TECHBRIEF

Guidelines for Establishing and Maintaining Construction Quality Databases

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Introduction

Construction quality databases contain a variety of construction-related data that characterize the quality of materials and workmanship. The primary purpose of construction quality databases is to help State highway agencies (SHAs) assess the quality of materials production and placement, including the establishment of pay factors for quality. A secondary purpose is to support other agency activities, including performance analysis and improvements to current standards and specifications. These databases have become a critical component in construction quality assurance (QA) programs.

Increasingly, SHAs are recognizing that the more data that a database contains, the greater potential there is for agency staff to use and analyze the data and thereby benefit from it. Agency staff also may integrate information assimilated in a construction quality database with other databases, such as State pavement management systems (PMS) and maintenance records. Integrating databases enables agencies to perform more advanced analyses, such as the type of research needed to develop or refine performance-related specifications, warranty specifications, innovative contracting procedures, and material/process pay factors, and to check the design adequacy of material or validate assumptions about a structure's design. For an integrated system to be effective, the construction quality database must be well constructed and its attributes clearly defined to permit widespread use within an agency. The study upon which this TechBrief is based, *Advanced Quality Systems: Guidelines for Establishing and Maintaining Construction Quality Databases* (FHWA-HRT-07-019), provides a detailed description of an ideal construction quality database. FHWA developed this description based on best practices synthesized from several agencies.

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Current Practice

While most SHAs have established and maintained construction-related databases for many years, it is only within the last 5 to 10 years that SHAs have realized the need for more detailed databases to accommodate the requirements of the new QA programs, which the agencies have developed in response to Title 23, Part 637, *Code of Federal Regulations*. A recent survey by the National Cooperative Highway Research Program on State construction QA programs (Hughes, 2005) found that all States are using some type of quality database and in particular databases to collect information on hot-mix asphalt and portland cement concrete paving materials. The SHAs have designed these databases to meet their specific needs; the purpose, data collection, storage, and management of the databases vary in every State. SHAs also commonly maintain multiple, disparate databases to meet their requirements.

Some agencies have been proactive in establishing a single, comprehensive QA system. Most modern databases are Web-based structures that permit statewide access and integrate all phases of the project life cycle—mix design, construction, maintenance, and performance.

State Surveys

The departments of transportation in Arizona, Florida, Georgia, Kansas, Louisiana, Maryland, Minnesota, New Jersey, Pennsylvania, Oregon, Texas, and Washington responded to a survey with queries regarding their database(s), QA program management, QA data collection procedures, QA process, database integration, specifications and standards, and data analysis processes. Researchers also conducted indepth reviews and discussions with select agencies. In general, the researchers found that the States' current systems serve their current needs. While some SHAs are implementing standard database programs such as the SiteManager™ module of AASHTO Trns·port®, and the Laboratory Information Management System (LIMS) database, some have implemented or are in the process of developing and implementing customized programs.

The surveys also pointed to certain issues that limit the utilization and full benefits of the information included in the databases. The researchers found that specifications or special provisions governing construction are not always part of the QA databases. Only one of the surveyed agencies makes validation test statistics, such as F-test and t-tests, available as part of their QA database.

The researchers also found that the States have been collecting extensive data for several years, but do not often or necessarily use the data to draw valuable conclusions or perform advanced analyses for broader use. For example, the States have established very limited correlations between construction quality and performance, or quality and cost benefits. The primary reason for not establishing these correlations is because the States store the data required for such analyses in different databases, such as State PMS and cost databases, with different referencing systems, resulting in the inability to crosswalk the data.

"Data rich and information poor," as explained by one agency, best describes the current status of today's databases. The focus of many agencies is on entering data, not retrieving or analyzing the data. While current systems have served the needs of agencies remarkably well over the past several years, most agency staff indicated that future upgrades should include more user-friendly, comprehensive, and efficient systems with real-time update features. The agencies also expressed a strong preference for allowing broader use of data for performing materials and performance correlations, improving QA procedures, and updating specifications.

The researchers identified that an effective means to establish and maintain an efficient database is to assign a dedicated position within an agency. The sole responsibility of the person holding that position would be to oversee the efficient management of the various databases.

This position would involve significant interdepartmental coordination, and the selected individual for this role should have a wide understanding of the functions and needs of all involved departments.

Recommended Model Database

The recommendations provided below are intended to help SHAs upgrade and maintain systematic and efficient database systems. Agencies are not expected to develop new systems based on these recommendations; instead, the recommendations describe the mechanics of developing efficient databases and cover basic database functions.

Special Considerations and Features

When developing an ideal database, the following features should be incorporated:

- Access by all departments and personnel.
- Different levels of access security.
- Ability to make user group assignments.
- Audit and tracking information to trace users.
- Offline use or wireless device access.
- Ability to generate system outputs and ad hoc reports.
- Common referencing system and interface with other systems.

Referencing System

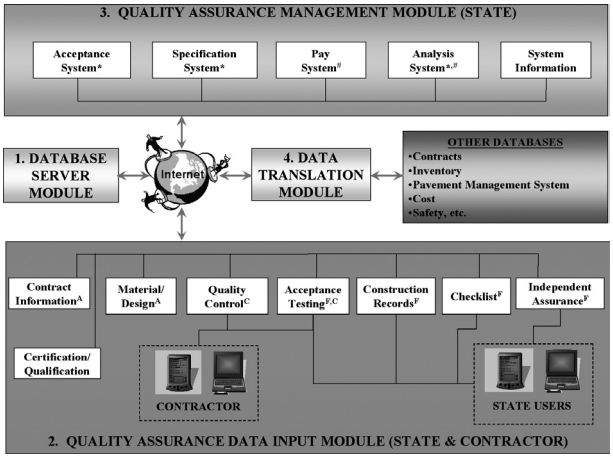
A referencing system is the scheme adopted to identify specific points or segments of a pavement. These systems form the critical link across databases for data integration.

Lots, characterized by the beginning and end stations, are the definable entities in a construction quality database that can be linked with a PMS to make meaningful correlations between datasets. Agencies should consider incorporating this common referencing scheme for immediate implementation or in their short-term plans. For the long term, using a geographic information system will provide greater flexibility in identifying attribute data, and is amenable for use in relational database systems and in databases where dynamic segmentation is necessary.

Software Architecture

The proposed system, illustrated in figure 1, consists of four modules:

1. **Database server module**—The database server module forms the core of the architecture and stores system data. All other modules connect with the server though the Internet.
2. **QA data input module**—This module provides an interface to record all information relevant to each construction project from project initiation to the final acceptance of the construction.
3. **QA management module**—The QA management module uses data input to analyze the quality of construction in the project.
4. **Data translation module**—This module provides the tools to translate data for compatible communication with other systems within a standard format, such as XML. This module also acts as a communication channel with other systems to provide the desired QA testing data to other systems.



A Data input by project management staff from State's central or district office.

F Data input by State field personnel. May be input using stand-alone input interface.

C Data input by contractor. May be input using stand-alone input interface.

***** Information common to the entire system and entered by the State.

Analysis and calculations performed for specific needs. May require data integration with other databases.

Figure 1. The architecture of a construction quality database system is shown.

Outputs and Analysis

In addition to outputting pay factors in the agency's format, the system described above enables the user to generate statistical reports, mix design information, construction quality reports for a specific project, appropriate QA data, and location, climate, and other information needed

to conduct an analysis of the correlation of the quality of construction with future performance.

The analyses that can be performed will depend on the extent of data maintained in the system. Agencies with databases containing basic material and construction quality data can perform fundamental statistical analyses and assess variability in construction quality. If condition survey databases are integrated, material and construction quality can be correlated to performance. This correlation can be used as a basis for establishing warranty specifications. Agencies maintaining advanced construction quality database systems that can be integrated with other databases or project information, such as a cost database, also can perform complex analyses to assess the cost-effectiveness of specifications and practices. Cost databases typically should include material and construction, maintenance, and user costs to determine life cycle costs accurately. In such cases, agencies can perform cost analyses to strike an optimum balance between quality and cost or performance and cost for the specific material types and construction practices they use.

Benefits

A well-developed database offers many benefits, including:

- Ability to securely upload or import data from external sources.
- Automated data entry and centralized storage of data and contract documents.
- Automated means to calculate pay factors.
- Ability to highlight specification nonconformance in real time.
- Generation of ad hoc and standard reports.
- Advanced engineering analysis, including performance correlations, effectiveness of specifications, warranties, etc.

References

Hughes, C.S. 2005. "State Construction Quality Assurance Programs," *NCHRP Synthesis 346*, National Cooperative Highway Research Program (NCHRP), Washington, DC.

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Distribution—This TechBrief is being distributed according to a standard distribution. Direct distribution is being made to the Divisions and Resource Center.

Availability—The publication from which this TechBrief was developed, *Advanced Quality Systems: Guidelines for Establishing and Maintaining Construction Quality Databases* (FHWA-HRT-07-019), is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. A limited number of copies will be available from the Research and Technology Product Distribution Center, HRTS-03, FHWA, 9701 Philadelphia Court, Unit Q, Lanham, MD 20706, 301–577–0818 (phone), 301–577–1421 (fax).

Key Words—quality, construction, materials, database, quality assurance, quality control, acceptance, pavement performance, pay factor