Managing Quality

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A remarkable evolution in quality assurance specifications has taken place during the last 35 years. This evolution has taken the form of various quality-improvement initiatives. The genesis of these initiatives was the American Association of State Highway and Officials' (AASHO) Road Test of 1956–1958 and the analyses that emanated from that historic study—in particular, the discovery of the magnitude of variabilities in the quality of highway construction, and resulting concerns about the need for improved specifications.

The various quality initiatives produced several forms of specifications, each an improvement on the previous:

- Statistically oriented end-result specifications (1960s);
- Statistical quality assurance (1970s);
- Total quality management (1980s); and
- Quality management (1980s).

This evolution is continuing, and there is more interest in quality today than ever before.

RECENT INITIATIVES

National Quality Initiative

In 1991 the American Association of State Highway and Transportation Officials (AASHTO) Standing Committee on Highways voted to endorse a national quality initiative. In 1992 a joint Federal Highway Administration (FHWA)/AASHTO/industry steering committee was formed with the mandate of focusing national attention on and guiding future efforts toward improving construction quality in the highway industry. The work of the steering committee resulted in the National Quality Initiative (NQI).

The first NQI conference, Partnerships for Quality, was held in November 1992 in Dallas, Texas. One of the major accomplishments of this conference was establishment of the National Policy on the Quality of Highways that was signed by all NQI members. Since that time, two additional national NQI conferences have been held, as have many regional and state seminars focused on improved quality in highway construction. The NQI is expected to provide continued leadership in the highway quality arena through the early years of the 21st century.

Performance-Related Specifications

A major goal in the development of quality assurance specifications is to advance them to the level of performance-related specifications (PRSs). PRSs are defined in Transportation Research Board (TRB) Circular 457, *Glossary of Highway Quality Assurance Terms* (*1*, p. 11) as:

> …specifications that describe the desired levels of key materials and construction quality characteristics that have been found to correlate with fundamental engineering properties that predict performance. These characteristics are amenable to acceptance testing at the time of construction. True performance-related specifications not only describe the desired levels of these quality characteristics, but also employ the quantified relationships containing the characteristics to predict subsequent performance. They thus provide the basis for rational acceptance and price adjustment decisions.

In simple terms, the development of PRSs can be considered primarily as an improvement in quality assurance specifications. One might expect, therefore, that the transition would be quick and easy. In fact, however, it has been neither quick nor easy. The main reason for the difficulty encountered is that performance models are essential elements of PRSs, and these models are still in the developmental stage. A 1990 report on PRSs produced by the National Cooperative Highway Research Program (NCHRP) states (*2*, p.1):

> The primary component of a performance-related specification is the collection of prediction models that are used to predict the life-cycle cost (LCC) of the target and as-constructed pavements. The models, test methods, and databases required for these prediction models have not been sufficiently developed to the point that they can be reliably used in a performance-related specification. Work planned, or currently underway, is expected to rectify this situation so that the necessary models should be ready for full implementation within the next 3 to 4 years.

Several prediction models have been developed or improved since the NCHRP report was published. State highway agencies can now use these models to develop their PRSs. Once an agency has developed and begun to use PRSs, the quality-versus-performance data generated for construction projects can be used to further improve or refine the models.

In retrospect, the NCHRP study was optimistic in stating the time frame for full implementation of predictive models. However, as the 21st century approaches, progress is being made toward PRS development. To effect the transition from quality assurance specifications to PRSs, FHWA has built upon the NCHRP work by issuing a bulletin, *A Cooperative Effort To Improve Pavement Quality* (*3*). This 1997 bulletin establishes two implementation levels for PRSs (p. 6):

> PRS level 1 is the basic PRS entry level. It provides the SHA [state highway agency] with experience in specifying and establishing LCCs while permitting the use of current tests of the SHA. PRS level 2 is more sophisticated and can offer greater advantages. It employs in situ testing and permits project-specific price adjustments. Under PRS level 2, one overall price adjustment is calculated, which reflects the interactions among quality characteristics. The FHWA recommends that SHAs gain experience with level 1 before moving to level 2.

This bulletin also suggests the development of an orderly plan for implementing a PRS and recommends several logical steps to this end. In addition, it establishes several criteria for PRS elements, including the distress types to be controlled, material and construction quality characteristics that influence the distress types, and test procedures that can be used to measure these characteristics. The test procedures should be timely, economical, nondestructive, reliable, reproducible, and capable of being performed in the field. Continuing improvements are being made in this area.

Pay Factors

The concept of disincentive and incentive pay factors is not new. An incentive pay factor was advocated as a means of focusing greater attention on process control and uniformity at a national Statistical Quality Assurance Workshop held in 1968, and disincentives were in use even earlier.

Until recently, disincentives were employed more frequently than incentives. Today the use of incentives is being regarded more favorably as a means of rewarding contractors that put extra effort and expense into improving their products. Benefits of the use of incentives are improved quality, the positive psychological effect of being rewarded for excellent performance, and fairness to the contractor. Moreover, the use of incentives for certain attributes, such as pavement smoothness, has grown in popularity at least partially because the practice results in customer satisfaction on the part of the traveling public.

The establishment of incentives and disincentives by most state highway agencies has involved both engineering judgment and trial and error. More rational approaches are now available. These approaches combine performance prediction models with maintenance or rehabilitation cost models, making it possible to pay the contractor more fairly for the value of the construction.

Warranties

One alternative to simply delegating quality control to the contractor is use of a warranty specification whereby the contractor "… guarantees the integrity of a product and assumes the responsibility for the repair and replacement of deficiencies" (*4*, p. 1). John Volker, of the Wisconsin Department of Transportation (WisDOT), in a presentation at the Association of Asphalt Paving Technologists conference in Baltimore, Maryland. 1996, suggested that a quality assurance specification is a first step toward a warranty specification, and that development of the latter is a natural evolution of quality assurance specifications. One obstacle to the use of warranties was removed in 1996 by FHWA, which until that time had not allowed federal funds to be used with warranty provisions except under special conditions. The FHWA 1996 Warranty Final Rule allows use of warranties for a wide range of applications.

Since 1995, state highway agencies have increasingly employed warranty contracts in the hot-mix asphalt area. WisDOT, for example, has been active in the use of warranty clauses for hot-mix asphalt, beginning with a few asphalt rehabilitation projects in 1995 and increasing in number and scope since that time. Early conclusions from these projects are as follows (*5*,p. 26):

- Indications are that a warranty specification for asphalt concrete pavements can be developed and used successfully on highway construction contracts within the low-bid environment.

- Early indications are that such specifications have been successful in reducing WisDOT's construction engineering costs, giving contractors more project control and flexibility and resulting in quality pavement.
- Warranties clearly have the potential to provide DOTs with a good alternative for administering construction projects and a means of coping with rising costs, staffing shortages, and losses of experienced personnel.

Another recent initiative in warranty projects occurred in 1998 when the New Mexico DOT entered into a 20-year warranty contract with Mesa Private Development Company. The $62 million warranty guarantees the overall performance of 121 miles of Highway 44. The warranty is secured by a $114 million surety bond that decreases in value annually.

Cost + Time (A + B) + Quality

Those involved in NCHRP Study 10-49, Improved Contracting Methods for Highway Construction Projects, are advocating several innovative contracting methods. Among these are refinements in warranty specifications and multiparameter bidding. Multiparameter bidding includes A + B + Incentive/Disincentive and the development of a quality parameter to be used in the bidding process. The concept of A + B + Quality allows quality to be a measurable quantity commensurate with cost and time.

FUTURE DIRECTIONS

The ultimate goal for the future of quality assurance is to achieve a state of enlightenment wherein statistical quality assurance practices are regarded as a logical and rational extension of engineering and mathematical knowledge. Achievement of this enlightenment would be demonstrated by a broad understanding and widespread application of the most effective quality assurance methods by highway agencies throughout the nation. Topics that will be of paramount importance in the near future include the following:

- Performance relationships and performance-related specifications;
- Statistical quality assurance and control techniques;
- Acceptance sampling, and accuracy and precision of tests;
- Optimal levels of inspection and testing;
- A rational and scientific basis for pay schedules;
- Cost-effectiveness of quality assurance procedures; and
- New methods of engineering or mathematical analysis related to these issues.

Attention must also be paid to the identification of poor or ineffective practices that either waste resources or provide a false sense of security regarding the level of quality achieved. Of particular concern are techniques and procedures published in national guide specifications that obviously must be held to the highest technical standards.

SUMMARY

At the dawn of the 21st century, a number of initiatives aimed at improvements in pavement quality and in specifications related to achieving this goal are under way:

- Quality assurance specifications are being used or developed by about 45 state highway agencies.
- Contractor quality control is a widely accepted practice.
- Several state highway agencies are using contractor test results for acceptance, given the requisite verification procedures.
- Development of PRSs is ongoing and appears promising.
- Warranty specifications are gaining in popularity.
- Several other innovative contracting practices are being developed.

ACKNOWLEDGMENT
The author thanks committee members Richard M. Weed, New Jersey Department of Transportation; Gerald J. Rohrbach, Minnesota Department of Transportation; and Peter A. Kopac, Federal Highway Administration, for their contributions to this paper.

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