Time-Saving Ideas in Highway Engineering

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It became apparent in 1954 that a likely expansion in the nation-wide highway improvement program would require utilization of every adaptable time-saving technique in order to extend to its optimum the specialized production of the highway engineers. In view of this emerging need the Highway Research Board's Committee on Highway Organization and Administration conducted a canvass of the highway departments of the 48 states, the District of Columbia, Hawaii, and Puerto Rico to learn what time- and labor-saving methods, procedures, and devices they had developed or adapted to use. Nearly 300 highway engineers responded, contributing over 1,500 statements on the subject.

The contributions are now being summarized for publication. Every area of possibility seemingly has been discussed in the responses. It is clearly evident that no single course of action will afford a solution to the complex set of problems in highway engineering manpower, and the memoranda submitted show that the several highway departments are seriously engaged in resolving the problems through combined advance on all fronts.

● WHEN President Eisenhower in July 1954 challenged the governors to evolve "a grand plan for an articulated highway system," he threw out a challenge not only to those who must find a way to finance the improvements but also to every agency and to every individual who must find ways to administer and execute that grand plan. The boldness of that plan and the daring required to initiate it and execute it fascinates and fires the imagination of the least poetic — the potential of that plan for the common good inspires the most prosaic to exclaim: "I want to have a part in that!"

Quick to recognize that the execution of the plan would demand additional professional highway engineers and also require the best use of available talent, the Highway Research Board's Committee on Highway Organization and Administration accepted the unmistakable challenge and began its attack on the manpower problem.

The committee found, first, that the proposed program would require at least 11,000 more highway engineers, possible 25,000 if present engineering productivity is not greatly increased (1). The next move was directed toward finding ways to obtain the most favorable utilization of available talent or, more specifically, toward finding ways to husband the time and energy of the highway engineer.

The committee recognized that no single course of action would solve the total manpower problem of the highway departments. Laws, policies, management, housing, and equipment would affect the problem. The rate of development of additional highway engineers through education and training would also have its effect. Notwithstanding, the committee was confident that, if time-saving methods were fully exploited, much would be done towards reducing the requirements for professional engineers from a maximum of 25,000 to a minimum of 11,000. The 11,000, plus replacements, must be trained and recruited.

On this premise the committee said: "Let's ask the highway engineers to pool their experiences in time-saving methods." This was done by a canvass made in April 1955. The canvass extended to highway departments of the 48 states, the District of Columbia, Hawaii, and Puerto Rico. Each of these highway departments made a contribution. Without doubt the challenge of the grand plan had captured men's minds, for more than 300 highway administrators, professional highway engineers, and supporting technologists contributed to the pool of 1,500 ideas in one of the finest of cooperative efforts.

This report will not attempt to recapitulate the ideas acquired in that vast pool, for they are being summarized and published by functional category (2). Rather, this report will attempt to interpret and to sketch in broad strokes the motif and meaning of these 1,500 ideas.

First of all, one is greatly impressed with the extent of interest manifested in the problem of best utilization of highway engineering talents, and by the great range in

methods of attacking the problem. It is evident from the suggestions received that there is a great variety of problems to be solved in the matter of saving time. It is also evident that the highway departments are alerted and are at work developing and adapting experiential methods. The response showed quite clearly that a good beginning has been made (3).

Second, the content of the ideas points out decisively the complementary character of administrative processes and special time-saving techniques. Administration deals with policy making, planning, and management, and as such vitally affects the potential of engineering production. The execution of the improvement program is essentially an engineering function, and technological advances can be effective in increasing production.

With this observation, the content of these 1,500 ideas can be examined to see where present administrative and technological developments are leading.

ADMINISTRATIVE RESEARCH

An idea must be put to work if it is to be effective. It is not self-executing or efficacious of itself: 1,500 dormant ideas are as useless as one. Without administrative guidance, invaluable ideas, born within the department or available from other agencies, may lie dormant while prodigal use of engineering talent continues unabated. Perception of this truth has led to salutary administrative action in several highway departments and bureaus.

Illustrative of this action was the creation of a unit of administrative research in the Minnesota State Highway Department, denoted as a "Section on Organization and Methods." (Activities of this section have been reported elsewhere in this symposium.) The purpose of the section is to make a continuing study of the department's organizational structure, functions, staffing, management, and housekeeping procedures, so that functions can be suitably related structurally and fitted to objectives, and so that business procedures can be kept simple and integrated to the whole system and adapted to machines where practical.

With similar objectives, the Wisconsin Highway Department began a reorganization of its structure about two years ago. A Division of Administration inaugurated at that time, working with the commissioners, has effected a complete reorganization of the structural, functional, and managerial aspects of the department, a reorganization and renewal that has permitted the accomplishment of twice as much highway construction without appreciable increase in the number of professional engineers. A monograph (4) of the Wisconsin experience recites a host of particulars, including greater delegation of responsibility and increased emoluments, better housing and equipment, instigation of training programs for engineers and technicians, better coordination of work flow, and use of special time-saving techniques.

The New Jersey State Highway Department also has included an office for research into administrative procedures. And the Civil Service Commission of New Jersey has given many substantial cash awards for practicable ideas.

Another example worthy of mention is the unit in the Highway Department of the District of Columbia that has been doing administrative research and has been helpful in the reorganization of the District Highway Department.

These illustrative examples, plus many others received, suggest the complementing value of administration, and the value of operations research to efficiency and economy in administration and engineering (5). Apart from the suggestions received during the canvass, interest in the potentials of better organization and administration is evidenced in the many requests for the Committee on Highway Organization and Administration to prepare a guide on the subject.

TRAINING AND RESEARCH

Some of the most rewarding efforts have been made in the training and research programs. Cooperative education is now conducted in 16 states and in-service training programs are being conducted in 12 state highway departments. Eight states have programs designed to prepare the high school graduate as a supporting technician (6).

It has been noted that at least 11,000 additional engineers must be trained and recruited to execute the contemplated program. When it is discovered that replacements of losses amount to more than 400 engineers per year, and then it is found that but 1,000 graduate civil engineers can be obtained annually, one comes to the inescapable conclusion that all of the engineers required cannot be obtained in the desired time period from engineering colleges (7). Upgrading of sub-professional personnel through in-service training should prove a fruitful source of supply of engineering and supporting disciplines.

Continuing inquiries and suggestions relating to form of research organization and scope of program give promise that research will become an important factor in an expanded highway improvement program. Socio-economic problems related to transportation, including system size, tax equity, traffic safety, highway law and administration, transportation economics, and economy of pavement structure, are just a few of the vital areas of research. Answers to these questions would affect the manner of improvement and provide a sound basis for taxing and apportioning funds. Research costs money, but the highway program costs more without it. Training and research will secure enormous savings in the expenditure of the $100,000,000,000 involved in the contemplated program.

LIAISON AND COMMUNICATION

Next is another aspect of administration, that of providing proper mechanism for coordination of operations. A great many ideas have evolved and have been put to practical use to provide linkage of the extensive and decentralized offices of the highway department. In order to expedite work orders, work flow, and to speed the exchange of information and ideas, new channels of communication and new formats are evolving for their transmission. To contain the transmitted information itself, new devices for recording, transcribing, reproducing, and storing have been developed.

To illustrate: 35 states are using two-way radios in the management function to save time of department personnel and the travelling public, and to save equipment mileage. Quite often linkage is provided with other governmental agencies, such as the Weather Bureau and Office of Civil Defense.

Other types of communication include teletype, television, direct telephone lines, aeroplane, inter-office communication systems, and loud-speakers. Studies have been made of routings of communications and work-flow to provide direct channels between sender and recipient. Forms and reports have been scrutinized to see that they are clear and can be integrated into the machine and manual procedures.

In the field of communication there is an increasing use of voice recorders, not only for dictating purposes but also for use in recording notes and ideas in the field. Sense-marking of punch cards eliminates manual punching. And for storage purposes punched cards, magnetic tapes and drums, micro-film, and 105-mm. film are finding increasing use.

Coordination offers many problems in a growing and decentralized organization. An expanded highway program will undoubtedly precipitate many problems in liaison and communication.

With this brief review of the administrative aspects, a look at the technical aspects and some of the special techniques is called for.

HIGH-SPEED COMPUTING

Among the highly reiterated suggestions was that of adapting highway engineering computations and statistical records to high-speed computers. The term "high-speed" has various connotations as used by the respondents, and with justification. It is still a relative term, as the truly "high-speed"—the "lightning-speed"—era has just been ushered in. In the recently developed electronic date-processing machines, actions are measured in terms of micro-seconds (millionths of a second). Notwithstanding, both the electric (mechanical) and the electronic computers are quite generally called high-speed machines. Perhaps the most noteworthy point is that there is now such a variety of calculators available that one can find the kind of machine best adapted to his specific job,

from the desk type to the "giant brain," and can procure the services of both the digital and analog types.

One of the significant developments among the highway departments is the exploration now underway to determine what highway engineering computations can be performed on the electronic-type computers. In this symposium a report is given on the progress made by the California Division of Highways in utilizing business machines in traverse and earthwork computations.

Another significant development was found in New York State, where the Bureau of the Budget has set up a section to explore the possible adaptation of computations to machines. The Bureau has already completed preliminary conferences with the staff of the Department of Public Works to determine what procedures can be mechanized.

The Oregon State Highway Department has mechanized earthwork computations by translating field cross-section notes into code for punch cards. The Bureau of Public Roads has assigned engineers to study the application of high-speed electronic computers to highway engineering operations and to consult with industries as to the use that has been made of these machines (8).

The Bureau of Standards likewise is studying the possibilities of adapting various procedures to electronic computers and other devices.

Additional work on adapting engineering computations to machines is covered in several significant papers presented at other sessions, sponsored by the Traffic and Operations Department, at the 35th Annual Meeting of the Highway Research Board (10).

Indeed, it would seem that any mathematical procedure that is frequently repeated and can be programmed as a series of sequential steps should be considered for mechanization.

STATISTICAL CONTROL AND INTERPRETATION

In materials testing, in physical research, and in statistical and administrative studies, the selection of the sample and determination of its probable degree of error are readily accomplished by the statistical control technique. This technique allows the highway engineer to process a minimum of statistical data, or conduct a minimum of tests to obtain an answer of required and predetermined accuracy.

Routine use of statistical control techniques was reported by 23 planning, 16 traffic, and 8 materials and tests bureaus.

Statistical techniques used to control and interpret research constitute a powerful tool and are gaining favor among engineers who have formerly looked askance at the utility of the probability theory in engineering procedures.

OTHER SPECIAL TECHNIQUES

Among the fast developing techniques are aerial photography, map-making, and reproduction processes. Aerial photography is used by 47 planning bureaus, 46 locating bureaus, 29 design bureaus, 21 materials and tests bureaus, 18 soils bureaus, and a substantial number of right-of-way bureaus. Aerial photography is used for measurements (photogrammetry), for identification of soils, structures, etc., and simply as photographs for many purposes.

Map-making has borrowed from the commercial graphic arts. Innovations include "stick-up" letters and symbols, negative scribing, and, of course, aerial mosaics. The Vari-Typer machine has been used with remarkable success to type notes and tabular data on road plans. Prints received from South Dakota which were prepared by Vari-Typer on tracing cloth are exceptionally neat and legible.

There have been so many developments in reproduction equipment and media that no attempt will be made to discuss them in this paper.

RESPONSE RELATED TO READINESS

In conclusion, it should be noted that the following questions have been asked: "What do the responses show? Have the highway departments fully exploited time-saving methods? Are they ready for the grand plan?"

A check of the responses discloses that there were five negative answers to every

three affirmative answers to questions asking if certain developments have been used. In other words, in more than 60 percent of the cases the respondent had not developed or tried the particular new method. Again, review of the 87 questions used in the canvass indicates that they do not nearly exhaust the possibilities in an inquiry into time-savings.

Hence, it would appear from a cursory appraisal that there is some basis for the recent statement that the survey "discloses that there is no concerted effort on a broad enough scale for a full 'package' modernization of highway engineering practices" (8). On the other hand it should be noted that it was not expected that all of the necessary forces would be or needed to be marshaled at the time of the canvass. The canvass was not intended to ascertain the degree of preparedness, but rather to obtain and make available time-saving techniques to those states which had not yet tried them. Therefore, it appears that the report will serve with optimum usefulness. The very fact that so many departments have not fully exploited all of the time-saving ideas gives promise that much can be done to prepare for the new program levels. Enough bureaus have pioneered in time-saving methods to prove them, yet a larger number of bureaus remain to profit from these pioneer endeavors.

There are, therefore, assurances that the technological advances already made are but the first fruits of the harvest.

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