100 YEARS TRB
MOVING IDEAS: ADVANCING SOCIETY

CENTENNIAL PAPERS

Standing Committee on Quality Assurance Management (AFH20)
Timothy Aschenbrener, Chair

Construction Quality Assurance Accomplishments and Outlook for the Next Century

KEVIN K. MCGHEE, *Virginia Transportation Research Council*
CHARLES. S. HUGHES, *AFH20 Emeritus/VTRC (retired)*
ASHLEY F. BUSS, *Iowa State University*

YESTERDAY

The Genesis

The body of academic, agency, and industry experts now known as TRB's Committee on Quality Assurance Management (AFH20) was originally formed in 1968 as the Quality Assurance and Acceptance committee. It was constituted to help focus the increased awareness of the need for a more scientific approach to developing construction and material specifications. This awareness was in large part brought about by findings from the AASHO Road Test (1956-1958).

Prior to the AASHO Road Test, specifications were, with few exceptions, methods and materials based, sometimes called prescription or "recipe" specifications (Bowery and Hudson, 1976). "It was during the construction of this project [the AASHO Road Test] that a sufficient number of unbiased test results of construction materials and techniques became available to expose the true variability of these results and their relationship to specifications." The analysis of results of the material and construction properties from this test road revealed variabilities that were much greater than expected. Carey and Shook stated that "AASHO Road Test specifications were intended to represent typical specifications, the kind used every day for control of our large highway construction program." (Carey and Shook, 1966) The specifications for the Road Test were based on what a panel of engineers judged could typically be built. A conclusion from this report on the Road Test stated:

> "Briefly summarizing, we want to show that with many more well-trained inspectors than could economically be used in normal construction, with high-speed testing techniques, with a large scale materials laboratory on site, with the ability to control in detail the contractor's construction procedures, with a highly competent and cooperative contractor who was well paid for everything he was required to do, and the eyes of the highway fraternity on the back of our necks, we were still unable to meet the specifications for many of the construction items within a country mile." (Carey and Shook, 1966)

The Road Test, heavily supported by the Highway Research Board (HRB) in terms of funding and personnel, inspired a national-level effort to write specifications that were scientifically based, defensible, and fair to both the owner agency and the contractor. Several papers emanating from this effort were presented and published through the HRB as the work progressed, but the first documentation developed by The Quality Assurance and Acceptance Committee was Special Report 118, "Quality Assurance and Acceptance" (1971). This special report was divided into two parts. The first, "State of the Art", contained five papers, each devoted to an individual material. The second

part, “Highway Department Needs”, set the stage for research efforts that were to take place in the ensuing years.

Committee Evolution

Designation and Name

The committee evolved throughout the years, along with an increased emphasis on quality assurance in the US as material and construction specifications began to incorporate statistical analysis to better describe what agencies needed to optimize highway performance. These analytical methods also provided the necessary tools to determine what contractors were providing. This allowed procedures to be developed that provided incentives for enhanced quality.

The evolution led to the recognition that the committee title was too restrictive and needed to be broadened. This led to the committee being renamed “Management of Quality Assurance” in 1985 and, more recently, to the present name, Quality Assurance Management in 2016. The numerical designations assigned by TRB have included A2H02, A2F03 and AFH20 (current).

Scope

In the early 90’s TRB began to ask committees to conduct “self-evaluations” every three years to, among other things, explore the committee’s scope, areas of research emphasis, and membership. The Triennial Self Evaluation (TSE) morphed into a Triennial Strategic Plan (TSP) by the early 2000’s, but effectively served the same purpose. A review of The Committee’s TSE/TSP’s is helpful in understanding its more fundamental evolution.

The 1990’s. The Scope statement from the first TSE (1993) claimed “total quality management in the transportation field” as the Committee’s purview. It further emphasized the application of engineering and statistical knowledge towards quality assurance for design, construction, and maintenance. It then goes on to include end-result and performance-related specifications – relatively new concepts at the time.

Early 2000’s. This first-documented scope statement (later dated to 1991/92) remained unrevised for the next decade until a new revision was posted with the 2001 TSE. This latest revision primarily consisted of a repackaging of the same basic concepts. Most notably dropped from the assortment of relevant techniques and tools that might be used to forward its mission were nomographs.

The next revision to the Scope (circa 2004) incorporated “maintenance and rehabilitation” among the kinds of construction with which the Committee should concern itself. “Laboratory testing, commercial or research,” as conducted in support of relevant quality management practices was also specifically addressed. Finally, the recognition that effective quality assurance procedures ultimately support lowest overall costs was qualified to also recognize the “needs of the traveling public”.

Today. The most recent revision (2014) takes a simplified, “back to basics” approach to communicating the Committee’s scope. While adding an emphasis on “materials” and “performance” to its opening statement, it no longer attempts to specifically cite the types of transportation-related activities and processes to which the Committee’s work applies. Continuing that theme, the growing list of example “efforts” the Committee might support was reduced to

simply those that support "sound, practical and effective quality assurance procedures, as well as methods to achieve quality transportation facilities to meet the needs of the traveling public".

Goals/Future Plans

1960s – 1980s. The original goal of developing and promoting "specifications that were scientifically based, defensible, and fair to both the owner agency and the contractor" took the form of *statically oriented end-result specifications* (1960s). That form evolved through various quality initiatives to become *statistical quality assurance* (1970s), *total quality management* (1980s), and *quality management* (1980s) (Hughes, 2001).

After nearly three decades of development and application, the first TSE recognized that owner-agencies still needed help (i.e., some "nudging") with the use of more statically-based, end-results specifications (SBER). With that as a goal, the 1992 TSE offered the following two tasks:

- Seek to determine why more agencies are not adopting SBER.
- Ensure that Total Quality Management (TQM) and SBER complement, not compete.

1990s. The Committee goals broadened over the next 3 years to emphasize the dissemination of sound quality management programs in general with its support of AASHTO's Quality Assurance Guide Specifications. Committee goals also recognized the need to strengthen the relationship between performance and specification requirements. It was also within this timespan that the community became acutely aware of the need to develop and promote a standard vocabulary. This inspired the Subcommittee on Definitions, which produced (and included with the 1995 TSE) the first "glossary of QA terms".

The early 1990's also brought forth the National Quality Initiative (NQI), a joint effort of AASHTO, FHWA, and the industry. The NQI's mandate to focus national attention on improving construction quality in the highway industry resonated perfectly with the Committee's mission. The final TSE of the 90s included plans to solicit and publicize NQI-related "success stories". The 1998 self-evaluation was also the first to recognize the tremendous potential for private sector innovation and the role that well-developed performance-based specifications may have in realizing that potential.

2000s. As the new century arrived The Committee continued to promote ideas to develop better relationships between performance and specification requirements. Plans to address accuracy and precision were documented, as were the need for a rational and scientific-based basis for pay schedules. The continuing move away from traditional inspection practices to those performed by either the contractor or a third-party consultant inspired emphasis on optimal levels of inspection and testing.

By this time The Committee well understood its responsibility to maintain the *Glossary of Highway Quality Assurance Terms*, including a revision among its essential tasks of the next triennial. The need to keep it relevant and current was only made more important by the continued shift of resources and responsibilities from agencies to industry.

2010s. The plans for today's Committee, as articulated through strategic plans (TSPs) from 2014 and 2017, include moving beyond construction quality assurance to also include facility design and performance functions. The Committee likewise recognized the need to address the growing application of alternative contracting for design, construction, and facility operation. Unresolved issues documented in The Committee's plan included quality standard for data generation,

manipulation, and interpretation. The plan also acknowledged a need to collaborate across transportation modes on common quality assurance related issues.

The last TSP of the decade reiterated the importance of addressing alternative project delivery methods – highlighting the success of the recently-formed subcommittee on alternative delivery projects, a joint effort with AFH15, Committee on Project Delivery Methods. The increasing push to cover more topics (beyond construction of pavements) prompted the Plan to include the recruiting of subject-area experts for membership on the Committee who have not traditionally been sought for membership.

Leadership

- Leo Sandvig - Chair 1968-1975
- Garland "Butch" Steele - Chair 1975-1981
- Ed Breckwoldt - Chair 1981-1987
- Orrin Riley - Chair 1987-1993
- Chuck Hughes - Chair 1993-1999
- Ron Cominsky - Chair 1999-2005
- Rita Leahy - Chair 2005-2011
- Kevin Hall – Chair 2011-2017
- Tim Aschenbrener – Chair 2017- present

Major Accomplishments - "The Glossary"

Although there have been many accomplishments of this committee during its existence, one that stands out is the development of the "Glossary of Highway Quality Assurance Terms". Recently the sixth update, or seventh edition, Transportation Research Circular E-C235 (August 2018) was published. It originated with the 1996 Transportation Research Circular Number 457. The first update was Transportation Research Circular E-C010 in 1999, the second was Transportation Research Circular E-C037 in 2002, the third was Transportation Research Circular E-C074 in 2005, the fourth was the Transportation Research Circular E-C137 in 2009, and the fifth was the Transportation Research Circular E-C173 in 2013.

The Glossary of Highway Quality Assurance Terms is extremely important in the communication of Highway Quality Assurance terms, which are often misunderstood and misused. The Committee intends to continue to provide updates when necessary. One objective of the regular updates is simply to improve the quality of the definitions. Such improvements certainly are anticipated once the definitions are put to use and specific problems or shortcomings are identified by users. The updates also permit for the addition of new terms that may come into use, along with the review and possible modification of existing definitions to accommodate new understanding resulting from the new term. This latter aspect attempts to account for the dynamic nature of the transportation construction QA language. Still another aspect of updating is the addition of new terms within topics not addressed in this publication. Many additional topics are possible for inclusion in future revisions of the glossary; some topics may require coordination with other TRB committees to best establish suitable definitions. Closely related to the update of glossary definitions is improvement of the overall publication. For example, some of the referenced sources in this publication may not be entirely accurate in identifying the earliest document that should receive credit for creating a definition; therefore, some of the references may need to be revised. Comments or suggestions are welcome on how either the definitions themselves or any other parts

of this publication can be improved to meet the users' needs or to better provide a reference document that fosters uniformity and understanding.

TODAY

Alternative Project Delivery – Subcommittee AFH20(1)

AFH20's collaboration with AFH15 to establish the Subcommittee on Alternative Project Delivery is indicative of where construction quality management is today. The subcommittee concerns itself with all aspects of quality management as related to the planning, procurement, design, construction, operations and maintenance of transportation facilities delivered by some alternative method (PPP, DB, CMG at Risk, etc.). Specifically, it focuses on the development and application of both engineering and statistical knowledge to achieve high levels of quality in the most cost-effective manner possible to meet the needs of the traveling public.

The larger committee continues to concentrate on areas that need clarification and emphasis. Continued emphasis on alternative approaches for project delivery is evident in recently proposed synthesis topics and workshops. Because of the increase in these types of contracts, QA in this context is a major topic today and expected to be well into the future.

Some highlights include Sunday workshops at the 2017, 2018 and 2019 TRB Annual Meetings regarding *Quality Management Systems for Design–Build Projects: Case Studies*. Additionally, the subcommittee created 27 research need statements and syntheses and then prioritized them for submission.

Validating Contractor Test Results

Other areas of emphasis have to do with improving ways of validating contractor test results for use in acceptance and payment, as well as further enlightenment on the importance of risks to both the agency and contractor. A recent *NCHRP* Problem Statement submitted by the committee, *"Optimal Procedures for Validating Contractor Test Data*" was selected for funding. This research is underway as a joint project with the University of Nevada Reno and National Center for Asphalt Technology (NCAT) and is titled "*Procedures and Guidelines for Validating Contractor Test Results"*. Owner/agencies and the industry alike have much at stake concerning this topic. Each must develop confidence that the testing is sufficient to characterize work quality and validate payment decisions within state and federal requirements. Similar to this work, the committee invited a FHWA sponsored paper entitled. "*Development of Guidelines for Selecting Optimum Sample Size Validation of Contractor Test Data with Improved Application of F and t Testing Verification"*. This paper provides analyses that provides evidence that small sample sizes do not provide the risk protection needed for state agencies and contractors to be assured that their acceptance plans are adequate.

Automated and Digital Construction Processes

Advancements in automation and the ability to continuously monitor construction processes provides opportunities in quality assurance management. Advancement in non-destructive testing technology also provides opportunities for enhanced quality assurance. Examples of these technologies include:

- Digital elevation models
- Intelligent construction technologies and nondestructive test methods
    - Intelligent compaction
    - Thermal profiling

- GPR density scanning
- Real-time smoothness measurement
- Nondestructive thickness measurement

Facility Life Cycle

As the concepts of sustainable development continue to grow, there is growing emphasis on the interconnectedness of the various elements associated with a facility's life cycle. For example, in the area of pavements, data necessary for design, construction, performance, preservation, and rehabilitation are related. Researchers continue to pursue platforms for incorporating pavement design, construction, and performance; indeed, many mechanistic-empirical design models require 'as-built' construction data and subsequent performance data for proper calibration and validation. Each of these life-cycle elements are increasingly data-rich; however, tools for comprehensive QA of that data may not be present or in routine use. Quality Assurance, as a science, is applicable across the spectrum of the life-cycle. Committee AFH20 must seek to partner with committees both within the Design and Construction Group and outside the Group to investigate a truly comprehensive approach to QA across the range of activities associated with the life cycle of infrastructure elements.

TOMORROW

The committee has identified trends and emerging issues by reviewing past TSPs and through committee discussion in the 2019 meeting. Trends and themes for tomorrow's challenges include strategies for incorporating data-intensive technologies into QA, strategies for risk-based inspection, and strategies for quality assurance in the software programs used in design and construction. Shrinking budgets and lean operations are requiring more outsourcing of day-to-day operations. Quality assurance plans that include overtones of partnering will be important for our future transportation infrastructure.

Evolving construction processes involve the use of increased technology on the construction site, i.e. digital elevation models, intelligent compaction, etc. These advances generate significant amounts of construction data – for which more traditional QA systems may be not equipped to handle. The QA process must also evolve and explore concepts of data-analytics to address both the increasing amounts and types of data generated during construction. Continual monitoring systems and strategies for how to incorporate monitoring data into defensible incentives/disincentives may be an area of future interest. There are also challenges regarding quality assurance of performance monitoring data.

Data collection systems have improved with time; however, the variability of parameters over time may change as well. The quality assurance of software packages and sophisticated design models are another area of interest to The Committee. Many agencies are challenged with a fast-paced world of evolving technologies that require quality assurance to adapt in new ways. When incorporating new technologies, how those technologies impact risk distribution should be considered, equitably distributed, and incorporated into a quality assurance management plan.

Over the next few years, NCHRP will fund research related to risk-based quality control/quality assurance to strategically allocate resources. Historically AFH20 has considered, almost exclusively, QA issues related to pavement construction – and further, the construction of pavement surface layers (asphalt and concrete). However, there are significant additional elements included in highway projects, i.e. base course and subgrades, bridge superstructure and decks, etc. QA procedures for construction-related data for these elements must be addressed as projects have

become more comprehensive and complex. Over the next three years, Committee AFH20 will seek to aggressively address the issues identified in the previous section:

- alternative delivery methods;
- data related to automated/digital construction processes;
- non-pavement infrastructure elements;
- data related to design and performance of infrastructure elements;

REFERENCES

1. Bowery, F.E., Jr., and S.B. Hudson, NCHRP Synthesis of Highway Practice 38: Statistically Oriented End-Result Specifications, Transportation Research Board, National Research Council, Washington, D.C., 1976.
2. Special Report 118, "Quality Assurance and Acceptance" (1971)
3. Hughes, C.S., Transportation in the New Millennium, TRB Committee A2F03: Committee on Management of Quality Assurance, 2001.