Summary Report of Ranking Methodologies

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SUMMARY REPORT
of
RANKING METHODOLOGIES

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SUMMARY REPORT
OF
RANKING METHODOLOGIES

Participants in the ranking methodologies workshops were a good representation of those various actors (types of agencies or organizations) in the pavement management process. There were nineteen participants, nine of whom were from the United States, six from Canada, and four from European countries. Of the nineteen, eight represented state or provincial governmental units, three represented municipalities, four were employees of national highway agencies, and another four were either consultants or representatives of universities. Unfortunately, however, all participants represented the technical levels involved in pavement ranking. No one was present to provide the viewpoint of the ultimate decision makers -- higher level staff of highway or street agencies or legislators.

THE WHAT AND WHY OF RANKING

Everyone ranks highway pavements, and they have been doing so for as long as highway networks have been provided for the convenience of the general public. Even the "little old man in tennis shoes" who may be no more than a passenger in some motor vehicle has something to say about the condition of those pavements over which he rides. Those highly subjective ratings or rankings, literally done by the "seat of the pants," are done for various reasons -- not the least of which is to complain about the inadequacy of services provided by public officials or simply to provide a topic of conversation. Even early highway agencies and officials rated pavements in order to reach decisions, even though highly subjective, concerning the maintenance, rehabilitation, and upgrading of various portions of the highway network for which they were responsible.

Workshop participants assigned the task of reviewing ranking methodologies considered these techniques as formalized systems utilized by some agencies to evaluate and rank the condition of highway pavement sections to provide input into various decision-making processes of administrators of highway systems and networks. Ranking methodologies in and of themselves are considered to be relatively simple and capable of being applied in a systematic manner. Ranking methodologies may be designed to utilize existing manpower and expertise and require only nominal training before the ranking procedure is implemented. Ranking methodologies are flexible and are applicable as a tool at different levels of decision making. Ranking schemes are sufficiently flexible to be adapted for use at different administrative levels -- field, central office, legislature. Ranking methodologies are easy to implement incrementally and may be considered by some agencies as an early but essential step in a much more complex and complicated decision-making process. On the other hand, ranking methodologies may be adequate for many agencies and would be one of the final steps in the ultimate decision-making process of selecting projects for maintenance and rehabilitation implementation. Ranking methodologies are sufficiently flexible that they can be designed to be compatible with the size and complexity of the particular road network under consideration and to match the size and expertise of the staff and funds necessary to support the activity for a particular highway agency.
There are several aspects of a highway system, such as structural adequacy, safety, capacity, and even other elements, worthy of ranking to provide input into decision-making processes. Of those ranking methodologies described by papers presented at this conference or known to participants of the workshops, it seems that all of these aspects of a highway system are considered either directly or indirectly in various ways. Recognizing that there are a number of aspects that may be ranked, questions arose as to the advisability and techniques of providing "composite" rankings incorporating two or more of the potential aspects that could be ranked for pavement management purposes.

In designing and implementing a pavement ranking methodology, decisions must be made as to the elements or attributes to be measured and observed. Elements generally considered in most ranking methodologies, either singly or in various combinations, include pavement condition, rate of change of condition, distress, performance, structural adequacy, and levels of service. To obtain measures of these elements, certain attributes such as road roughness, skid resistance, rutting, and pavement deflections are observed or measured. The frequency of obtaining the various measurements of the different attributes varies depending upon the agency and the extent of the highway system under their jurisdiction, as well as the function of the various portions of the roadway system. It is interesting to note that, of those European agencies represented by participants of the workshop, the attributes of roughness, skid resistance, rutting, and deflections have been automated to minimize subjectivity. On the other hand, in many jurisdictions in the United States and Canada, these attributes are still being observed and evaluated visually. Those European jurisdictions that reported, however, often had a limited geographical area and a limited mileage of highways and streets for which they were responsible.

Ranking of highway pavements is done on at least three levels. The first is the technical evaluation or ranking of pavement sections in the network. These rankings are based upon objective measurements or visual observations of such attributes as roughness, skid resistance, rutting, and pavement deflections. Some agencies also consider cost and traffic (level of service) at this level. The second level of ranking considered by some agencies may be referred to as an economic evaluation. At this level, the costs of various maintenance and rehabilitation strategies are considered in comparison to the accompanying benefits. Workshop participants disagreed as to availability of input data. Some thought costs of various maintenance and rehabilitation strategies were not readily available. Others felt that the benefits of various alternative strategies were more difficult to quantify. At the third level, various overriding socio-political considerations are introduced into the decision-making process. At this level, for example, overall conditions of roads or streets in different geographic areas of a jurisdiction may be considered. Because of variations in soil conditions, weather, traffic characteristics, etc., the general conditions of the highway network may be different, and decisions may be influenced in part by a policy of attempting to maintain all roads in the system at some specified level of service.

The objective of ranking pavements is to provide an orderly arrangement of candidate projects for maintenance and rehabilitation actions. Ranking may be done on the basis of a number of criteria: condition ranking, first-cost
ranking, long-term cost ranking, or benefit/cost ratio ranking. Whatever the ranking procedures, it is only a tool in the overall decision-making process and is not itself an end product.

Ranking and scheduling are separate processes. Ranking is an input to the scheduling process. When preparing schedules for maintenance and rehabilitation programs, other constraints (funding and political) should be taken into account to arrive at optimal programs.

COMPOSITE RANKINGS

Since most agencies consider a number of elements in ranking pavements, there are questions as to the need for, validity of, and procedures for obtaining composite scores or rankings. Scores for all elements or attributes need not be combined into one number. But if the scores for various elements are to be combined, the need for weighting parameters accounting for the relative importance of components or elements are introduced. There also is a danger of "double" weighting a variable because of interrelationships between the elements being considered. The combination of element scores may be linear, but is more likely nonlinear when more than two elements are considered. Nonlinear combinations of element scores are not considered in most ranking methodologies. An alternative to a composite score or ranking of separately ranked attributes is to rate directly the pavement section. This approach is not used in typical, formalized ranking methodologies, but may be the basis of rankings made by the non-professional such as the public or a legislator.

A significant deficiency of pavement ranking methodologies is the lack of a comprehensive model relating all of the attributes of pavement condition and performance. Decision criteria, whether for individual components (attributes) of the ranking or whether it is the overall composite ranking score, must be established. These threshold values trigger considerations of possible remedial or rehabilitation strategies. The threshold values may be variable from one year to another, depending not only on what is considered to be technically desirable levels of performance but also upon funding that may be available to support corrective and upgrading measures or actions as well as the level of service that is expected by the general public for a particular facility.

It was noted that it is difficult to develop a composite rating score when generic-type pavements are compared. It is relatively simple, conceptionally, to rank rigid pavements against rigid pavements, for example, or flexible pavements against flexible. However, rankings of rigid pavements against flexible or against composite pavements may be more difficult. For example, when the same ride index values (roughness) are obtained on a rigid pavement and a flexible pavement, do these values have the same meaning and significance in an overall composite score used to compare the two pavements. How, for example, is the severity and extent of alligator cracking of flexible pavements to be compared to transverse cracking of rigid pavements? Does the same score in terms of the ranking scale of these two types of distress on two different types of pavement mean the same in the overall ranking of all types of pavements.

In developing weighting procedures and ranking models, the interests of a state or provincial highway agency may be different from those of a national
or municipal agency. Therefore, the combination of various elements into ranking methodologies may be different. Procedures to weight and combine elements into a composite score must, in general, match the perceptions of the various users of the output of ranking methodologies. Unfortunately, because of the wide range of "users", it is difficult sometimes to identify and properly combine those elements considered important and significant by each class of users. For example, rideability and appearance may be extremely important to a legislator while the highway engineer may be more concerned with such factors as structural capacity and safety.

DEFICIENCIES OF RANKINGS

Ranking methodologies in and of themselves are difficult to use in long-term planning and do not permit an analysis of various tradeoffs available in a particular situation. Long-term impacts of decisions and precise cost-benefit analyses cannot be based on ranking alone. Participants of the workshop felt there should be a definite move toward the implementation of optimization techniques and procedures to evaluate tradeoffs and the relationships between cost and benefits of various alternative maintenance and rehabilitation strategies. Insight into the values of weighting factors also may be obtained. Optimization may be beyond the capabilities of many smaller highway and street agencies. However, implementation of optimization by some agencies would provide a means whereby ranking methodologies themselves might be fine tuned so as to improve the output from such schemes. Optimization may be beyond some agencies inasmuch as the expertise and level of understanding to implement such procedures would not be available, and the funding to support the implementation of optimization would not be adequate.

Ranking concepts may be easy to explain and "sell" to higher management and legislators because of their simplicity. Legislators tend to think in short time cycles, which is compatible with output of ranking schemes. However, ranking is a intermediate step to higher levels of the management process, for example, optimization. The level of accuracy and completeness of available roadway inventory and traffic data in many agencies does not warrant higher levels of the decision-making process. The decision process should be commensurate with data accuracy.

STABILITY OF DATA AND RANKINGS

Another concern was that of the repeatability and stability, not only of the raw data that might be the basis upon which ranking methodologies are based, but also upon the output of the ranking scheme itself. A large number of attributes are involved; each is highly variable, making it difficult in some cases to observe a stabilization of the raw data. Sometimes output from ranking methodologies indicate different listings of candidate projects from one year to the next. This creates credibility gaps with those who might be trying to utilize the outputs from ranking methodologies.

In the development of composite ranking models, weighting factors may be selected in such a way as to arrive at rankings that would have been obtained by more "traditional" ranking schemes. If there is a difference between the output of a ranking system and the perception by other actors in the pavement management scene, such as the maintenance engineer, a state highway engineer, or legislators, a loss of credibility may result. This may not be desirable
from the point of view of the pavement management staff, but weighting factors may be modified over time to achieve desirable effects. The objectives of design, construction, and maintenance functions of an agency must be considered in the weightings.

Much expertise is leaving the highway industry in the next few years as a result of retirements. Should the subjective judgment criteria of experienced personnel be "captured" to minimize repeating years of "mistakes"? Is the state of knowledge to pulsate (expand with the experience of staff as they mature, and then to shrink again when that expert staff retires and younger people come into the picture and make their own "mistakes") or is the expertise of the matured staff to be captured so as to actually extend the state of knowledge? However, the development of ranking models on the basis of the expertise and perceptions of mature staff and engineers of highway and street agencies or those of legislators does have a disadvantage. Such an approach assumes that past decisions were good decisions. In spite of this disadvantage, it was felt that the expertise and perceptions of those practicing pavement management, even though on an informal basis, should be quantified to the extent possible. Logistic regression techniques and discriminate analyses may assist in providing objectivity to the output of such efforts.

JURISDICTIONAL DIFFERENCES

Participants from municipalities pointed out that pavement management is a subsystem of an overall infrastructure management scheme. Those individuals were much more cognizant of the competition for funding among various public services such as education, social services, transportation, buildings, utilities, parks, etc. A formalized system of optimization might be used to provide input into the process of allocating funds to the various public services. This, in general, has not yet been done. Even in the transportation area, optimization has not been utilized to allocate funds to various activities such as construction, structural rehabilitation, safety enhancement, capacity improvements, etc. Generally speaking, various "pots" of money are allocated by some means, usually upon the subjective perceptions of legislators and high level administrators, to various activities without the formal consideration of the needs and payoffs that might result from each. Because of the jurisdictional differences, the weighting parameters and component elements may vary from one agency to another.

There is a need for liaison and increased cooperation with utilities inasmuch as many activities of utilities impact upon pavement and street management. For state or provincial highway agencies, the control of utilities within the right of way is much more effective than in municipalities where there is generally no accountability of utilities to the agency responsible for developing and maintaining the road and street system.

BASIS OF PAVEMENT MANAGEMENT SYSTEMS

Pavement management systems must be independent of hardware or equipment. A ranking methodology that becomes "locked in" to a particular piece of equipment is doomed to eventual misuse and disuse. For example, an element of a ranking system should be based upon the structural adequacy of a pavement section and not upon the deflections of that pavement section as
measured by a particular device or piece of equipment. New technology should be developed and evaluated to automate data collection systems, but the ranking methodology must not be permitted to become hardware (equipment) dependent. Particular concerns with regard to equipment and hardware development included the protection of observers (safety of personnel), repeatability of the raw data obtained as well as the output of the ranking methodology, objectivity of the data and output, encouragement of innovative thinking with regard to equipment development, and development of equipment and methodologies for the structural evaluation of portland cement concrete pavements and composite pavements.

GENERAL MANAGERIAL CONCERNS

Going beyond the concerns of ranking methodologies themselves, workshop participants were concerned about a number of factors that effect the effectiveness of the overall pavement management system. These concerns are summarized here to provide a complete record of the workshop on ranking methodologies.

The success or failure of an effective pavement management system would be dependent in part upon the organizational needs and location of the pavement management activity within a particular agency. The organizational development of pavement management activities has been observed to pass through at least three stages or phases. In the development phase, the pavement management task often is assigned to an individual and a very small staff with the knowledge, interest, and desire to make the system effective. During the second phase, this task is recognized as being too great for a single individual. The task, then, very often is assigned to a high-level task force. Unfortunately, members of this task force assume pavement management activities as secondary responsibilities. This leads eventually to delays and an ineffective implementation of the system. In the third phase, a complete staff is identified at the executive level to facilitate and implement a pavement management system.

Output from a pavement management staff should be made directly to the deputy chief executive officer of the agency. Pavement management systems provide input upon which major highway and street investment strategies are based and thus should be provided to the high-level administrators making those decisions. Secondary and balancing opinions may be obtained from line units. When a pavement management procedure is housed in a line unit, the major objectives of that particular line unit may overshadow all other concerns that an effective pavement management system should consider.

Packaging of information obtained from a ranking methodology and from an overall pavement management system is of critical significance. Data and information development by a pavement management staff must flow in all directions: upward, downward, and horizontally to other staff and agencies concerned with funding of transportation systems and implementing various maintenance and rehabilitation programs. Depending upon the particular group of users to which the information is provided, the packaging of that information may be entirely different than for other groups. For other engineers on the highway agency staff involved in the planning, design, and implementation of recommendations from a pavement management staff, the why’s
and the numbers may be very important. The engineering staff may be concerned with long-term impacts. On the other hand, information provided to chief executive officers and legislators may need to be in terms of words. Legislators, in particular, tend to think in terms of short time cycles (term of office, for example). In all cases, particularly when the information is provided to high-level administrators and legislators, the information must be delivered in small packages.

Another important factor that is essential to the success of a pavement management system and that is sometimes overlooked is feedback. In general, in most organizations, there are a number of staff people outside the pavement management staff who are providing input data into the ranking methodologies and into the pavement management system as a whole. Feedback must be provided to those people so they will understand and appreciate the significance and importance of the accuracy of the data they provide to the system. They must observe the impact of their part in the overall scheme as it plays upon the implementation of maintenance and rehabilitation strategies. In a like manner, the raters or providers of data to the pavement management staff must communicate to the staff concerning possible deficiencies and improvements with regard to the data collection scheme. Communications also must be open to allow feedback from those to whom output of pavement management systems are provided. The pavement management staff must be in a position and willing to obtain feedback from legislators and administrators as to their needs. All of this communication and feedback provides input to the pavement management staff that may be used to refine and modify the pavement management system so as to make it more effective. Unfortunately, many road agencies are not organized to facilitate feedback and resultant modifications and refinements of ranking methodologies.