Use of Pavement Evaluation Techniques in Maintenance Management by the New York State Thruway Authority

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The engineering report of the resurfacing program is presented to the Thruway's top management with the chief engineer available to expand on the content in areas where questions arise. Top management sets policy by indicating acceptance of the report and its conclusions. The chief engineer and the superintendent of maintenance in conjunction with the finance officer, can now use the pavement evaluation report as a management tool. In our case, a long-term reserve fund has been established with money from operating revenues set aside in an orderly schedule to be available according to requirements of the pavement rehabilitation schedule. On an annual basis, the long-range requirements are used as a framework on which to hang our annual budget requirements.

In its fourteen-year life the Thruway has had two complete evaluation studies. The first one covered the period from 1962 to 1975 and the second one enlarged the period from 1966 to 1982 with the experience in the first four years being used to refine earlier projections. In at least one instance the pavement rehabilitation financing schedule was used in a statement to prospective bond holders.

IMPLEMENTATION OF PROGRAM SCHEDULES

The projections covering long-range maintenance are updated annually by running a roughometer survey over the entire Thruway system. In addition to any wide variation shown on the roughometer graph from year to year, a judgmental evaluation is provided. The service life curves are adjusted if necessary by the following factors:

1. Yearly traffic volumes which are automatically tabulated from toll records.
2. Comparison of the roughometer surveys.
3. Establishment of new PSI values on new overlays.
4. Occasionally new crack and patch surveys are conducted in local areas.

The superintendent of maintenance, a local division engineer and two men from the chief engineer's office make an annual visual inspection each summer to confirm the exact location of major rehabilitation work for the following year. Since this work falls into the categories of resurfacing, installation of additional drainage, and added improvements for safety, most of these projects are handled by contracting firms rather than our existing maintenance organization.

After the inspection and approval of work for contract, Thruway office engineers prepare contract documents during the winter and early spring. These contracts are generally available for bidding in April which gives us the advantage of starting pavement work prior to the busy season. It also generally results in low bid prices because contractor obligations have not yet been made on summer construction work. The contracts are written with definite traffic sequential considerations. It is necessary to allow traffic to pass through the construction area due to the nature of this limited-access highway.

Thruway management of the highway rehabilitation contracts is divided as follows—our Department of Traffic and Services sets overall policy on traffic control; the contract preparation, bidding and inspection is the responsibility of the Bureau of Construction and Design, and the Bureau of Thruway Maintenance provides all designated traffic control devices but is not directly involved in the reconstruction project.

Coordination between the Bureau of Thruway Maintenance and the Bureau of Construction and Design is assigned to the assistant chief engineer.

GENERAL OBSERVATIONS

Why should Thruway experiences be of general interest?

1. Because the entire 559 miles of the Thruway was built in its entirety in a relatively short period of time in the early fifties. The Interstate System in other states has very similar characteristics except that it is 10 to 12 years younger.
2. Normal state budget appropriations dictate a year-to-year program for repair and maintenance of highways which hinders long-range plans. While an annual hand-to-mouth existence must be used on the overall state highway network, some long-range provisions should be made to insure the future value of the Interstate System.
3. Some provision for a 10- to 20-year master plan of Interstate highway maintenance should be developed so that money for major rehabilitation is spread over a number of years even though a considerable mileage will grow old at one time.

On the Thruway, operating funds for normal pavement maintenance are provided on a calendar year basis. By the nature of normal maintenance, there is fluctuation in the amount of money provided annually but a reserve fund for pavement rehabilitation tends to equalize the year-to-year demands.

The pavement evaluation reports and subsequent long-range policy which is established tends to stabilize the pavement maintenance program. Quite often we are able to avoid the waste of maintenance effort which commonly occurs when maintenance programs are strung together on a year-to-year basis. For instance, we avoid such things as putting down a shoulder surface treatment one year and tearing up the shoulder the following year to install underdrains. By noting the progressing signs of age, we are able to predict more closely the need for maintenance repairs and can alter the timetable to our economic advantage. A side effect of having formal professional pavement evaluation reports is that our top management is made aware of specific trends in year-to-year costs. This effect is similar to the in-door out-door thermometer function in that we are able to anticipate and adjust to new conditions without as wide a fluctuation. This is particularly important when you are geared to an income budget where revenues must be in harmony with operating expenses.

continuous observation and detailed study. The advantage of work sampling is that the taking of a few random observations can be done economically, usually as a collateral duty of supervision, while other detailed methods of appraisal are more expensive and may require the full-time services of groups of specialists.

The exact degree of reliability required of any study is dependent upon the end use to which the study will be put.

An essential condition of work sampling is that observations be taken at random. Randomness in the statistical sampling sense means the condition that any given instant of time has an equal likelihood of selection as the time for observation as any other instant, that there is no apparent order to the times of observation, and thus, that one time of observation is independent of all other times of observation. Finally, the entire period of time over which samples are taken must be subject to selection as the random times of observation are drawn. If these conditions are met and enough observations are taken, inferences of known reliability may be made through work sampling. There are several straightforward tests by which the randomness of times of observation may be verified or tested. If careful attention is paid to these tests, the accuracy and reliability of work sampling studies can be developed to within any practical limit. By "practical" is meant the answer, dollarwise, to the question: "How much certainty of results is desired for the expense involved?"

STANDARDS

The logical step after work measurement is the creation of maintenance standards. Many states, for example, Minnesota, Virginia and Louisiana, are engaged in extensive standardization programs. It can readily be seen that maintenance cannot be adequately scheduled unless management has some idea of how long it should take to do a job. Conversely, the time taken to do a job cannot be ascertained unless the job is standardized, that is, unless the job is done in the same manner each time it is performed. The method study and motion technology aspects of industrial engineering help the engineer to design a method which requires the least effort. Once this method has been performed then the time taken to do the job can be ascertained and this used by the maintenance planner in his scheduling work. Additionally, this information can be used to ascertain the long-range manning requirements for any highway maintenance effort.

A modern aspect of the method analysis procedure lies in the area of value engineering. This is but a new name for an old idea. Value engineering identifies a specific system of decision-making which is aimed at the creation of a product or service with the highest possible value to the user at the least possible cost. Instead of looking at the cost production problem from the narrow view point of "how can we produce this service most economically?", a more comprehensive concept is taken by questioning "how can we produce the function that is required for the least total cost?" This is the philosophy underlying the value engineering approach. This approach has already effected the development of the new production and maintenance systems, and it will exert an even greater influence on methods and machines as it permeates the engineering maintenance and manufacturing field more widely. In highway maintenance work, an example of value engineering might be the consideration of the total grass cutting problem, not just how to cut grass better with mowers. The entire system from beginning to end would be formalized, that is written down, and consideration would be given not only to mowers but also to chemical treatment, elimination of grass and replacement with aggregates and any other ideas which in total would minimize the cost of roadside maintenance.

PERSONNEL RELATIONS

Necessary to any industrial engineering curriculum is one or more courses having to do with industrial and personnel relations. Typical of the topics covered in such courses are union and management collective bargaining, recruitment and selection, employee appraisal, promotion, transfer, lay-off and demotion, training, supervision, effective use of meetings, communication, discipline, wage and salary administration, and wage incentive programs. The applications of these topics to maintenance management is so clear that specific examples to the highway maintenance field are not required.

MAINTENANCE CONTROL

In preparing a student for the industrial engineering field, a course in production control is usually included in the curriculum. Some universities, particularly Louisiana State University, are lending greater emphasis to maintenance control than production control merely because most of their students go into work in a chemical or chemical-processing plant where maintenance control is a large factor. Nevertheless, the technology underlying the production and/or maintenance control field is common. The emphasis is on the word "control," whether it be maintenance or production.

Traditionally, these control procedures have included: (a) forecasting, (b) planning, (c) scheduling, and (d) follow-up. To these four traditional areas have been added network analysis known as critical paths scheduling and PERT. In addition, the use of the computer in performing these jobs is now emphasized with all the attendant problems.

The forecasting aspect of control encompasses the ascertaining of what resources will be needed by the maintenance supervisor for some foreseeable future. The resources, of course, are men, material and machines. The planning aspect is the methodology of how the resources will be put to best use. The scheduling function is the determination of when the resources will be used and the follow-up aspect is the feedback mechanism by which the maintenance manager ascertains how well the plan is keeping up to the schedule. The PERT and critical path analysis techniques are used to determine the longest job or endeavor in the maintenance system and the shifting of idle resources to this longest path function so as to cut down on the total time and cost required for the function.

ENGINEERING ECONOMY

Engineering economy differs from classical economy in that the engineer learns about the value of money rather than price theory. Most engineers do not receive the financial motive emphasis in their undergraduate curriculum. This concept permeates the entire industrial engineering curriculum in that the student is constantly made aware of the fact that the engineer is a person who can do with one dollar what any other damn fool can do with five dollars. The newer concepts of engineering, and this is particularly emphasized in industrial engineering, include the idea that a product or system should not merely just work but it should be the most economical method of doing the particular effort. A logical question at this point might be: How do you teach students to be economy minded? In industrial engineering this is done by subjecting the student to a course in engineering economy early in his career and making frequent use of engineering economy principles in other courses.

This typical engineering economy course might include the following topics:

1. Interest, equivalence, and depreciation
   a. Interest and interest formulas
   b. Calculations of equivalence involving interest
   c. Depreciation and depreciation calculations
2. Planning engineering economy analysis
   a. Classifications of cost for economy analysis
   b. A pattern of engineering economy analysis
   c. Treatment of estimates in engineering analysis
3. Engineering economy analysis and evaluation of alternatives
   a. Basis for comparison of alternatives
   b. Break-even and minimum cost analysis
   c. Evaluations of replacements
   d. Economy in the utilization of personnel
   e. Evaluation of public activities
4. Accounting, cost accounting, and income taxes
   a. Accounting, cost accounting and economy analysis
   b. Income taxes in economy analysis
   c. Evaluation of existing operations
   d. Evaluation of proposed operations

down to an average length of 28 men and an average waiting time of 58 minutes. In each hour, then there would be 28 man-hours lost in waiting. Further calculations show that one extra store man will reduce the average to 0.28 man, releasing 27.3 men for productive work. Addition of a third man, however, will only cut the average to 0.04 and might not be justified when weighing the third man's salary against the production time gained.

There are other techniques in operations research such as game theory, dynamic programming, and simulation techniques, but these techniques are so theoretical that there are not many examples in highway maintenance work. This does not mean that the techniques are useless. It merely means that our state of knowledge has not reached the point where we can apply these techniques to the specific problem that we have in highway maintenance.

In summary, I have attempted to give an idea of how some industrial engineering techniques can be useful in highway maintenance operations. The list of applications is a long one, and only a few of the techniques which could be useful in this type of work have been covered.

There is much need for industrial engineers in state highway departments in general, and in maintenance operations in particular. Tradition dictates that state highway departments hire mainly the civil engineer. It is difficult to understand why this practice persists, when, in a number of positions, the job demands knowledge in the scheduling, planning, and budgetary fields much more than a knowledge of concrete and reinforcing rods.