

Developing Pavement Management Systems at County and City Levels

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ABSTRACT

The experience of San Francisco Bay Area cities and counties in collectively attempting to improve pavement maintenance practices by use of a pavement management system (PMS) is discussed. The development of this tool is viewed as a major factor that is necessary to assist in securing additional road maintenance revenues and in improving performance in an environment of limited revenues. The findings of the Metropolitan Transportation Commission, the agency that served as the catalyst for this effort, are summarized. These findings should have relevance and broad applicability as many other cities and counties begin developing or upgrading their pavement maintenance capabilities. Better understanding about what a PMS is, what it can do, and what should be considered before such a system is implemented are addressed. A user's manual to help guide the implementation of PMSs will be developed as these efforts continue.

The San Francisco Bay Area includes 94 cities and 9 counties. There are 1,400 miles of freeways maintained by the state. However, the focus of this report relates to the 11,000 miles of streets maintained by the cities and the 6,000 miles of roads maintained by the counties. These 17,000 miles of local roads were budgeted at \$18 billion in replacement costs, making it the single biggest public investment in the Bay Area.

The Metropolitan Transportation Commission (MTC) is the metropolitan planning organization (MPO) for the region. It was created by state legislation in 1970. Historically, most of its staff have concentrated on administering federal and state transit grants and preparing and updating a regional transportation plan and a transportation improvement program. However, in early 1981 a group of public works directors came to MTC seeking help in documenting local street and road maintenance needs.

An ensuing study, taking 18 months to complete (1,2), documented numerous maintenance shortfalls, which have since fostered substantial follow-up activities. Three recommendations from that study were as follows: (a) significant new additional revenues must be found (in aggregate about \$170 million was being spent, whereas it was estimated that roughly \$310 million was needed); (b) local officials and the general public were largely unaware of the problem, and a large-scale public information program was needed; and (c) significant cost savings could be achieved through improved maintenance practices. The subject of this paper deals largely with the latter recommendation.

BACKGROUND

Reviewing Bay Area Maintenance Practices

In initially estimating maintenance needs, surveys of street pavement conditions were required. It became evident in seeking condition data that few cities or counties had systematically documented their information. Moreover, even fewer jurisdictions built road maintenance budgets or planned annual or multiyear maintenance programs on an automated pavement management system (PMS) basis. The definition of PMS used in this paper is as follows: An integrated set of systematic procedures designed to assist engineers and managers in making consistent and cost-effective decisions related to the design, maintenance, and restoration of pavements. Arguably, it appeared prudent to try to establish some sort of prototype PMS.

Apparently, others had the same idea. In early 1982 a proposal was submitted to MTC to develop such a system. The proposal was to take 5 years and cost roughly \$1.5 million. Ten to fifteen cities and several counties were to jointly participate in the development of such a system. Public works directors from several major Bay Area cities and counties met with MTC during the course of several months to evaluate the proposal. The group concluded that 10 jurisdictions could probably come up with \$30,000 per year for 5 years, but this was not the direction to go at that time. Instead, it was recommended that a pavement management evaluation committee (PMEC) be formed, made up of pavement experts from local jurisdictions who had been working in this general area. This group was both to review their collective experiences with PMSs and formulate next-step recommendations that MTC, acting as a catalyst and facilitator, would help implement.

Representatives from 15 jurisdictions met over the course of six monthly meetings in the latter half of 1982. Most of the time was spent reviewing the positive and negative experiences that four jurisdictions had encountered in working with PMSs. Four consultants with PMS experience also presented their systems and made various suggestions on what to do and what not to do. The collective recommendations of this PMEC resulted in MTC securing the services of a consultant to assist the jurisdictions in improving their pavement management practices.

The Consultant Effort

The effort of using a consultant to help MTC act as a catalyst marked a significant departure from the prototype PMS development work mentioned earlier. It was a recognition that a step backwards was necessary (i.e., even more reconnaissance was needed). There was strong sentiment from city and county jurisdictions that they did not want to "reinvent the wheel." There was also a strong indication that there were issues beyond merely developing a PMS that had to be addressed. [These issues will be

discussed in greater depth later; but several of them are as follows: there was a need for stronger management support and emphasis in this area (pavement maintenance is generally not at the top of the public works director's list), there was a need to gain better public understanding and support, and it was important to recognize the different and sometimes competing needs within a public works department from budgeting, engineering, maintenance, and administration.]

To be able to go beyond the development of a PMS and to grasp some of the issues just mentioned, the expertise of a consultant was required, which proved difficult to find. Many consultants in this field were well skilled in developing maintenance management systems, but this dealt more with work flow, scheduling, and tracking, which was not the management system desired. Several consultants had developed excellent PMSs but could not see beyond the need to sell their own systems.

What was desired by MTC, beyond the capability to provide a useful PMS, was to have such a capability grow and increase in utility in subsequent years. Therefore an understanding of the public works milieu was required. The ability to communicate with the technician, the administrator, the engineer, top management, the public, and elected officials was needed. Other desirable skills of no less importance included the ability to (a) conduct training classes and lead seminars, (b) write clearly and succinctly at several levels, and (c) have a national perspective on pavement maintenance experience.

In the remainder of this paper the major findings acquired from the 18-month study of maintenance needs, the reviews of pavement management practices with local public works personnel, and a questionnaire that surveyed local perceptions of PMSs and other maintenance problems and needs are discussed. It is primarily findings from these three areas that have helped define the scope of work for the consulting contract that is currently under way. It is believed that these findings will have broad applicability as many other cities and counties begin to develop or upgrade their pavement maintenance capabilities. In the concluding portion of the paper the basic orientation that has evolved in the Bay Area because of the findings is described. The basic products and activities that will be produced as a result of this contract are also described.

FINDINGS

Findings from the 18-Month Study of Bay Area Local Road Maintenance Needs

The overwhelming conclusion drawn from this study was that the Bay Area's 17,000-mile local road system was not being adequately maintained. It was noted that local jurisdictions were actually falling further behind. That is, roads were deteriorating at a rate faster than they were being repaired. Roughly \$170 million was being spent annually for road maintenance purposes:

Maintenance Category	Expenditure (\$000,000s)
Preventive	41
Routine	31
Nonpavement	
Street lighting	29
Traffic safety	18
Street cleaning	10
Landscaping	11
Miscellaneous	11
Other	
Special programs	5
Administrative, engineering	14
Total	170

The evaluation indicated that \$270 million (or a shortfall of about \$100 million) should have been spent. (More important, 65 percent of this shortfall was for preventive maintenance.) The money was spent only for ongoing maintenance, or maintenance that was required to keep roads in adequate condition. A backlog of \$400 million was also documented. This would have been the amount required to bring roads that had deteriorated because of deferred maintenance back to adequate condition. Converting this shortfall to a 10-year capital improvement program would have meant the total required maintenance expenditure would have to be \$310 million, or roughly 80 percent more than the current level (3).

Moreover, the revenue shortfall was found to have been part of a gradual revenue reduction that had been taking place for more than a decade. This bleak revenue situation underscored deeper seated problems associated with staff resources, morale, and methods of planning, programming, and budgeting. For example, a typical city's or county's overall approach at budget time was reduced to one of picking which line items in the prior year's budget were to absorb the new cuts. In some cases long-term revenue decline had fostered complacency and a sense of lack of urgency from top management.

The shortfall was determined by conducting a windshield survey of visual pavement distress in 11 jurisdictions representing about 10 percent of the Bay Area's road mileage. In aggregate, 55 percent of the pavements were noted to be in adequate condition and the remainder required some sort of corrective maintenance. Twenty-five percent required seals, 15 percent required overlays, and 5 percent had deteriorated to the extent that complete restoration was required.

It was also found that wide variations existed among jurisdictions. There were significant differences in the conditions of pavements depending on not only the quality of past maintenance activities, but also on such factors as the commitment of the council, the age of the streets, and the growth in traffic. There were variations in how maintenance was performed and the types of treatments used. For example, some jurisdictions tried to direct limited funds to higher-order streets (arterials), whereas others merely repaired on a complaint basis with no overall strategy. There was also wide variation in the amount of surface preparation done before the application of seals and overlays. In summary, there was diversity in pavement condition, maintenance strategies, and maintenance treatments and their application. Most of the problems that were found across jurisdictions could be substantially improved by the establishment of or improvements in PMSs.

However, the conditions previously described underscore the futility of merely upgrading PMS capabilities if those other issues are not addressed. If pavement maintenance practices were expected to be improved, the first need had to be additional revenues, but this was only the first step. Issues such as public, council, and even management priority and support; staff adequacy as well as morale and motivation; maintenance strategies that seek ways to hold the line instead of constructing what-if scenarios that do not speak to reality; as well as a host of other issues must all be dealt with head-on.

Findings from Working with Local Public Works Personnel

In the initial efforts to develop a large-scale prototype PMS, six public works directors were asked to review the 5-year, \$1.5 million proposal. They concluded that a common mistake was to be too am-

bitious initially, particularly in terms of what was actually needed. They also indicated that PMSs were often oversold, and worse, were developed beyond the jurisdictions' resources so that the resultant system was only partial, or not usable in an ongoing sense, particularly by maintenance personnel. The orientation was often theoretical and did not fit the needs of the jurisdictions by considering the public works milieu.

The public works directors also pointed out that PMS was such a broad concept that it could mean all things to all people. Therefore it was difficult and confusing to talk about a PMS. For example, a public works director may see a PMS as a tool that primarily helps to build a road budget. A road chief may want to have a system to schedule treatments and allocate personnel. Engineers may want a system to test alternative maintenance strategies. The maintenance researcher may want to build a pavement performance model for a maintenance optimization process. Finally there is the programmer whose primary interest is the logic systems that organize, manipulate, and display the data. Because of these numerous confusions and varying perceptions, it would appear necessary, particularly during the initial steps, to clearly define the major users and what level of effort would be required to develop specific PMS elements for specific needs.

The public works directors' advice was to not reinvent the wheel, but rather to build on the substantial body of experience that existed within local departments, and build incrementally. Different jurisdictions were at different steps in developing a PMS; what was needed was to use the best parts of existing systems. Other jurisdictions already had the necessary information, but they lacked the knowledge of what to do with it or the computer expertise to process it. They therefore concluded that MTC should take personnel from cities or counties who had some experience and use this group's experience in charting a new course or direction for PMS development.

Therefore PMEC was formed, and their collective experience was reviewed over the course of six monthly meetings. They made five major recommendations.

1. Develop guidelines to help jurisdictions improve maintenance practices: This would be a user's guide that contained sections pertinent to understanding, promoting, and implementing a PMS.

2. Develop techniques to promote standardization: Because many cities and counties were considering the development of a PMS, it was thought that an opportunity to achieve some standardization could provide real cost savings in three ways: uniformity in measuring pavement distress (common elements would be gathered because individual jurisdictions might not use all measures or may weigh measures differently), uniformity in treatment options, and potential uniformity through centralized computer, equipment, and inventory procedures and personnel.

3. Improve communication: The key to this recommendation was the recognition that clear information and education was needed at several levels, such as information and visual aids for officials and the public, general information for management, and materials and techniques for training. The following improvements were needed: information on the effectiveness of new maintenance treatments, educational materials for elected and administrative officials on the potential benefits from PMSs, increased sharing of mutual problems and practices, and more relevant training for engineering and road maintenance personnel.

4. Develop three basic elements of a PMS--pavement condition index, maintenance treatment options, and a technique to match the index to the options: The development of these three elements is viewed as occurring incrementally, beginning with manual systems and moving toward full automation. Current thinking has these elements being developed at three different levels depending on the varying sizes and needs of each jurisdiction.

5. Gather more comprehensive information to better define maintenance problems and needs by jurisdiction size: Given the variations in experiences among jurisdictions, PMEC suggested that a questionnaire be prepared that surveyed all cities and counties. In this way information could be stratified by grouping common responses to such things as experience in implementing PMSs, perception of maintenance problems and needs, securing views on potential facilitator and catalytic functions, and other needs or deficiencies that might have been overlooked.

Findings from the Questionnaire

All Bay Area jurisdictions were sent a questionnaire in June 1983. To date, 8 of 9 counties and 40 of 94 cities have responded. This represents jurisdictions responsible for 75 percent of the 17,000 miles of local streets and roads.

The following maintenance problems, in priority order, were listed as the most serious:

1. Lack of resources (both revenues and staff),
2. The ability to design an overall maintenance strategy,
3. Cost-benefit information on various maintenance strategies, and
4. Knowledge of road conditions.

Two other problems frequently cited were decisions on maintenance versus construction and lack of council or board support.

In an attempt to more accurately measure the extent of PMS development, city and county personnel were asked if they had PMSs that were implemented and functional. Eight said yes, 10 said they were in the implementation stage, and of the remainder 8 were at the developmental stage and all but 4 said they were interested in implementing a PMS. Of the four that indicated no interest, three said they were too small and lacked the necessary funds, and the fourth indicated they did not know what a PMS was.

A PMS can be developed at various levels of sophistication and at various levels of data gathering. Cities and counties can also implement a few basic elements or all possible elements of a PMS. To better understand this issue, additional information on desirable levels of data, sophistication, and elements of a PMS were gathered. PMS information cited as being of greatest utility, in priority order, were pavement condition, maintenance history, design and construction data, structural capacity, average daily traffic, and functional class. Most respondents assigned much lower priorities to ride quality and skid resistance. PMS elements cited as being of greatest utility were identification of street conditions, identification of required maintenance treatments, and budget data on needs. Elements rated as slightly lower in priority included projection of future pavement condition, economic analysis of alternatives, and determination of cause of deterioration.

These answers confirm the finding that most jurisdictions initially want the three basic elements of a PMS: (a) a process to measure pavement

condition, (b) a list of the most cost-effective maintenance treatments to correct the problems identified in the pavement condition measurement, and (c) a means of matching treatments to problems by street segment so that priorities can be established. Two underlying issues relate to varying responses based on jurisdiction size and stage of PMS development.

Additional analysis indicated that larger jurisdictions, and those jurisdictions with more developed PMSs, consider the more advanced PMS elements (projections of future conditions, alternative network analysis) to also be of high utility.

Correcting maintenance practices goes beyond just the development of PMS. Jurisdictions were asked to indicate what types of information sharing would be most useful. Roughly 85 percent of the responding jurisdictions indicated that forums for periodic information exchange, training on pavement inspection and other aspects of pavement maintenance, seminars on maintenance options and treatments, and seminars on PMS experience would be useful.

Only 30 to 40 percent indicated that monthly bulletins on bid prices or joint purchases would be useful. This information indicates a high level of interest in both developing and expanding PMSs, and improving other areas of pavement maintenance practices.

RECOMMENDATIONS

Orientation

It is worth summarizing the major overall orientation gained from synthesizing the experiences and findings from the Bay Area. Before considering the development of a PMS, jurisdictions should be aware of the factors presented in the following list. These factors represent the major findings that ought to be directly addressed before developing a PMS. A jurisdiction can easily spend in excess of \$100,000 for a system and discover later that spending more time on deciding what was needed and phasing that process in incrementally could save dollars and increase utility.

The major factors to be aware of before implementing a PMS are as follows:

1. Most cities and counties already have PMSs. It is only a matter of how complete, automated, and sophisticated these systems have become.

2. There appear to be great opportunities for several jurisdictions to pool efforts in developing PMSs: (a) standardization of basic PMS elements can promote cost savings, centralization of some data and computer functions, and a better basis for ultimately comparing effectiveness of treatment options; (b) information sharing about positive and negative PMS experiences becomes increasingly important as more are developed (it also helps to alleviate the "black box" syndrome); and (c) technology transfer does not occur readily, and therefore seminars on new maintenance treatments, materials, and techniques are needed.

3. Two major needs are readily apparent in most cities and counties: What are the most cost-effective maintenance treatments for similar pavement conditions? What overall maintenance strategies are most cost effective given certain budget levels? (It is critical to be able to determine whether current budget levels are gaining or losing ground in terms of keeping streets in adequate condition.)

4. Different size cities have different needs and capabilities. In the Bay Area roughly one-third of the cities have less than 50 miles, one-third

have 50 to 150 miles, and the other third have more than 150 miles. Probably two-thirds of the cities (those having up to 150 miles of streets) will have little need to develop PMSs beyond the three basic elements. (Only nine jurisdictions have systems greater than 500 miles.)

5. Locating a PMS in a public works department is no minor matter. All of the following disciplines can play a vital role: engineering, maintenance, planning, and budgeting. Locating a PMS on the periphery where interrelationships are weak can limit or doom its utility.

Many of the variabilities across jurisdictions that were discussed earlier argue convincingly for a great deal of tailoring at the front end of PMS developmental efforts. However, the experience of actually getting 11 jurisdictions to conduct pavement condition surveys, and completing this effort in several months, also argues convincingly that there are great opportunities for standardization, sharing, and centralizing some functions as well.

What follows are several overall orientations that should be considered and emphasized. First, a PMS is merely a tool. For that tool to work effectively it must be supported, understood, and used by the management and personnel in each jurisdiction. The latter point is key. In smaller public works departments where the public works director, the budget analyst, the engineer, the maintenance supervisor, and the data processor may be the same person or only a few, the fragmentation may not be critical. But in larger departments, for example, if the engineers implement a PMS, but it is not really used to develop budgets, secure funds, and implement a maintenance program, the investment might as well not have been made. This suggests that all of these groups must not only be involved but must be addressed in terms of organization, education, training, and required performance.

A related but more implicit part of this view concerns the broader context into which a PMS is developed. That is, effective road maintenance can only be achieved if practices above the public works department level are addressed (e.g., citywide budgeting and priority setting processes). As stated earlier, in the Bay Area the process of estimating what it would take to keep roads adequately maintained appears to have been replaced by trying to hold the line against further cuts. When maintaining the status quo or retrenchments become institutionalized, strategies developed across broad fronts must be addressed if there is to be any hope of improving pavement maintenance practices.

A second overall orientation is in a sense directly related to the first. It is important to keep in mind that in preparing reports, different requirements in the political, financial, technical, and management fields must all be addressed. This means that to have a PMS generate 30 different reports on different maintenance priorities is not adequate. Different audiences (elected officials, the public, engineers, administrators, and so forth) all require different information presented at different levels. Technical manuals, slide shows, simply illustrated summary reports, and the like are all necessary.

A third overall orientation relates to PMSs at several levels. The development of a PMS is given in the following outline. The process assumes starting with a simple framework and using existing information as much as possible. The system should be developed at the network level first, with a strong link to the budget development process. The system should provide a list of segments that require maintenance by maintenance options, alternative strat-

egies to achieve required maintenance with costs by year, and identification of the match or mismatch of required costs with anticipated revenues. The work flow framework is as follows:

- I. Preliminaries
 - A. Decide what is wanted based on needs and resources
 - B. Define initial required data elements to define pavement condition, including survey process
 - C. Define road system by segment and functional class
 - D. Develop a data management package (start with a simple system and automate incrementally)
 - E. Set up an agreed on institutional and organizational structure with time lines and management reviews
- II. Basic elements
 - A. Construct pavement condition scales
 - B. Formulate cost-effective treatment options
 - C. Develop a logic system to match street segments to treatment options
- III. Enhancements
 - A. Develop prediction models of pavement performance as pavement condition surveys are repeated
 - B. Develop maintenance strategies using optimization techniques

The previous outline gives the basic elements of a PMS, but the elements are not monolithic in either sophistication or in when they are implemented. Although a great deal of individual tailoring is necessary, a prototype PMS is possible. It is only that different jurisdictions start at different points in the process timewise. Different jurisdictions may also only choose to implement the three basic elements in a manual process. Others may stay with the three basic elements but move to more automated processes. A few may have needs and the necessary resources to add all the enhancements and fully automate on a large frame data base manager.

In addition to the overall orientation, it is useful to also emphasize and consider important points that would apply within individual elements of a PMS or in the design of the implementation process.

1. Do not underestimate the data management and computer aspects. Included here would be the importance of clarifying what data are gathered, when, and at what levels. The complete street segment inventory versus sampling, as well as updating, are also not trivial matters.

2. There are many ways to measure pavement distress, but relying on a single dimension index is probably an oversimplification. For example, to meaningfully relate treatments to conditions, the condition should discriminate among underlying causes such as subgrade drainage failures or excessive heavy traffic. This suggests differing levels of measurement at different stages (e.g., at the network level visual distress may be sufficient, but at the project level, once a class of segments has been highlighted as deficient, more detailed measurements including deflection and core samples may be required).

3. In developing PMS elements, it is important to remember not only the building-block approach, but also that elements should be modular. That is, it should be possible to upgrade one PMS element to a more comprehensive option without having to change any other elements.

Consultant Work Tasks

The major focus of the consultant effort will be to produce a report composed of stand-alone modules, which will act as a user's guide to developing PMSs (see Table 1). Some of these modules will be technical in orientation, others will be simple summaries for lay audiences, whereas others may actually be packaged slide presentations stressing the importance of developing systematic pavement maintenance strategies.

Most of the modules highlighted in Table 1 are self-explanatory at this stage in their development. However, module 2 does require some additional explanation, particularly because the economic benefits of PMSs have seldom been clearly documented. Economic benefits at two levels will be illustrated: (a) different combinations of maintenance techniques on different distress conditions, and (b) a structured PMS.

TABLE 1 User's Guide to Developing PMSs

No.	Module	Purpose
1	Evaluation of successes and failures in PMS efforts	Through case studies and actual experiences with PMSs, document major causes of failures and requirements for success
2	Economic analysis of elements of PMS	Such an analysis will help illustrate to decision makers the economic benefits of (a) different combinations of maintenance techniques on different distress conditions, and (b) a structured PMS
3	Questions concerning PMS	Major questions voiced by public works directors, managers, and engineers will be compiled and addressed
4	Define, describe, document, and chart PMS elements	Major elements will be summarized, different implementation levels will be described, and a step-by-step procedure for moving up the ladder will be provided
5	Potential catalytic and facilitator functions to promote PMS	Utility of following functions will be analyzed: training, seminars, centralized data structures and computer facilities, standardized PMS elements, standard output reports, and so forth
6	Packaged technical and public presentations	On the technical side, a training course would be produced that combines the basic concepts of a PMS with state-of-the-art pavement rehabilitation techniques; on the public side, the cost-effectiveness of a structured approach to pavement management will be provided

For the first level, a range of typical pavement conditions and treatments will be described for a sample of street segments. Next, the different maintenance techniques will be applied both individually and in logical combinations to the different pavement conditions. For each application, the cost of construction and future maintenance over the extended life of the street segment will be estimated. Extended life will of course not be precise, but by assuming a range of possible lives, the economic effects over this range can be calculated. Through the application of this approach, the relative cost-effectiveness of each maintenance technique and combination of techniques can be illustrated.

For the second level--economic benefits of a structured PMS--a more involved approach will be necessary. First, a small pavement network of 20 to 30 street sections will be described in terms of design, conditions, traffic, age, and so forth. Life prediction models will be developed based on previous research and information from Bay Area experiences. Two different PMS concepts will be analyzed: one will be a nonstructured approach typical in most

cities and counties, and the other will be a structured PMS. The nonstructured system will reflect the typical policy of letting pavements fail before performing maintenance work, then overlaying or reconstructing the pavements. The system will have no formal procedures for selecting segments for maintenance treatments. The structured system will have the basic components of a PMS, including a pavement condition rating procedure, a procedure for setting priorities, and a reasonable procedure for selecting maintenance treatments based on cost-effectiveness.

The two approaches will be applied to the network over a period of 40 to 60 years. All of the costs of maintenance will be accumulated, and the condition of the pavement sections will be recorded over the analysis period. A direct comparison of the pavement network costs and overall network condition will be made for each of the systems. The results should graphically show the economic benefits of the structured system, particularly if some measure of user cost increases, caused by allowing pavements to deteriorate below acceptable standards, can be factored in.

The other major focus of the consultant effort will be to develop the three basic elements of a PMS as provided in the previous outline. The objective of this effort is to go beyond the description of the framework necessary for establishing PMSs. The

three basic elements will be described at a level of detail sufficient for individual jurisdictions to pursue actual PMS development. In this way actual implementation problems can be experienced, and opportunities for standardization can be tested. The ongoing interest in improving Bay Area PMSs and maintenance practices can continue to be explored.

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A Stable, Consistent, and Transferable Roughness Scale for Worldwide Standardization

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ABSTRACT

Since the AASHO Road Test there has been great interest in the measurement of road roughness for evaluation of serviceability as defined by Carey and Irick, and, perhaps more broadly and importantly, for evaluation of road roughness as it affects vehicle operating costs and road maintenance, particularly in developing countries. In this paper work done in the United States, Brazil, Canada, Bolivia, Nigeria, Panama, and elsewhere with respect to the selection of a uniform method for calibrating road roughness devices is reviewed. Because most roughness measurements are made with response-type roughness measuring instruments, there needs to be a calibration technique for such instruments that can be easily used by any country. It is essential that the method be based on characteristics of the road surface and not on characteristics of

any individual vehicle or measuring velocity of the response-type roughness meter. A specific calculation algorithm is also needed. A calibration technique is recommended that is based on a true profile of the roadway surface analyzed with waveband analysis to determine root-mean-square vertical acceleration for several applicable waveband statistics that are combined to produce the calibration factor. The development of the methodology is presented.

Since the AASHO Road Test, where the concept of pavement serviceability was developed by Carey and Irick (1), increasing importance has been given to user-related pavement evaluation. This type of evaluation is concerned primarily with the overall function of the pavement; that is, how well it serves traffic or the riding public.