it be sent out.

The Louisiana Department of Highways, for example, handles this decision through the research and development engineer with the guidance of a general maintenance research advisory committee. The North Carolina State Highway Commission's equipment department assigns the study of individual equipment problems to small working committees. Others assign this responsibility to the research engineer or the special projects engineer.

A careful study of daily maintenance operations will indicate that the engineer at present is handicapped because of the lack of a certain type of material to do a given type of work, or because of the lack of proper knowledge in some fields of maintenance management.

Generally speaking, maintenance of roads is being done in a haphazard way. How many times are maintenance crews sent to repair a roadway simply because the residents of that area have asked them to do so? How many resurfacing jobs have been performed on this basis, or on the basis of some similar arbitrary decision? Needless to say, this is far from being the proper engineering procedure.

Throwing a few shovels full of cold mix into a base failure on a heavily traveled road is wasteful, yet this is routine procedure for some maintenance units. The thought may appear that this is the only way maintenance can be performed, that is, that scientific methods cannot be applied to maintenance. Such thoughts probably occurred in the same minds when revolutionary engineering principles were to be applied to highway construction and design. Fortunately, these thoughts proved to be wrong then, and they should be proved wrong again.

If research is made a part of the maintenance program, and if the maintenance engineer does make provisions for developing a maintenance research staff, he will find that such a staff will provide him with answers to many questions. These may include such information as when to reseal roads, how to repair base failures properly, what type of paint is best suited for painting bridges in industrial sections, and what type of patching material will produce the strength and durability to withstand today's traffic loads, speeds, and repetition.

An excellent example of this is the maintenance management study of the City of Los Angeles. An a result of the management study conducted to optimize maintenance operations of the city "the quality of jobs and service to the public improved.... [C]ertain job classes received pay increases, no one lost his job as a result of improvements, and savings were accomplished through normal attrition and reassignment of excess personnel.... [T]he program has yielded net savings of three quarters of a million dollars each year" (3).

The maintenance engineer is in need of the answers to problems such as personnel training; management; deflection measurements; how to deice thousands of miles of elevated structures; what is the economical point of no return in maintenance; when should maintenance of a road be terminated; what is the proper time, material, and method of repairing concrete roadways; what are the proper materials to overlay highways; how does one tell the difference between a surface failure and a base failure so that the proper kind of maintenance can be performed; what is the best way to optimize all types of maintenance operations? These are but a few of the hundreds of unanswered questions which certainly can be solved through a proper research program. Solutions to most of these problems can be found most effectively by studying the everyday maintenance operations in a methodical way.

The Indiana State Highway Commission offers an excellent example of the latter type of research. Through studies of day-to-day operations and performance records, such as items of shoulder retreatments and guardrail painting, very valuable data are being collected which, in turn, are being put into use in everyday operations (4).

The Louisiana Department of Highways has issued forms for reporting grass-mowing operations (5). The data are applied to a mathematical model established to optimize this operation.

These examples indicate that a few of the highway departments around the nation have taken the initiative of studying some of the critical aspects of their operations. These studies are conducted in connection with day-to-day work. Most valuable information is being gathered by these agencies. The data gathered are being studied in an effort to "de-bug" their daily work. This work is being done, with the encouragement of the maintenance engineer, by assistants, by small working committees composed of maintenance and research department personnel, and by "special projects" engineers. Some agencies, after studying a problem, have turned it over to a research agency, such as a university or a consulting engineering firm, for its solution. In all cases, the maintenance engineer has established direct communication with the personnel via product evaluation reports, equipment catalogs, photographs, inspection programs, manuals and reports indicating the performance of different materials utilized in maintenance.

For example, the Texas Highway Department has issued a manual on Procedure for Interpreting General Deck Conditions (6), which provides guidance in the form of photographs showing bridge deck failures in supplying the proper data through the bridge deck survey forms.

The Louisiana Department of Highways has prepared a similar up-to-date manual including instructions for the preparation of daily gang reports. This manual includes instructions, examples and some "Do's" and "Don'ts" for the preparation of these reports (7).

This type of research which departs from the conventional approach has already produced successful results which are being used to prepare maintenance standards, policies and procedures.

The computerized library of the Highway Research Board Information Service and the Research Correlation Service of the Highway Research Board, and the Bureau of Public Roads, can provide guidance in setting up similar studies.

Also participation in departmental and Highway Research Board committees, attendance at technical society meetings, and discussions with engineers of other organizations in the same field will provide training for studies of this type.

Conclusion

The modern maintenance engineer has committed himself to the care of precision-built structures. The maintenance of these structures requires as much precision and as much engineering as did their construction and design.

The challenge facing the maintenance engineer is that of achieving at least as much engineering perfection in his everyday work as the materials, traffic and other design and construction oriented fields are trying to achieve.

Modern technology bears witness to the fact that achievements such as this can be obtained only through research. As for the research engineer, the time has long past when he could lie under a tree and wait for an apple to drop on his head so that he could discover the law of gravity.

The research engineer's curious mind has to explore his field of interest to find problem areas in order to look for a solution. The solution should be provided quickly and completely, rather than leisurely and partially. Quite often, the researchers fail to find new fields to study. This results in the study of a subject already saturated with research.

Here is a new science to be developed, and this is the time to do it. Otherwise, in the very near future, maintenance engineering will be set back by its

meager knowledge of modern methods and materials to a point which may result in the collapse of the entire maintenance system.

Funds for the development of research should be made available—even if this means no maintenance for a few miles of road which is hardly necessary in most cases—since funds have been provided for highway research by the Federal Highway Act of 1962 (Public Law 87-866). If this is not done today, there will soon be 3,700,000 miles (existing road mileage 3,644,099 miles according to the Bureau of Public Roads, Highway Statistics, 1964) of roadways, including 41,000 miles ($47 billion worth) of Interstate highways, that will have to remain without proper maintenance.

Monies invested in good research will pay dividends far surpassing the original investment and will continue to produce dividends in the form of sound engineering and economical work, the net results being safe and aesthetically acceptable roads produced and maintained by the better use of man-power and machinery. In addition, it should be kept in mind that an ambitious engineer tends to look for challenges in his field. When they are found, they provoke his curiosity, they make his job more attractive, and thus make him dedicated to his job.

A look at the past performance of maintenance operations will show many cases in which the field of maintenance has not offered such a challenge to engineers and researchers.

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