RECENT DEVELOPMENTS IN MAINTENANCE CONCEPTS

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Introduction

The importance of proper maintenance of highways is one of the first concerns we hear about upon entering into highway engineering as a profession. The value of good shoulder and ditch drainage, the proper sealing of cracks and joints in pavements, the troublesome problems of local settlement in embankments, and the frustrating, costly correction of landslides receive very early attention in our education processes.

Along with maintenance, we are usually taught about "traffic operation" problems. Frequently, these operations are also termed "maintenance." I happen to prefer to class maintenance as those activities which either rehabilitate, repair, or protect the life of the physical part of our equipment, pavement or structures. Operations, then, would consist of the requirements to keep traffic flowing efficiently and safely. For the purpose of this discussion, I will be using the terms under these definitions, but will be using the term 'maintenance' to cover the work force, whenever the specific activities are not of the primary consideration.

Curiously, even though maintenance receives early emphases, the major impact for most of us is with respect to design considerations for minimizing maintenance. Periodically we have agreed that maintenance should receive more attention; have the highest caliber engineering, is the key to a successful department, etc.

Perhaps the most significant development in the maintenance picture is that more and more departments are doing something besides talking. The soul-searching study in Iowa was one of the early efforts in this regard. Several States are initiating research and development projects using their 1½-percent funds. Two States have had major training programs directed to the maintenance question.

Why such activity? Perhaps it is because the maintaining of traffic at an efficient level has been finally recognized as our real reason for being in business. Perhaps it is because the toll roads, expressways, and the Interstate Highway System are bringing in a much higher quality of service as a routine matter. Perhaps it is because the financing of maintenance is becoming a major source of concern.

Regardless of the season, it is a fact that the Interstate System poses several new challenges to the highway engineer in the maintenance field. For one, it is estimated that the completed system in 1972 will be carrying 20 percent of all highway traffic. The high rates of speed will require that the pavement surfaces and the directional paint, signs and lighting be maintained at a high level in order to minimize the number and severity of accidents. It is further estimated that the quantitative data makes the preparation of a plan most difficult and leads to in-system in 1956.

The growing concern about maintenance, along with my natural interest in R&D, leads me to concentrate in this discussion upon the R&D developments in the
maintenance field. This emphasis will deal with the increased concern as to the management problem and with a few of the studies relating to actual maintenance and operation activities.

The Management Problem

Those who have studied the maintenance problem in recent years are emphasizing the major role of the management problem. In fact, the importance of this phase goes back many years, but the improvements which could be produced by improving equipment and materials have received most of the attention.

The basic elements of construction or maintenance are the three M’s: manpower, machines, and materials. Infrequently mentioned—and of real significance to the management question—is the interaction or interrelation between the three M’s.

It is essential to combine the ingredients of labor, equipment, and materials in the most economical and efficient manner. In the management field, efficient management depends increasingly upon application of scientific techniques so as to accomplish the objective of lowest maintenance costs.

Because highway maintenance is greatly characterized by high labor costs, time is one of the most important elements in successful management. It requires a plan of action but facts are needed to develop a reliable plan. The absence of quantitative data makes the preparation of a plan most difficult and leads to inefficient operations.

The following are some possible areas of research or experimentation which are needed in order to provide sound plans.

1. How many hours should a maintenance man be permitted to work during a snow storm? For example, should it be 12, 16, 20, 36, or some other number? This number is critical. Even in military operations, a practice of extended hours under fire is watched closely. The problem is further compounded by differences in human capabilities. A given number of continuous hours of duty followed by a minimum period of rest is no doubt most efficient—but how many hours of work per hours of rest will produce the most efficient operation?

2. How many men can a foreman supervise? Is it 8, 10, 15, 20, or some other number? Perhaps the answer is, “it depends.” If so, upon what? How is the work load divided between supervisors and between the men themselves? Is it on the basis of quantity of work or is it on an empirical basis such as—mile of road—so many square miles of territory?

3. What are the qualifications for a good foreman? Do we really know what it is that makes a good maintenance foreman, and then how many kinds of work can he be responsible for? Is it 5 or 50 or maybe 100?

4. What is the optimum size of the labor crew for a given job? Is there confusion as to the objective? Generally one can see inconsistency and confusion growing out of desire to get the job done in a hurry and to get the job done for the least cost. Occasionally one suspects too much attention is given to the problem of getting the job done in a hurry when, in reality, the situation calls for the most economical solution. Or does one assume that the most economical is the most rapid?

5. Do foremen or other responsible supervisors actually plan or assist their subordinates in planning the work? If they do have a plan, is it developed five minutes before the work starts or is it actually thought out and scheduled several days in advance?

6. Is there really a plan for snow and ice control or is it the practice to just throw everything into the battle? Take the problem of head light positioning on a snow plow. This one factor is important in keeping plows on the road during a storm period. If the operator cannot see, he cannot plow effectively. And, how about the eyesight of the driver operating the plow? His night vision?

It is now possible to plan for snow and ice control work in somewhat the same manner as a bridge is designed to accommodate runoff. Meteorologists tell
us that current weather records can be analyzed to produce probability charts for snow fall, thus opening up potential new avenues for planning the snow and ice control operation.

7. When does the drop off of the shoulder become hazardous to the safety of motor vehicles? Is there a maintenance policy which says that shoulders should be worked when this drop off exceeds, for example, 3 inches or maybe it should be 4 inches?

8. What is the best way to make a bituminous patch? Surely there must be a best way, but what is it? So it varies with conditions? What conditions and to what extent? This is the kind of question that is answered one million times each year. A saving of only a few minutes for each patch could mean a lot.

A brief study of the eight preceding items will indicate the interrelationships between the three M's. Most all of the questions will need to be qualified and related to specific characteristics of the manpower, the machine, and the materials.

For those who have not read Special Report 65 of the Highway Research Board, I would strongly recommend it to you. This report of the studies of the Iowa State highway maintenance problems was the result of a project sponsored by the Iowa State Highway Commission and the U.S. Bureau of Public Roads. The following quotation from that report will serve to conclude this part of the discussion of the maintenance management problem:

“The research data clearly show the complexity and far-reaching extent of highway maintenance. It is evident that maintenance operations of a highway department must be treated as a unity, and that an effective program requires that directives, procedures, and decisions be viewed not as isolated actions but as elements to be fitted into their proper places in the total program.

“In this respect, the whole maintenance operation may be likened to the characteristics of an inflated balloon. Applying pressure against one spot at a time makes a visible indentation. The consequence, however, of this indentation is to produce distortions elsewhere that are almost imperceptible. Thus, the visible gain at the point of pressure may be offset by failure to control the interlocking and dependent relationships elsewhere. Only a grasp which encompasses all aspects of maintenance operations simultaneously can effectively control the whole and hence the cost and quality.”

In other words, even though research is needed in many areas, there is still the problem of putting the pieces together in a manner which achieves greatest overall economy.

New Techniques and Procedures

There are many innovations taking place, and many being studied. Time for only a few of these is possible in this discussion. Certainly the maintenance of highway structures is a critical item.

The presence of a major highway structure in each mile of the Interstate System means increased maintenance efforts in this area. Structural steel and steel bridge rails must be painted at 5- to 6-year intervals under most conditions of exposure. In the snow belt, perhaps the most critical bridge maintenance problem is the deterioration of portland cement concrete in the deck and curbs from de-icing chemicals and other causes.

While the use of entrained air seems to improve the resistance of concrete to the effects of chloride salts, there is always the question of how much air is

retained at the deck surface after the vibrating, tamping and finishing of the concrete is completed. This is one research area which has been given a high priority.

Some $400,000 has been allocated in the National Cooperative Highway Research Program to seek immediate solutions to some of the related problems. Contacts for research in eight critical problem areas are to be let shortly with reports due within the next two years. We are all hopeful that these studies will develop ways and means of reducing bridge maintenance effort.

With rights-of-way of 300-foot width and wider and interchanges spaced at average intervals of about four miles, the scope of roadside maintenance will depend to a large extent on the type of cover provided for in construction. If the entire right-of-way is turf and maintained like a golf course fairway, mowing costs will be substantial. Some areas such as medians, the outer shoulders, and the inslope and outslope of longitudinal ditches must be maintained with low vegetation for sight distance purposes. Maintenance effort on the remaining portion of the right-of-way, however, can be minimized by keeping this area in its natural cover of trees, shrubs, and grasses which often offer a more pleasing appearance than a fine-graded slope. Care must also be used in the placement of plantings in cleared areas so as not to interfere with the efficient use of mowing equipment. The degree of side slope also has an influence on the effective use of mechanical mowers. In general, side slopes steeper than 2½:1 are difficult to mow with machines especially from the standpoint of operator safety.

Even if only 100 feet of right-of-way is retained in turf on Interstate highways, it will involve about 12 acres per mile of mowing to perform. Studies show that it costs from $6.00 to $10.00 per acre for each mowing. It can be seen that four mowings during the growing season would cost from $300 to $500 per mile for an average width of 100 feet of roadsides. New equipment and techniques, including the use of three-section rotary mowers, are making it possible to cut a swath 15 feet wide in medians and on other roadside areas with gentle slopes.

The use of herbicides for sterilizing the soil around guardrail and sign posts helps to reduce mowing effort in these areas where otherwise machine output would be substantially reduced.

One of the newest innovations in mowing equipment is a remote control rotary mower which was developed by the South Carolina State Highway Department. The unit is mounted on a low chassis equipped with dual wheels. It is powered by electricity from a truck-mounted generator which operates on the shoulder. A 200-foot multi-conductor cable fed from a 12-foot boom provides power and enables the unit to be steered and maneuvered from the operator's quarters on the truck bed.

Seventeen States have undertaken roadside maintenance cost studies under the 1½-percent Federal-aid program. Most of these are 3- to 5-year studies, and several are nearing the completion of their second year. As part of the new National Federal-Aid Highway Research and Development Program, these studies will be interrelated and findings passed along under an over-all analysis.

As in the case of physical maintenance, uniformity of Interstate highway operation is highly essential. One of the first Interstate Highway operational standards adopted was a Manual for Signing and Pavement Marking of the National System of Interstate and Defense Highways. This manual was originally published by AASHO in 1958 and revised in 1961.

These standards have been approved by the Bureau of Public Roads. Those responsible for maintenance of the Interstate System must be aware that the signs, markings, and delineators used whenever renewal or replacement is needed must be of approved design and color.

The advent of large informational and direction signs, including increased use of overhead installations has intensified sign maintenance efforts on Interstate highways. While most major signs have not been through a full cycle of maintenance, which includes replacement, several problem areas are apparent at this time. In some cases, it has been necessary to replace letters because of vandalism or other
causes. Cleaning and other maintenance to overhead signs are particularly difficult problems. A recent survey shows that most States which have had experience with overhead sign maintenance close the traffic lane under the sign when cleaning liquids are used. Extensive traffic control measures must be taken even to the extent of using State police. To reduce interference and hazard to traffic, catwalks and handrails on the overhead structure frequently are provided. In other instances, sign maintenance men do their work from baskets or platforms mounted on a hydraulic operated crane.

In 37 of the 50 States, snow and ice control will require considerable operational effort. Users of the Interstate network will expect to travel with safety in all kinds of weather on an around-the-clock basis. Snowplowing and sanding operations must be organized with this objective in view.

Current median designs generally permit the windrowing of snow from the inside lane to this area. Snow on the remainder of the traveled way and outside shoulder is generally removed by one-way plows operating in echelon so as to remove the snow in one pass.

One of the new displacement type plows which is facilitating snow removal on Interstate highways is a special double-edged reversible model sometimes called a "roll-over" plow. It is power operated by a hydraulic system which enables the operator to change from a right- to left-hand plow from controls in the truck cab.

Several new rotary plow models have also been developed for the deep snow zone so that the snow can be cast a considerable distance from the roadway. An hourly handling capacity of 2,000 tons of snow is claimed for one of the new models.

Although geometric standards provide for flat horizontal curves and streamlined cut and fill slopes, sizable quantities of guardrail are still required at interchange ramps and at other critical locations. In urban areas, limitation on rights-of-way width may require a median barrier. It will not be uncommon to have a foot of guardrail for every foot of Interstate highway in some areas. Studies are being made to develop warrants for the use of guardrail so that greater uniformity of application can be achieved on a nationwide basis.

Deep beam guardrail with paint coatings has been used on many of the earlier Interstate projects. Experience shows that annual maintenance costs of about $0.05 per linear foot prevail where repainting is done at 3-year intervals. Galvanized steel beam rail is being used in larger quantities on Interstate construction in an effort to reduce repainting costs. Other permanent type guardrail coating systems are being field tested for durability and visibility characteristics.

Truck-mounted guardrail cleaning equipment for beam type rails has also been developed in an effort to reduce the frequency of repainting. Where snow drifting is a problem, cable-type guardrail is often used to reduce maintenance.

A number of new innovations have already been tried in operating the Interstate System and many other technological advancements show considerable promise for improving safety and service to the traveling public. One of the latest of these is an emergency radio communication system to aid disabled motorists. Units are installed along the highway at frequent intervals. When a motorist needs help, he goes to the nearest unit and presses a button. This sends a coded signal to a traffic control center so that help can be dispatched immediately. A unique feature of these units is that the batteries which power them are recharged by the sun.

Closed circuit television is being used for surveillance of traffic operations on urban sections for determining the positioning of vehicles in the traffic lane, for the immediate discovery of disabled vehicles, and many other purposes. Multimessage warning signs which can be energized by radio or other remote control methods are being used to indicate the type of driving hazard which is to be expected ahead and to post safe driving speeds for such conditions. Ice sensing equipment for bridge decks which automatically energize distant and close-up warning signs are being used on an experimental basis.
Concluding Remarks

The increased interest in maintenance problems is undoubtedly associated with the cost of protecting our investment and with the requirements of providing services to the users. Estimates of these costs amount to $2,000 per mile for Interstate Highway facilities and similar routes. In snow belt, this figure has amounted to $4,000 per mile.

While these figures sound high, when one considers the essential nature of the highway transportation system to our present national economy, there appears to be little choice. Furthermore, the user, who is paying for these services, continues to ask for good signing, ice-free roads, and aesthetic-pleasing facilities.

In order to provide clearer insight into the nature of maintenance and operation costs, I would strongly urge the separation and clear identification of how much we are spending to protect our investment as opposed to those being expended to keep traffic moving efficiently. The need to protect our investment is obvious, and it also provides a basis for better structural and durability design. The need to provide services is more a function of what the user wants and is willing to pay for. Thus, the basis and decision as to financing can be more readily achieved.

Your Conference Program Committee is to be congratulated for including this one-day program emphasis on the maintenance picture. I hope that the program will serve to stimulate the studies which are needed, and that new insight, imagination, and attention will be directed to the organizational and physical requirements of highway maintenance and operations.