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Introduction

For many years, transportation departments (DOTs) performed testing and inspection to verify the quality of materials used in highway construction. During those years, DOTs were the sole testing and inspection authority. Later, as some of the testing duties were shifted to the contractor, the DOTs continued performing tests for acceptance or verification. The contractor testing was then referred to as quality control, while the DOT testing and inspection were termed quality assurance.

In the past two decades, the use of alternative project delivery methods challenged the traditional quality management approach where the contractor performed quality control while the owner conducted quality assurance. This caused a shift in perspective about quality assurance. As Figure 1 illustrates, in today’s work environment quality assurance is viewed as an umbrella under which all quality management activities take place and the owner’s primary quality assurance role is one of acceptance. Use of the term quality assurance is now favored over the previously used abbreviation QAQC or QCQA.

Figure 1. FHWA Concept of Quality Assurance

Quality construction is fundamental to meeting the mission of the California Department of Transportation (Caltrans), and quality assurance is the primary means by which Caltrans ensures the quality of constructed highway projects.

Quality assurance encompasses all materials and construction activities on a project and directly impacts the service life of a transportation facility. The elements of an acceptable quality assurance program include quality control by the contractor, acceptance testing and inspection by Caltrans,
independent assurance, qualified personnel, accredited laboratories, and a dispute resolution process. These elements work together to ensure an effective quality assurance program. Any elements missing from the program increase the risk of a reduced service life.

The Construction Quality Assurance Program (QAP), developed by Caltrans for highway construction projects, adheres to the quality assurance requirements outlined by the Federal Highway Administration (FHWA) in 23CFR 637, Construction Inspection and Approval, Subpart B – Quality Assurance Procedures for Construction, Section 637.205, “Policy,” and Section 637.207, “Quality Assurance Program.”

The role of the QAP is to provide confidence that the quality of the materials and workmanship incorporated into all highway construction projects is in conformity with the requirements of the plans and specifications.

Quality Assurance Program Manual Overview

Purpose
Completed projects represent tangible products by which Caltrans is measured in the delivery of its programs. The public ultimately defines the success of Caltrans’ performance based on these projects.

Caltrans makes every effort to achieve quality construction in all its projects. As a result, over the years, Caltrans has developed many procedures and methods to ensure that every construction project achieves the desired level of quality for both materials and workmanship. The responsibility for ensuring quality construction has been shared by various functional groups in the department. This has resulted in distribution of quality-related policies, procedures, and guidelines throughout the department, with no single, consolidated document available as a guide for all quality-related requirements.

Scope
This manual documents the QAP by identifying existing requirements from all applicable department policies, procedures, and guidance documents (see Appendix B, Caltrans Quality Assurance Documents) and references them in one document. This manual also demonstrates compliance with 23 CFR 637 referenced above.

The provisions of this manual do not apply to projects for which Caltrans has entered into a public-private partnership or a design-build agreement, but they do apply when the project is under a construction manager/general contractor (CM/GC) agreement. The Caltrans document, “Design-Build Demonstration Program Quality Manual Outline,” provides guidance to designers-builders regarding quality assurance. For alternate project delivery methods, Caltrans retains responsibility for acceptance. The implementing agency may use its own program when authorized by Caltrans; however, Caltrans retains authority for the project and performs independent quality assurance to ensure that the implementing agency’s quality assurance activities result in projects being developed in accordance with Caltrans standards, policies and practices and the quality control plan provided by the project sponsor.
The manual does not repeat information contained in other manuals but references where the inspection, acceptance testing and independent assurance requirements are found for materials used in highway construction.

Organization

- Chapter 1, Construction Quality Assurance Program, describes the QAP activities performed by Caltrans to achieve the specified quality for constructed highway facilities. These activities include control of documents and records, management responsibilities, resource management, process control, inspection and testing, control of nonconforming work, control of testing and measuring equipment, and project materials certification.

- Chapter 2, Construction Quality Assurance Roadmap, describes the six major components of the QAP; presents the route to developing quality assurance specifications for materials, workmanship, products, and services; summarizes the various quality assurance methods used by Caltrans; and provides guidance in determining which of those quality assurance methods are needed to achieve a level of quality assurance commensurate with the application of an item and severity of the consequences of its failure.

- Chapter 3, Construction Quality Assurance Long-Range Plan, recommends and describes a potential long-range plan for improvements to the QAP. The long-range plan includes establishing a construction quality assurance database, adopting a system-based acceptance process, implementing performance specifications, and adopting risk-based acceptance criteria based on use of performance-related specifications, risk-based acceptance, and system-based acceptance. Development and implementation of a materials management system construction quality assurance database is the primary recommendation to improve the efficiency and quality of the QAP.

Process for Updating

The Division of Construction issues Quality Assurance Program Bulletins (QAPBs) (Appendix A) to improve this manual and to respond to procedure and policy changes. As needed, subsequent revisions will be made to the manual to incorporate QAPBs. QAPBs supersede any conflicting information, guideline, or instruction in the manual. If a policy contained in this manual is unclear or has been superseded and a QAPB has not been issued covering the changed policy, notify the Division of Construction manual coordinator.

The Division of Construction will routinely revise the manual to make improvements and to incorporate issued QAPBs.
Chapter 1

Construction Quality Assurance Program

Overview

The Quality Assurance Program (QAP) includes an acceptance program for materials and workmanship, an independent assurance program, and preparation of a project materials certification. Consistent with the Code of Federal Regulations Title 23, Section 637 (23 CFR 637), the QAP ensures “that the materials and workmanship incorporated into each Federal-aid highway construction project on the National Highway System (NHS) are in conformity with the requirements of the approved plans and specifications, including approved changes.” The QAP is also applicable to all California Department of Transportation (Caltrans) projects on the state highway system.

Chapter 1 describes QAP-related organizational roles and responsibilities and the policies and procedures designed to ensure that specified construction materials and workmanship incorporated into each project are acceptable and in conformance with the contract documents. The chapter is organized into 10 sections as follows:

1. Definitions and Abbreviations
2. Specified Level of Quality – Materials and Workmanship
3. Document and Record Control
4. Management and Staff Responsibilities
5. Resource Management
6. Process Control
7. Inspection and Testing
8. Control of Nonconforming Work and Materials
9. Control of Inspection, Measuring and Testing Equipment
10. Project Materials Certification

Section 1 addresses the definitions and abbreviations associated with the specialized vocabulary in quality assurance programs.

Sections 2 through 10 are based in part on the International Organization for Standardization (ISO) 9001, Quality Management Systems. The ISO 9001 standard lists 20 quality management elements that must be addressed in developing and operating a quality assurance program. These sections demonstrate the QAP’s conformance with the ISO 9001 elements applicable to transportation construction. Some ISO 9001 elements are not addressed in the QAP because they reflect the manufacturing-related origins of the ISO 9000 series and a literal application to transportation construction is not appropriate.
Section 1
Definitions and Abbreviations

The terms related to the Caltrans quality assurance program are defined below.

1.1.1 Definitions

acceptance: The process of deciding if the material and workmanship meet contract requirements.

acceptance program: All factors that comprise Caltrans’ determination of the product’s quality as specified in the contract requirements. These factors include verification sampling, testing, and inspection, and may include results of quality control sampling and testing. (Refer to 23 CFR 637B.)

acceptance tests: Defined in Chapter 6-102, “Types of Sampling and Testing,” of the Construction Manual as “tests performed on samples from the materials that will be incorporated into the work.”

acceptance sampling and testing: Sampling, testing, and assessing test results to determine whether the quality of produced material or construction is acceptable in terms of the specifications.

accredited laboratories: Laboratories that are accredited by Caltrans in accordance with the requirements of the Caltrans Independent Assurance Manual (IAM), Section 2.4, “Laboratory Accreditation,” for performing tests on aggregates, asphalt concrete materials, embankment and soils, and cementitious concrete materials.

authorized laboratories: Independent testing laboratory: (1) not employed or compensated by any subcontractor or subcontractor’s affiliate providing other services for the contract, and (2) authorized by Caltrans. (Refer to the Standard Specifications.) This includes laboratories accredited in accordance with Section 2.4 of the IAM, as well as laboratories authorized using other methods.

construction manager/general contractor: A project delivery method where the contractor is selected during the design process and makes input to the design via constructability, cost engineering, and value analysis reviews. Once the design is complete, the same entity builds the project as the general contractor. The construction manager/general contractor delivery method assumes the contractor will self-perform a significant amount of the construction work.

construction manager-at-risk: A project delivery method similar to the construction manager/general contractor method, except the construction manager does not self-perform any of the construction work.

design-bid-build: A project delivery method where the design phase and the construction phase are done by separate entities.
design-build: A project delivery method where the design phase and construction phase of the project are both simultaneously awarded to a single entity.

documentation: Proof in the form of detailed records or charts supporting the effectiveness of a quality control system.

fabricated: Custom made under controlled conditions to Caltrans specifications.

independent assurance program: Activities that are an unbiased and independent evaluation of all the sampling and testing procedures used in the acceptance program. (Refer to 23 CFR 637.)

implementing agency: The entity charged with the successful completion of each project component as defined in California Government Code Section 14529 (b). (Refer to Deputy Directive 90, Funding of Quality Management Work on State Highway Projects, December 2006.)

independent quality assurance: The activities performed by Caltrans at a project level to ensure that the implementing agency’s quality assurance activities result in projects being developed in accordance with Caltrans standards, policies and practices, and the quality control plan provided by the project sponsor. (Refer to Deputy Directive 90, Funding of Quality Management Work on State Highway Projects, December 2006.)

manufactured: Mass produced under controlled conditions to standard industry specifications.

process control: The method for keeping a process within boundaries; the act of minimizing the variation of a process. (Refer to American Society for Quality, “Quality Glossary.”)

public-private partnership: Comprehensive lease agreement between Caltrans, or regional transportation agencies, and public or private entities for transportation projects.

qualified laboratories: Laboratories that are capable as defined by appropriate programs established by Caltrans. As a minimum, the qualification program shall include provisions for checking test equipment and the laboratory shall keep records of calibration checks. (Refer to 23 CFR 637.) (Note: Caltrans uses “accredited laboratories” as an equivalent to this term.)

qualified sampling and testing personnel: Capable personnel, as defined by appropriate programs established by Caltrans. (Refer to 23 CFR 637.)

qualified tester: Personnel qualified by successfully completing the process in the Independent Assurance Manual Section 2.3, “Tester Qualification,” or as defined in the plans and specifications.

quality: (1) the degree or grade of excellence of a product or service, (2) the degree to which a product or service satisfies the needs of a specific customer, and (3) the degree to which a product or service conforms to a given requirement.

quality assurance: All those planned and systematic actions necessary to provide confidence that a product, facility, or service will satisfy given quality requirements. (Refer to 23 CFR 637.)
quality control: All those actions and considerations necessary to assess and adjust production and construction processes to control the level of quality produced in the end product or facility, and to fulfill specified requirements.

quality control plan: Contractor’s plan to ensure quality control. (Refer to Caltrans Standard Specifications glossary.)


verification: The process of determining or testing the truth or accuracy of a test result by examining the data and providing objective evidence. Caltrans applies this process as part of the acceptance program by inspection, sampling, and testing to determine the accuracy of the contractor’s test results.

verification sampling and testing: Sampling and testing performed to validate the quality of the product. (Refer to 23 CFR 637.)
1.1.2 List of Abbreviations

The following abbreviations and their definitions are used in this manual.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transportation Officials</td>
</tr>
<tr>
<td>AFAL</td>
<td>Authorized Facility Audit List</td>
</tr>
<tr>
<td>AML</td>
<td>Authorized Material List</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials</td>
</tr>
<tr>
<td>BCRP</td>
<td>Caltrans Bridge Construction Records and Procedures Manual</td>
</tr>
<tr>
<td>CAPE</td>
<td>Contract Administration Process Evaluation</td>
</tr>
<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
</tr>
<tr>
<td>DES-SC</td>
<td>Division of Engineering Services, Structure Construction</td>
</tr>
<tr>
<td>DOT</td>
<td>Department of Transportation</td>
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<tr>
<td>FHWA</td>
<td>Federal Highway Administration</td>
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<tr>
<td>HMA</td>
<td>Hot mix asphalt</td>
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<tr>
<td>IAM</td>
<td>Caltrans Independent Assurance Manual</td>
</tr>
<tr>
<td>LCCA</td>
<td>Life Cycle Cost Analysis</td>
</tr>
<tr>
<td>METS</td>
<td>Division of Engineering Services – Materials Engineering and Testing Services/Geotechnical Services</td>
</tr>
<tr>
<td>MPQP</td>
<td>Material Plant Quality Program</td>
</tr>
<tr>
<td>NHS</td>
<td>National Highway System</td>
</tr>
<tr>
<td>OSM</td>
<td>Division of Engineering Services – Materials Engineering and Testing Services/Office of Structural Materials</td>
</tr>
<tr>
<td>PAVEM</td>
<td>Caltrans Pavement Management System</td>
</tr>
<tr>
<td>PBS</td>
<td>Performance-Based Specifications</td>
</tr>
<tr>
<td>PRS</td>
<td>Performance-Related Specifications</td>
</tr>
<tr>
<td>QAD</td>
<td>Quality Assurance Database</td>
</tr>
<tr>
<td>QAP</td>
<td>The Caltrans Construction Quality Assurance Program documented in this manual</td>
</tr>
<tr>
<td>QASI</td>
<td>Quality Assurance and Source Inspection</td>
</tr>
<tr>
<td>QCP</td>
<td>Quality Control Plan</td>
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</table>
Section 2
Specified Level of Quality—Materials and Workmanship

The QAP includes specifications and plans that describe the quality requirements for all material and workmanship to be incorporated into a project and the acceptance criteria by which Caltrans will verify conformance with the quality requirements. Material and workmanship quality requirements are established in the design process and reflect the minimum necessary to ensure that the material or item will function as designed. During construction, tests and inspections evaluate the acceptability of the material and workmanship based on the acceptance criteria.

1.2.1 Materials

The quality requirements for materials are contained in the (1) specifications for submittals, quality assurance, and materials; (2) contract plans; and (3) change orders. These documents include or reference the acceptance criteria for determining if the prescribed quality for materials has been met. For example, Standard Specifications Section 19-3.02 B, “Structure Backfill,” requires that structure backfill comply with the grading requirement of 100 percent passing the 3-inch sieve.

1.2.2 Workmanship

The quality requirements for workmanship are contained in the same types of contract documents described in Section 1.2.1, “Materials,” above. For example, Standard Specifications Section 73-3, “Sidewalks, Gutter Depression, Island Paving, Curb Ramps and Driveways,” requires that “The finished surface must not vary more than 0.02 foot from a 10-foot straightedge…”
Section 3
Document and Record Control

Activities affecting quality are prescribed by and accomplished in accordance with documented instructions, procedures, and drawings. These documents also include appropriate quantitative or qualitative acceptance criteria for determining that the activities have been satisfactorily accomplished.

The following types of documents are used in the QAP:

- Documents that provide consistent information, both internally and externally, about Caltrans’ QAP. Such documents are referred to as quality manuals.
- Documents that describe how the QAP is applied to a specific product, project or contract. Such documents are referred to as quality plans.
- Documents stating requirements. Such documents are referred to as specifications.
- Documents stating recommendations or suggestions. Such documents are referred to as guidelines.
- Documents that provide information about how to perform activities and processes consistently. Such documents include documented procedures, work instructions, and drawings.
- Documents that provide objective evidence of activities performed or results achieved. Such documents are referred to as records.

1.3.1 Document Control

The QAP includes procedures to control the issuance of documents, including changes, which prescribe all activities affecting quality. These procedures ensure that documents, including changes, are (1) reviewed for adequacy, (2) approved for release by authorized personnel, and (3) distributed for use where the prescribed activity is performed.

The process of preparing, issuing, and updating or revising those documents that specify quality requirements or prescribe activities affecting quality is controlled to ensure that correct, up-to-date documents are being used. The document control system ensures distribution and availability of the latest authorized documents to all required users prior to the start of work.

- Program level documents, such as the Construction Manual and changes thereto, are reviewed for adequacy and authorized for release by appropriate division personnel. For example, Construction Policy Bulletins are used to make immediate changes in policy to the Construction Manual and are reviewed and controlled by the Division of Construction. Manual Change Transmittals are used to incorporate Construction Policy Bulletins into the Construction Manual and are likewise reviewed and controlled by the Division of Construction. Another useful guide is the Office of Structural Materials Practices and Procedures (OSMPP) manual, which is controlled by the Office of Structural Materials (OSM).
Project level documents such as plans and specifications are controlled and issued by district office engineers as part of the construction contract for a project. Changes to these documents after project award are controlled by a change order process.

Table 1.3.1 lists supporting documentation.

<table>
<thead>
<tr>
<th>Title</th>
<th>Chapter/Section</th>
<th>Description</th>
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<tbody>
<tr>
<td>Construction Manual</td>
<td>Chapter 1, Section 0</td>
<td>Construction Manual Overview</td>
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<tr>
<td>Construction Manual</td>
<td>Chapter 5, Section 1</td>
<td>Project Records and Reports</td>
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<td>Construction Manual</td>
<td>Chapter 5, Section 3</td>
<td>Change Orders</td>
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<td>Construction Manual</td>
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<td>Projects Funded by Others</td>
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<td>OSMPP</td>
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<td>Shop Plan Review</td>
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<tr>
<td>BCRP</td>
<td>Section 16</td>
<td>Bridge Construction Forms</td>
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</tbody>
</table>

1.3.2 Records Control

The QAP includes procedures that ensure sufficient records are maintained to furnish evidence of activities affecting quality. At a minimum, inspection and test records must identify the inspector or data recorder, the type of observation, the results, the acceptability, and the action taken in connection with any deficiencies noted. Records must be identifiable and retrievable. Records retention requirements, such as duration, location, and assigned responsibility, are established.

Quality records describe the work involved and contain evidence that work items met the requirements of the plans and specifications; sampling and testing personnel, procedures and equipment were properly certified or accredited; and corrective action was taken for any nonconforming conditions. Records generated for the project by Caltrans, consultants, contractors, subcontractors, and suppliers represent an important and integral part of each construction project. Contractors are required to maintain quality records as evidence of their activities and those of their subcontractors and suppliers.

Resident engineers and structure representatives maintain records at the projects during the construction phase. After project closeout, those records are transferred to district archives and retained in accordance with record retention schedules. As-built plans for all projects on the state highway system are submitted to the document retrieval system unit at the Headquarters Office of Computer Aided Drafting Design and Engineering Global Information System Support. The official as-built plans are the microfilm copies stored with the headquarters microfilm unit.

Required quality records are indexed, filed, readily retrievable for authorized personnel, maintained, stored to minimize deterioration and prevent damage or loss, and archived according to applicable written procedures. Refer to Table 1.3.2 for examples of quality records indexed and filed in the uniform filing system.
Table 1.3.2. Records Control File Categories

<table>
<thead>
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<th>File Category</th>
<th>File Description</th>
<th>File Category</th>
<th>File Description</th>
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<tr>
<td>9</td>
<td>Welding</td>
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<td>Materials Testing Qualification of Employees</td>
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<td>11</td>
<td>Information Furnished at Start of Project</td>
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<td>Field Laboratory Assistant Reports to Resident Engineer</td>
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<tr>
<td>36</td>
<td>Concrete (other than structure items)</td>
<td>49</td>
<td>Change Orders</td>
</tr>
<tr>
<td>37</td>
<td>Initial Tests and Acceptance Tests</td>
<td>63</td>
<td>Project Completion Documents</td>
</tr>
<tr>
<td>38</td>
<td>Quality Control and Quality Assurance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Most project records are paper documents and are located either at the project field office for current projects, or the district archives for completed projects. To conduct a document review, one must visit the appropriate site. An example of a document review would be to determine if qualified testers were used in performing tests. The first step would be to sample records from Category 37, Initial Tests and Acceptance Tests, to obtain the names of testers. Then review records from Category 39, Materials Testing Qualification of Employees, to determine that testers are qualified. For more information, refer to the Construction Manual.

Table 1.3.3 lists supporting documentation.

Table 1.3.3. Records Control References

<table>
<thead>
<tr>
<th>Title</th>
<th>Chapter/Section</th>
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<tr>
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<td>BCRP</td>
<td>Section 9</td>
<td>Final Records and Reports</td>
</tr>
<tr>
<td>OSMPP</td>
<td>Section 1.17</td>
<td>Uniform Filing System for Project Specific Documents</td>
</tr>
</tbody>
</table>
Section 4
Management and Staff Responsibilities

1.4.1 Quality Objective
Caltrans’ strategic goals include efficient delivery of quality transportation projects and services, and promotion of quality service through a skilled workforce.

1.4.2 Quality Commitment
Caltrans is committed to providing adequate technical, administrative, and managerial services to ensure that each construction project is completed to the specified level of quality and, when placed in operation, provides a safe, reliable, easily maintained facility that fulfills the intended function and meets all applicable statutory and regulatory requirements.

1.4.3 Responsibility and Authority
Caltrans’ key organizations and management positions responsible for managing, performing, and verifying work affecting quality are described in Chapter 1, “Caltrans Construction Organization,” of the Construction Manual.

1.4.3.a Division of Construction
- The chief of the Division of Construction, located in headquarters, leads the QAP to deliver quality transportation products and services.
- Headquarters office chiefs and staff and construction field coordinators assist with contract administration processes and reviews.

1.4.3.b District Construction
- The district construction division chief or district construction deputy director is responsible for implementing the QAP in each region or district.
- District construction engineers are responsible for ensuring adequately trained resident engineers, ensuring that materials and work comply with plans and specifications, and maintaining project quality records.
- District materials engineers are responsible for district and field materials laboratories and the independent assurance program in each district. Depending on district or region structure, the district materials engineer is managed by either Engineering Services or Construction.
- The resident engineer assigned to each project is the onsite construction representative and is responsible for contract administration, construction engineering, and the acceptance of all materials and workmanship on each assigned project.

1.4.3.c Division of Engineering Services
- The Division of Engineering Services, Structure Construction (DES-SC) is responsible for technical control of structure work and has ultimate responsibility and authority for decisions relating to the structural adequacy of contract work on structures. DES-SC engineers are
assigned to all districts to provide field engineering for structures. The district may request that the assigned structure representative act as the resident engineer on projects where structure work predominates.

- Materials Engineering and Testing Services (METS) conducts specialized laboratory and field testing, provides source inspections, and gives expert advice on all phases of transportation engineering involving materials and manufactured products. METS also provides technical expertise for the development of statewide standards, procedural guidelines, and manuals.

1.4.3.d Other Divisions

The Division of Maintenance and Division of Design are available to support the resident engineer in implementing the QAP. Figure 1.4.1 reflects the many support services available to the resident engineer.

![Figure 1.4.1. Resident Engineer Support Services](image)

Individuals responsible for implementing the QAP and for verifying that activities affecting quality are properly performed have sufficient authority, access to work areas, and organizational freedom to:

1. Identify quality problems.
2. Initiate, recommend, or provide solutions to quality problems through designated channels.
3. Verify implementation of solutions.
4. Ensure that further processing, delivery, construction, or use are controlled until proper disposition of a nonconformance, deficiency, or unsatisfactory condition has occurred.

These individuals have direct access to the management level where appropriate action can be taken, with sufficient independence from cost and schedule considerations unduly influencing those decisions.

Table 1.4.1 lists supporting documentation.

<table>
<thead>
<tr>
<th>Title</th>
<th>Chapter/Section</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Construction Manual</td>
<td>Chapter 1, Section 1</td>
<td>Construction Organization</td>
</tr>
</tbody>
</table>

### 1.4.4 QAP Process Evaluation

Evaluations are conducted routinely to determine the effectiveness of the various QAP processes. When deficiencies are found, corrective actions are taken by the appropriate division.

The Division of Construction conducts an annual Contract Administration Process Evaluation (CAPE). The CAPE typically reviews four to six different elements of the contract administration process and reports strengths, weaknesses, and recommendations for improvement. The CAPE is described in the Caltrans Division of Construction Charter: Contract Administration Process Evaluation (CAPE). (Refer to Appendix C.)

OSM performs annual audits of each Quality Assurance and Source Inspection (QASI) Branch to ensure that the branches are using consistent practices and procedures.

DES-SC management conducts an annual Project Record Review for each structure representative. If inadequacies are found during a project record review, the reviewer conducts another review within 1 month to verify that the noted problems have been corrected.

Table 1.4.2 lists supporting documentation:

<table>
<thead>
<tr>
<th>Title</th>
<th>Chapter/Section</th>
<th>Description</th>
</tr>
</thead>
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<td>1.6</td>
<td>Quality Assurance and Source Inspection (QASI) Branch Audits</td>
</tr>
<tr>
<td>BCRP</td>
<td>3-3.0</td>
<td>Project Record Review</td>
</tr>
</tbody>
</table>
Section 5
Resource Management

The QAP includes guidance for Caltrans to provide necessary resources to implement, maintain, and continually improve the effectiveness of the program. Adequate personnel and technological and environmental resources are provided to support project delivery in conformance with regulatory requirements. These provisions are consistent with 23 CFR 637.205B requirements that adequate, qualified staff be maintained to administer the QAP. Caltrans also maintains a central transportation laboratory in Sacramento, California. The Transportation Laboratory is accredited by the American Association of State Highway and Transportation Officials (AASHTO) Accreditation Program for the testing of aggregate, asphalt binder, asphalt concrete, cement, Portland cement concrete, and soils.

1.5.1 Competence, Awareness, and Training

The QAP includes procedures to ensure the training of personnel performing activities affecting quality and to ensure that suitable proficiency is achieved and maintained. Managers of activities affecting quality are responsible for determining the personnel competencies necessary for the assigned activities and assessing needs; ensuring that actions such as training are taken to satisfy those needs; and evaluating the actions to confirm that personnel are adequately trained and qualified to manage and perform assigned work activities.

Quality assurance training is provided to ensure that Caltrans project personnel are knowledgeable regarding the QAP, procedures and guidelines, specific contractual requirements, specialized technical training, and employee development. Lists of available training courses and seminars are periodically provided to senior management for distribution to managers to select desired courses. Managers also review the education and experience of employees to determine whether additional training is required to perform specific tasks. Managers are periodically requested to select personnel for scheduled safety training and other employee development training such as project management and field inspection. Classes provided to the resident engineer or the structures representative include:

- American Welding Society Welding
- Concrete Technology
- Contract Administration and Inspection of Field Clean and Paint Steel
- Deck Construction
- Foundations
- Prestressed Concrete
- Profilograph Training
- Resident Engineer Academy
- Resident Engineer Certification Program-Structure Inspection Class
- Structure Construction Field Engineer Training
Table 1.5.1 lists supporting documentation:

<table>
<thead>
<tr>
<th>Title</th>
<th>Chapter/Section</th>
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<td>Deputy Directive 75</td>
<td>Training</td>
<td>Establishes policy for training</td>
</tr>
</tbody>
</table>
Section 6
Process Control

The QAP includes procedures to control contractor construction processes that affect the quality of materials and workmanship using specifications, procedures, drawings, process parameters and approvals, and other appropriate methods. Typical elements of construction process control addressed throughout this manual include, but are not limited to:

- Approved material sources
- Quality workmanship standards
- Quality control requirements
- Acceptance criteria
- Inspection and testing

1.6.1 Proposed Source of Materials

The contractor must notify the resident engineer of the sources of all materials obtained for incorporation into the work. Such notification is required prior to the preconstruction conference.

1.6.1.a Material Identification and Traceability

The QAP includes procedures to ensure that contractors maintain identification, control and traceability of materials and components, from point of production through material incorporation into the project. These procedures specify the methods and extent of identification and traceability of materials to ensure that only correct and acceptable items are incorporated into the project. The procedures ensure that item identification is maintained by heat number, part number, serial number, or other appropriate means either on the item or on records traceable to the item throughout fabrication, erection, delivery, installation, and use of the item. These procedures are designed to prevent the use of incorrect or defective material, parts, and components. The Standard Specifications specify the particular identification requirements for different materials. For example, Section 49-2.02B(1)(e), “Markings,” requires the contractor to provide steel pipe piling with markings showing the heat number. Commercial-quality items are not required to be traceable.

The following methods are applicable:

- Contractor quality control plan. When applicable, the contractor is required to maintain the traceability of materials.
- Certificate of Compliance. These certificates are required to show a unique shipment number, or a serial number traceable to a specific silo, bin, or lot.
- Source inspection. Inspected materials meeting specifications are identified by lot numbers. The METS inspector enters the lot number, a description, and the quantities of materials inspected on Form TL-0029 “Report of Inspection of Material.”

A special process is any production process that generates outputs that cannot be measured, monitored, or verified until after the resulting products have been used.
Table 1.6.1 lists supporting documentation.

<table>
<thead>
<tr>
<th>Title</th>
<th>Chapter/Section</th>
<th>Description</th>
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<td>Chapter 3, Section 5</td>
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<td>Chapter 3, Section 6</td>
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<td>Chapter 6, Section 2</td>
<td>Acceptance of Manufactured or Fabricated Materials and Products</td>
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<tr>
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<td>Section 1.9.5.2</td>
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</tr>
<tr>
<td>OSMPP</td>
<td>Section 1.14.5</td>
<td>Documentation Guidelines</td>
</tr>
</tbody>
</table>

1.6.1.b Handling, Storing, and Transporting

The QAP includes procedures to ensure the contractor’s control of handling, storage, shipping, cleaning, and preservation of material and equipment to prevent damage or deterioration. When necessary for special products, protective environments such as specific temperature levels are required. Examples of materials requiring such measures include hot mix asphalt, Portland cement, asphalt emulsions, and prestressing steel. When no requirements are specified, manufacturer’s requirements are followed.

Table 1.6.2 lists supporting documentation.

<table>
<thead>
<tr>
<th>Title</th>
<th>Chapter/Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSMPP</td>
<td>Section 3.13</td>
<td>Storing, Handling, and Transporting</td>
</tr>
</tbody>
</table>

1.6.1.c Control of Special Processes

The QAP includes procedures to ensure that special processes such as welding, non-destructive testing, structural steel coating, and masonry construction are controlled and performed by qualified personnel using procedures as stated in applicable codes, standards, specification criteria, and other special requirements. For example, Standard Specifications Section 11-3, “Welding,” sets forth personnel requirements and procedures required by applicable codes.

Table 1.6.3 lists supporting documentation.
## Table 1.6.3. Special Processes References

<table>
<thead>
<tr>
<th>Title</th>
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<td>Section 180</td>
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<td>OSMPP</td>
<td>Section 3.6</td>
<td>Prestressing Procedures</td>
</tr>
</tbody>
</table>
Section 7
Inspection and Testing

The QAP includes procedures for inspecting activities that affect quality to verify conformance with the documented instructions, procedures, and drawings for accomplishing the work. Examinations and measurements are required for each work operation to ensure quality. Procedures also ensure that all required testing of material or products is identified and performed in accordance with written test procedures that incorporate the requirements and acceptance limits in applicable construction documents.

1.7.1 Role of Resident Engineer

Caltrans resident engineers must review and monitor the technical inspection activities performed by the contractor and Caltrans personnel to ensure: (1) necessary inspections and testing are performed in a proper manner; (2) proper inspection techniques are used; and (3) contract requirements for quality control and acceptance of material and workmanship are enforced.

Procedures and guidelines prescribe source and field inspection activities that collectively provide for the desired level of quality. Written inspection procedures provide guidance on: (1) characteristics to be inspected; (2) inspection methods; (3) acceptance and rejection criteria; and (4) methods for documenting inspection results.

Table 1.7.1 lists supporting documentation.

<table>
<thead>
<tr>
<th>Title</th>
<th>Chapter/Section</th>
<th>Description</th>
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<td>Chapter 4</td>
<td>Construction Details</td>
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<td>OSMPP</td>
<td>Section 1.8</td>
<td>QASI Branch Duties and Responsibilities</td>
</tr>
<tr>
<td>BCRP</td>
<td>Section 4</td>
<td>Control of Materials</td>
</tr>
</tbody>
</table>

1.7.2 Quality Control Inspection and Testing

The quality control function is the responsibility of the contractor. The contractor is responsible for establishing, implementing, and maintaining a quality control system to manage, control, document, and ensure that all work complies with the requirements of the plans and specifications. The quality control system must ensure the adequate control and assurance of quality for materials, equipment, workmanship, fabrication, and construction by the contractor and its subcontractors, suppliers, authorized laboratories, and consultants.

The purpose of quality control activities is to measure the quality characteristics and inspect the activities that impact production when corrective action can be taken to prevent appreciable nonconforming material from being incorporated into the project. Effective quality control tests are
those whose results can be obtained during the process to allow adjustments to be made to ensure items will meet acceptance criteria. For example, *Standard Specifications* Section 39-4, “Quality Control/Quality Assurance Construction Process,” details requirements for contractor quality control of hot mix asphalt.

Caltrans may use results from contractor quality control testing for acceptance. For acceptance of results, the following Caltrans activities must occur:

- Authorization of the contractor’s quality control plan.
- Accreditation of the contractor’s laboratory.
- Authorization of qualifications of contractor’s testing personnel.
- Evaluation of quality control sampling and testing.
- Verification that validates the quality of sampling and testing.

Details for the production and placement of hot mix asphalt are provided in the Caltrans Division of Construction *Quality Control Manual for Hot Mix Asphalt*.

Table 1.7.2 lists supporting documentation.

<table>
<thead>
<tr>
<th>Title</th>
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<td>Chapter 3, Section 6</td>
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<td><em>Construction Manual</em></td>
<td>Chapter 6, Section 6-107</td>
<td>Materials Acceptance Sampling and Testing</td>
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<tr>
<td>BCRP</td>
<td>Section 4</td>
<td>Control of Materials</td>
</tr>
</tbody>
</table>

1.7.3  Acceptance Inspection and Testing

Caltrans typically uses the design-bid-build method of project development, but sometimes also uses alternative contracting methods such as design-build (California Streets and Highway Code, Section 143). Caltrans is responsible for the acceptance function on all construction projects regardless of the contracting method used.

Acceptance includes inspecting the component materials upon delivery, placement or installation, and inspecting the workmanship and quality of the finished product. The *Construction Manual* and the BCRP include guidance for activities to be conducted by the resident engineer or structures representative in the workmanship and materials acceptance process. For example, Section 4-1903B (2), “Structure Backfill,” of the *Construction Manual* requires the resident engineer to inspect the backfill to ensure it is brought up uniformly and in the specified layer thickness. Records of this inspection would be filed in Category 45, Resident Engineer’s Daily Reports; and Category 46, Assistant Resident Engineer’s Daily Reports of the project files.

1.7.3.a  Quality Assurance Methods

Chapter 2, Section 3 of this manual details the seven categories of quality assurance methods Caltrans uses to ensure the quality of material and workmanship. The listed methods can be used singularly but are generally used in combination or series to achieve the level of quality assurance desired. Decisions on the level of quality assurance required are based on the use or application of
the item and the severity of the consequences of its failure. Table 2-2.8, “Quality Assurance Method Application Matrix,” of this manual illustrates the use of each quality assurance method.

1.7.3.b Acceptance Criteria

The Standard Specifications and Standard Special Provisions provide acceptance criteria for all materials. Caltrans meets the 23 CFR 637.205(d) verification requirements by performing acceptance inspection, sampling, testing, and measurement activities to ensure the product’s quality. When specified, the contractor’s quality control sampling and testing may be used in the acceptance decision in accordance with 23 CFR 637.207.

1.7.3.b (1) Manufactured and Fabricated Materials

For all manufactured and fabricated materials incorporated into the project, the acceptance program provides for:

- Acceptance sampling and testing of the materials at the site of manufacture or fabrication.
- Acceptance by the resident engineer upon delivery of the materials at the job site on the basis of a manufacturer-provided Certificate of Compliance.
- Acceptance based upon these materials or the source of these materials having been previously authorized and listed on the Caltrans Authorized Materials List.

1.7.3.b (2) Job Site Produced Materials

For all job-site-produced materials incorporated into the work, the acceptance program contains:

- Frequency schedules for acceptance sampling and testing which give general guidance to personnel responsible for the program and allow adaptation to specific project conditions and needs.
- Identification of the specific location in the construction or production operation where random acceptance sampling and testing is to be accomplished.
- Identification of the specific attributes to be inspected which reflect the quality of the finished product.

All incoming material or equipment items require documentary evidence that they conform to specified quality and contractual requirements before use, processing, or installation. This documentary evidence is retained at the job site or central file (upon project completion) and is sufficient to identify specific requirements, such as codes, standards, or specifications, that the material or equipment meet.

Table 1.7.5 lists supporting documentation.
### Table 1.7.5. Materials Acceptance References

<table>
<thead>
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<td>Sampling and Testing</td>
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<tr>
<td>California Test Method</td>
<td>CT 539</td>
<td>Method of Sampling Fresh Concrete</td>
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</tbody>
</table>

### 1.7.4 Independent Assurance

The Caltrans Independent Assurance Program, documented in the IAM, is a system-based process that ensures that the laboratories, testers, and equipment used to provide test results for material acceptance decisions on construction projects are capable of performing tests and producing test results consistent with Caltrans standards. In the system-based process, written and practical examinations ascertain a tester’s qualifications. Also, Caltrans’ independent assurance staff annually review equipment calibrations and laboratories. This approach removes the need for project-specific independent assurance samples. The Independent Assurance Program is applied to testing on aggregates, asphalt concrete materials, embankment and soils, and cementitious concrete materials based on Federal Highway Administration (FHWA) “Questions and Answers on the Quality Assurance Regulation (23 CFR 637).”

The Caltrans Independent Assurance Program includes:

- Evaluation of testing equipment.
- Evaluation of testing personnel.
- Prompt comparison and documentation of test results obtained by the tester being evaluated and the independent assurance tester.
- Annual reporting to FHWA.

Table 1.7.6 lists supporting documentation.

### Table 1.7.6. Independent Assurance References

<table>
<thead>
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<td>IA Staff Certification</td>
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<td>IAM</td>
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<td>Tester Qualifications</td>
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<td>Section 2.4.3.</td>
<td>Proficiency Testing</td>
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<tr>
<td>IAM</td>
<td>Section 2.5.</td>
<td>Dispute Resolution</td>
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</tbody>
</table>
Section 8  
Control of Nonconforming Work and Materials

The QAP includes procedures to ensure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformances are promptly identified and corrected. Procedures are also included to control materials or components that do not conform to requirements to prevent their inadvertent use or installation.

Nonconformance is a deficiency in characteristic, documentation, or procedure that may render the quality of an item unacceptable. QAP procedures identify, segregate, and track all nonconforming work and materials until a disposition is made preventing the inadvertent use or installation of such work or material. Nonconforming items are reviewed and rejected, reworked, or accepted in accordance with change order or other documented procedures. An example of a nonconforming item that would be rejected is a pre-cast girder with a missing strand. An example of a nonconformance that could be accepted based on repair would be damaged cast-in-place concrete pipe. Nonconforming materials may also be accepted by applying a specified pay factor adjustment, such as for hot mix asphalt pavement when compaction test results indicate that the density is outside the specified limit, but is suitable for the intended purpose. Any nonconforming condition that results in a change to the technical requirements of the original contract or previously authorized shop drawing requires documented engineering review and acceptance.

Table 1.8.1 lists supporting documentation.

<table>
<thead>
<tr>
<th>Title</th>
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<td>Acceptance of Manufactured or Fabricated Materials and Products</td>
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<td>OSMPP</td>
<td>Section 1.19</td>
<td>Blue Tag Material Release Procedures</td>
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</table>

1.8.1 Corrective and Preventive Action

Corrective action is defined as action to eliminate the cause of a detected nonconformity or other undesirable situation. Preventive action is defined as action taken to eliminate the cause of a potential nonconformity or other undesirable potential situation. Corrective action is taken to prevent recurrence whereas preventive action is taken to prevent occurrence.
The QAP includes requirements for corrective and preventive action by the contractor to ensure that conditions adverse to the quality of materials and workmanship are identified, analyzed, and documented, and that corrective action is implemented when warranted to prevent recurrence. The processes outlined in these procedures include:

- Investigating the cause of nonconformance and the corrective actions needed to prevent recurrence.
- Analyzing processes to detect and eliminate potential causes of nonconformance.
- Initiating remedial actions to address problems to a level commensurate with the risks encountered.
- Ensuring that corrective actions are taken and are effective, and implementing and recording changes resulting from the corrective action.

According to these procedures, the contractor is required to investigate the cause of the nonconformance and immediately take corrective action, including retesting repaired and reworked items. Items that require repair, replacement, or repeated testing are re-inspected for compliance with contract requirements only when the agreed upon corrective actions have been implemented. For example, in accordance with the Quality Control Manual for Hot Mix Asphalt Production and Placement, the contractor’s quality control plan must include a daily inspection provision requiring that, if a single quality characteristic has two consecutive acceptance or quality control test results not in compliance with the specification, the contractor must stop production, notify the engineer, take corrective action, and demonstrate compliance with the specification before resuming production.

Table 1.8.2 lists supporting documentation.

<table>
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<th>Title</th>
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<td>TL-0015</td>
<td>METS Form</td>
<td>Quality Assurance Nonconformance Report</td>
</tr>
<tr>
<td>TL-0016</td>
<td>METS Form</td>
<td>Quality Assurance Nonconformance Resolution</td>
</tr>
</tbody>
</table>
Section 9
Control of Inspection, Measuring, and Testing Equipment

The QAP includes procedures to ensure that inspection, measuring, and testing equipment used for contract acceptance are properly identified, controlled, and calibrated by qualified technicians at specific frequencies to maintain accuracy within required tolerances. Records of calibration activity are maintained in sufficient detail to provide objective evidence of planned frequency of calibration, actual calibration, repair, or removal from service. In addition, Caltrans re-evaluates the validity of previous inspection and test results when equipment used previously for inspecting, measuring, and testing is found to be defective. When contractor quality control tests are used for acceptance, the contractor is required to have a calibration program for applicable test and inspection equipment.

Table 1.9.1 lists supporting documentation.

<table>
<thead>
<tr>
<th>Title</th>
<th>Chapter/Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAM</td>
<td>Appendix H</td>
<td>Calibration of Materials Testing</td>
</tr>
<tr>
<td>MPQP</td>
<td>Appendix</td>
<td>Calibration and Production Error Limits</td>
</tr>
<tr>
<td>Construction Manual</td>
<td>Chapter 6, Section 6-304</td>
<td>Field Testing Equipment</td>
</tr>
<tr>
<td>Standard Specifications</td>
<td>13, 15, 20, 37, 40, 41, 46, 50, 55, 59, 61, 84, 90, 92, 93, 94</td>
<td>Various</td>
</tr>
<tr>
<td>California Test Methods</td>
<td>100–199</td>
<td>Calibration, Nuclear Gauges, Sampling, Materials Report</td>
</tr>
</tbody>
</table>
Section 10
Project Materials Certification

The QAP includes procedures to ensure the resident engineer prepares and submits a project final materials certification. Upon project completion, the resident engineer must prepare Form CEM-6302, “Final Materials Certification.” The resident engineer must certify that, other than for the exceptions listed on the form, the results of tests performed on acceptance samples indicate the materials incorporated in the construction work and the construction operations controlled by sampling and testing were in conformity with the authorized plans and specifications. This certification is consistent with 23 CFR 637.207(a) (3) requirements that each acceptance program include the preparation and submission of a project materials certification.

Examples of exceptions to be listed on the certification form include:

- Materials accepted by applying specified pay factor.
- Materials out of “operating range” but within “contract compliance” for which a specified payment deduction was made.
- Materials not in compliance with the plans or specification for which a change order was authorized to accept the material.
- Materials that require certificates of compliance but one or more have not been submitted.

Table 1.10.1 lists supporting documentation.

<table>
<thead>
<tr>
<th>Title</th>
<th>Chapter/Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Manual</td>
<td>Chapter 6, Section 6-106</td>
<td>Project Materials Certification</td>
</tr>
</tbody>
</table>
Chapter 2
Construction Quality Assurance Roadmap

Overview

This chapter provides guidance to Division of Construction and Materials Engineering and Testing Services/Geotechnical Services (METS) staff, specification owners, and others involved in determining quality assurance requirements for materials and workmanship in highway construction contracts.

The chapter discusses the primary elements of the quality assurance program, provides a guide for developing quality assurance specifications, and discusses methods to ensure the quality assurance standards in the plans and specifications are met.

The specification owner has the primary responsibility for the specification content, including the quality control requirements and acceptance criteria. This document provides guidance for selecting quality assurance requirements and methods, but specification owners must apply engineering experience and judgment when making the final selection. The Construction Quality Assurance Program Manual cannot replace this valuable experience and judgment.
Section 1
Quality Assurance Elements

The building blocks of an acceptable quality assurance program are quality control by the contractor, acceptance inspection and testing by Caltrans, independent assurance, a dispute resolution process, use of authorized laboratories, and use of qualified personnel. These elements work together to ensure a complete and effective quality assurance program. If any elements are missing, the program as a whole is significantly weakened and risk is increased.

These elements must be included in the specifications for all items that use contractor quality control test results in the acceptance decision.

2.1.1 Contractor Quality Control

Contractor quality control is designed to monitor, assess, and adjust the production or placement processes of specific materials to ensure that the final product will meet the specified quality level. Quality control testing is different from acceptance testing discussed in Section 2.1.2. Quality control testing measures quality characteristics and inspects activities that impact the quality of the finished product at a time when corrective action can be taken, if needed. The efforts and testing defined and performed by the contractor should be able to identify nonconforming material and prevent its incorporation into the final product. It also identifies proper control and provides a level of confidence that the work is being completed according to the specifications.

Assigning this function to the contractor evolved primarily for two reasons. First, if Caltrans controls the contractor’s process, then Caltrans implicitly accepts responsibility for the product and must accept it, regardless of the quality. Secondly, because the contractor’s production equipment and personnel are used to produce the material and construction, the contractor is the best entity to control these items.

The contractor is responsible for establishing, implementing, and maintaining a quality control plan to manage, control, document, and ensure that work complies with the requirements of the contract documents. The minimum contractor quality control activities are defined in the construction contract. The contractor’s quality control plan should address the following elements for each contract item:

- Managing the work to ensure that both onsite and offsite work complies with the contract requirements, including the work of subcontractors, suppliers, and testing laboratories.
- Managing submittals, including but not limited to, supplemental quality control plans, qualification and certification documents for laboratories and testing personnel, certificates of compliance, shop drawings and proposed methods for fabrication and construction activities, mix designs, inspection reports, and test results.
• Providing the necessary inspection to ensure effective quality control and assurance of quality for acceptance of materials and workmanship. This includes but is not limited to fabrication, sampling and testing, production, storage, delivery, construction, and placement.

• Identifying, controlling, and documenting materials and workmanship that do not meet the specified level of quality. Documentation should include the nature of the non-conformance, location, extent, and disposition (such as removed and replaced, reworked, accepted based on engineering judgment). The final disposition of non-conforming materials or workmanship must be authorized by Caltrans.

• Training to ensure that proficiency is achieved and maintained by personnel performing activities that affect quality.

• Ensuring that the equipment used in the production and testing of the materials provides accurate and precise measurements in accordance with the applicable specifications.

• Maintaining a record of all inspections, including but not limited to, date of inspection, results of inspection, and any subsequent corrective actions taken.

While the primary purpose of quality control activities is to provide timely information for the contractor to monitor and guide each production or placement process, quality control test data for certain quality characteristics may also be used in the acceptance decision. If the data is used in the acceptance decision, it must be validated by independently obtained verification data, as discussed in Section 2.1.3.

2.1.2 Acceptance Program

The Non-Regulatory Supplement for 23 CFR 637.207 requires that, “The State’s acceptance program should provide a reasonable level of inspection to adequately assess the specific attributes which reflect the quality of the finished product. Verification inspection should include inspection of the component materials at the time of placement or installation, as well as the workmanship and quality of the finished product.”

The Caltrans’ acceptance program activities of verification sampling, testing, and inspection provide a product quality assessment completely independent of the contractor’s quality control process. These activities enable Caltrans to verify that the product meets the quality specified in the contract requirements. In some instances, determining a quality-based pay factor for a given finished item is also involved. The acceptance program includes inspection schedules, lot sizes, sample sizes, testing frequency, quality measure, pay factors, and acceptance limits. When contractor data is used in the acceptance decision, the program also includes verification sampling and testing and risk evaluations. Not all characteristics monitored by quality control are required to be verified, such as those used for process control.

2.1.3 Independent Assurance

According to 23 CFR 637, independent assurance activities provide an unbiased and independent evaluation of all the sampling and testing procedures used in the acceptance decision. Independent assurance provides a mechanism for formally evaluating the competency of sampling and testing personnel and testing laboratories to perform specific tests on construction materials. This process is designed to verify the quality of the data, not the quality of the material, which is being obtained during the course of highway construction.
An overview of the independent assurance process, including detailed procedures and requirements, is included in the Independent Assurance Manual available at:


2.1.4 Dispute Resolution

In accordance with 23 CFR 637.207, Caltrans’ dispute resolution is a documented process used to resolve conflicts resulting from discrepancies between the Caltrans verification test results and the contractor’s quality control test results when the results from the contractor’s quality control sampling and testing are used in the acceptance program. This type of resolution specifically addresses test results used in the acceptance decision and must not be confused with contract administration dispute resolution processes outlined in Section 5-1.09, “Partnering,” of the Standard Specifications.


2.1.5 Authorized Laboratories

In accordance with 23 CFR 637, each state must have a central laboratory accredited by the AASHTO Accreditation Program or a comparable laboratory accreditation program approved by the FHWA. In addition, any laboratory used by Caltrans to provide acceptance, verification, or independent assurance test results and all contractor and vendor laboratories that perform quality control testing included in the acceptance decision must be authorized by Caltrans. The primary objective in establishing laboratory accreditation, qualification, and authorization requirements is to ensure the capabilities of the laboratories that provide test results and information used in the acceptance decision.

Authorization is granted on a test-by-test basis and is a means of formally recognizing the competence of testing laboratories to perform specific tests on construction materials. An authorized laboratory must also have a current accreditation for those test methods applicable to any test for which the laboratory will be providing test results for acceptance consideration on Caltrans projects.

Laboratories that conduct quality control testing for process control purposes only are not subject to the requirements.

2.1.6 Personnel Qualifications

Qualifications for production personnel at production facilities and for construction personnel at the job site are specified for certain critical fabricated and manufactured products, items having a prior history of quality or workmanship issues, and items having a personnel qualification requirement mandated by building codes or state statutes. Qualification requirements of this type ensure that work performed by contractors and fabricators is executed by qualified personnel. Required qualification examples include American Welding Society certification for construction and...
inspection personnel, and American Society for Nondestructive Testing certification for nondestructive testing personnel.

In accordance with 23 CFR 637, all sampling and testing data to be used in the acceptance decision must be performed by qualified sampling and testing personnel. All Caltrans personnel performing acceptance, verification, or independent assurance sampling and testing and all contractor personnel who perform quality control testing included in the acceptance decision are required to be qualified, as outlined in 23 CFR 637.209 (b). Personnel who perform contractor quality control sampling and testing for process control purposes only are not covered by the regulation.

The primary objective in establishing technician qualification programs is to ensure that the technician is capable of performing the appropriate sampling and testing procedures correctly. The qualification criteria include formal training, hands-on demonstration, written examination, proficiency testing, and periodic re-qualification.

An overview of the Caltrans tester qualification process, including procedures for written and practical examinations plus proficiency testing and re-qualification requirements, is presented in Section 2.3 of the Independent Assurance Manual.
Section 2
Specifications

Quality assurance involves everything from project planning and design to construction materials, workmanship, and durability of the finished product. Highway engineers see quality in a highway that conforms to certain design and construction standards while providing excellent long-term performance. The public sees quality in congestion relief, increased mobility, and safety benefits. Quality assurance is not one definition or a one-step process, but an end result that provides value to all.

The easiest and most straightforward way for Caltrans to obtain quality construction is simply to ask for it—that is, to specify it. Specifications tell the contractor what Caltrans wants. Caltrans must be able to describe the level of quality construction it desires regardless of the type of specifications it chooses to employ—method or quality assurance.

Under method specifications, the contractor follows Caltrans-prescribed methods while using Caltrans-authorized materials and equipment. The resulting construction quality depends on the methods, materials, and equipment described in the specifications. The resulting quality is the minimum quality level described in those specifications. The low-bid contractor has no incentive to use better methods or materials that will result in a higher quality than that corresponding to the specified methods and materials.

Conversely, the contractor working under quality assurance specifications typically does have an incentive, in the form of positive-negative pay adjustment provisions, to provide as high a quality as is profitable. Thus, assuming use of the same specified minimum level of acceptable quality, properly developed quality assurance specifications can result in higher quality than method specifications. However, the very nature of materials and construction may sometimes impede the use of statistical parameters to measure construction quality. For example, because of the diverse characteristics of in-place soils and embankments, it is often more difficult to use statistically based specifications for these materials than for plant-produced materials. Thus, there is typically greater reliance on the use of method specifications for these types of materials having wide variation in the quality characteristics to be measured.

The best indicator of the quality to be achieved on a project is the quality level being specified, not the type of specifications.

2.2.1 Deciding Between Method and Quality Assurance Specifications

The primary function of a specification is to communicate a project’s requirements and the criteria by which Caltrans will verify conformance with those requirements. In this respect, quality assurance specifications are similar to conventional method specifications. They differ in how they define and verify the desired quality level and how much latitude they extend to contractors to meet project requirements.
2.2.1.a Advantages and Disadvantages

Both method and quality assurance specifications hold unique advantages and disadvantages that should be carefully weighed by Caltrans when considering how best to specify requirements for a particular project or project element.

2.2.1.a (1) Method Specifications

Method specifications require contractors to use specific materials, equipment, and methods to complete the work. The prescribed requirements are typically based on materials and methods that have historically produced satisfactory results for Caltrans, thus eliminating risk associated with newer, less proven methods and risk associated with varying contractor performance. Contractors are provided few, if any, opportunities to deviate from the specified requirements, allowing the department to retain significant control over the work.

Under this traditional approach, Caltrans bases acceptance on the “reasonable conformance” or “substantial compliance” of the work with the specified requirements. If test results are a component of the acceptance decision, usually only individual or representative field samples are taken. Those individual results may fail to recognize the inherent variability in the material itself, potentially leading to disputes between the contractor and Caltrans over acceptance decisions. Moreover, because method specifications do not establish a range of quality levels, they generally do not include procedures for pay adjustments. The contractor therefore typically receives 100% payment for the work completed as long as it strictly adheres to the specified requirements. Table 2.2.1 summarizes the advantages and disadvantages of using method specifications.

Table 2.2.1. Advantages and Disadvantages of Method Specifications

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Method specifications are well established, easily understood, and applicable to a wide range of topic areas.</td>
<td>• The contractor has little opportunity to deviate from the specifications and, provided, that the specifications are met, is not responsible for performance deficiencies of the end product.</td>
</tr>
<tr>
<td>• Caltrans can exert significant control over the work (although this may come at the expense of increased Caltrans inspection efforts).</td>
<td>• Method specifications lack built-in incentives for contractors to provide enhanced performance.</td>
</tr>
<tr>
<td>• Requirements are based on materials and methods that have worked in the past, minimizing risk associated with newer or less proven methods or varying contractor performance.</td>
<td>• The prescribed procedures may prevent or discourage the contractor from using the most cost-effective or innovative procedures and equipment to perform the work.</td>
</tr>
<tr>
<td></td>
<td>• Contractor payment is not tied to the performance or quality of the work.</td>
</tr>
<tr>
<td></td>
<td>• Acceptance decisions based on test results of individual field samples can increase the potential for disputes.</td>
</tr>
</tbody>
</table>

2.2.1.a (2) Quality Assurance Specifications

In place of the explicit materials and construction requirements found in traditional method specifications, quality assurance specifications contain statements of required results that focus on the desired quality level of the finished work. Quality assurance specifications require contractor quality management and department acceptance activities throughout the production and placement
of a product. Final acceptance of the product is usually based on a random, statistical sampling of the measured quality level on a lot-by-lot basis for key quality characteristics. Price adjustments are generally based on a mathematical assessment of the measured variability of the product. To the extent that Caltrans is willing to relinquish control over some aspects of the work, this approach has the potential to foster contractor innovation and improve the quality or economy, or both, of the product. The advantages and disadvantages of quality assurance specifications are identified in Table 2.2.2.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Quality assurance specifications promote contractor innovation.</td>
<td>• Caltrans has less control over the work.</td>
</tr>
<tr>
<td>• The contractor assumes more performance risk.</td>
<td>• Identifying all of the parameters critical to performance and establishing related thresholds is challenging.</td>
</tr>
<tr>
<td>• Contractors have the flexibility to select techniques and procedures to improve the quality or economy, or both, of the product.</td>
<td>• Roles and responsibilities of the contractor and Caltrans often become blurred if not adequately defined in the specifications or contract documents.</td>
</tr>
<tr>
<td>• A quality assurance specification provides a more rational mechanism for adjusting payment on the basis of the quality or performance of the as-constructed facility.</td>
<td>• The potential for disputes is reduced.</td>
</tr>
</tbody>
</table>

The motivation for using quality assurance specifications will likely vary from project to project. Past practitioners have shown that implementing quality assurance specifications has the potential to improve quality and long-term durability, encourage innovation, accelerate construction, and reduce an owner’s quality assurance inspection costs during construction.

2.2.1.b Choosing the Specification Type

The decision to use method or quality assurance specifications is often a matter of degree. Different approaches to specifying may be appropriate to particular project elements. The appropriate mix of requirements is generally driven by a project’s scope and objectives, as well as the project delivery approach and risk allocation strategy. In practice, this means that the decision to use quality assurance specifications should be supported by evaluating the type and level of quality requirements appropriate for the project characteristics and delivery approach.

Table 2.2.3 summarizes the typical conditions under which method and quality assurance specifications can best be applied.
Table 2.2.3. Appropriate Conditions for Using Method Versus Quality Assurance Specifications

<table>
<thead>
<tr>
<th>Method Specifications</th>
<th>Quality Assurance Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>• End-product quality characteristics cannot be easily defined.</td>
<td>• End-product quality characteristics can be defined in terms of desired outcomes or user needs.</td>
</tr>
<tr>
<td>• End-product quality characteristics cannot be easily or economically measured and verified.</td>
<td>• Key quality characteristics can be measured and tested; the test methods are rapid, reliable, and economical.</td>
</tr>
<tr>
<td>• Limited methods exist that would satisfy Caltrans’ minimum requirements.</td>
<td>• Multiple approaches can achieve the desired results.</td>
</tr>
<tr>
<td>• Caltrans must retain performance risk because of permit requirements, maintenance considerations, the need to tie into existing or adjacent construction, and similar issues.</td>
<td>• Industry is willing to assume performance risk.</td>
</tr>
<tr>
<td>• Pre-existing conditions would compromise the transfer of performance risk to the contractor.</td>
<td>• Caltrans is willing to relinquish control over some aspects of the work.</td>
</tr>
</tbody>
</table>

Quality assurance specifications typically have the advantage when the nature of the project provides the industry with the opportunity to innovate and influence performance outcomes. This is often the case on complex projects involving major reconstruction or new capacity, multi-phased work zone management, major or nonstandard structures, and high traffic volumes requiring accelerated design and construction.

In contrast, less complex projects involving minor resurfacing or restoration of the pavement surface, or use of standard structural components to match existing facilities, tend to be the least likely project types to benefit from a quality assurance specification.

A well-drafted quality assurance specification will not in itself ensure that Caltrans’ quality requirements will be met. Cultural and organizational changes will also be necessary to support the implementation of quality assurance specifications across a wide spectrum of work and projects.

2.2.2 Specification Development Process

Each bid item must be covered by the Standard Specifications or the special provisions. If a work component is not covered by the Standard Specifications, add the appropriate standard special provision (SSP). If an appropriate SSP does not exist, create a non-standard special provision (NSSP).

The process for initially drafting a quality assurance specification consists of seven major steps.

1. Identify the tier level.
2. Identify the production mode.
3. Define the quality characteristics for quality control and acceptance.
4. Specify the quality control and acceptance test methods.
5. Specify the location and frequency of sampling and testing.
6. Define the acceptance criteria and acceptance limits.
7. Identify the quality assurance methods to be specified.
These steps are identified on Figure 2.2.1 and discussed in the following subsections.

**Figure 2.2.1. Quality Assurance Specification Development Process**

2.2.2.a Step 1—Identify Tier Level

Caltrans’ tier-level system is based on the consequence of failure of each item. For example, Tier Level 1 items have the greatest consequence of failure, while Tier Level 4 items have the least consequence. The appropriate level of inspection, sampling, and testing resources are assigned to each contract item commensurate with the item’s consequence of failure—the greater the consequence of failure for the item, the greater the amount of resources devoted to quality assurance for the item.

The tier levels described in Table 2.2.5 provide the specification owner guidance in determining the type and level of quality assurance requirements for each item.
## Table 2.2.5. Tier Levels for Contract Items

<table>
<thead>
<tr>
<th>Tier Level</th>
<th>Failure Category</th>
<th>Consequence of Failure</th>
<th>Example Items</th>
<th>Quality Assurance Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Catastrophic</td>
<td>Greatest consequence of failure. Failure is likely to cause loss of life or serious injury.</td>
<td>Typically, fabricated structural-type products, such as structural steel, precast girders, pre-stressing.</td>
<td>Quality assurance methods designed to provide the maximum level of confidence in the quality control efforts of both the contractor and the producer.</td>
</tr>
<tr>
<td>2</td>
<td>Safety</td>
<td>Although not catastrophic, failure creates a safety hazard for employees or the public.</td>
<td>Manufactured and fabricated safety-related products, such as delineation, safety barriers, lighting, signal controllers.</td>
<td>Quality assurance methods designed to provide a high level of confidence in the quality control efforts of both the contractor and the producer through extensive use of pre-qualified materials from the Authorized Materials List.</td>
</tr>
<tr>
<td>3</td>
<td>Interrupt Service</td>
<td>Failure or repair may cause an interruption in service, or environmental impact.</td>
<td>Job site-produced base and pavement structure, embankment, and drainage items; and environmental items, including stormwater pollution prevention plan best management practice devices.</td>
<td>Quality assurance methods based on 23 CFR 637 requirements for job site-produced items, applicable rules and regulations included in the contract for the environmental items; and certificates of compliance from the contractor or producer combined with intermittent inspection, sampling, and testing of in-progress work for drainage items.</td>
</tr>
<tr>
<td>4</td>
<td>Monetary</td>
<td>Monetary loss only. Consequence of failure is considered minimal in terms of project performance.</td>
<td>Grass seed, drainage and irrigation products, fencing.</td>
<td>Quality assurance methods typically based on use of commercial quality products or extensive use of certificates of compliance from the contractor or producer combined with periodical random inspection of in-progress work.</td>
</tr>
</tbody>
</table>
Table 2-2.6. *Standard Specifications* Sections with Associated Tier Levels

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Tier 1</th>
<th>Tier 2</th>
<th>Tier 3</th>
<th>Tier 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Temporary Traffic Control</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Existing Facilities</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Clearing And Grubbing</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>17</td>
<td>Watering</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>18</td>
<td>Dust Palliative</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>19</td>
<td>Earthwork</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>20</td>
<td>Landscape</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>21</td>
<td>Erosion Control</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>22</td>
<td>Finishing Roadway</td>
<td></td>
<td></td>
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<td>X</td>
</tr>
<tr>
<td>24</td>
<td>Stabilized Soils</td>
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<td>X</td>
</tr>
<tr>
<td>25</td>
<td>Aggregate Subbases</td>
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<td>X</td>
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<tr>
<td>26</td>
<td>Aggregate Bases</td>
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<td>X</td>
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<tr>
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<td>Cement Treated Bases</td>
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<td>Concrete Bases</td>
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<td>X</td>
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<td>29</td>
<td>Treated Permeable Bases</td>
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<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>37</td>
<td>Bituminous Seals</td>
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<td>X</td>
</tr>
<tr>
<td>39</td>
<td>Hot Mix Asphalt</td>
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<td></td>
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<td>X</td>
</tr>
<tr>
<td>40</td>
<td>Concrete Pavement</td>
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<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>41</td>
<td>Concrete Pavement Repair</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>42</td>
<td>Groove and Grind Concrete</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>46</td>
<td>Ground Anchors and Soil Nails</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>47</td>
<td>Earth Retaining Structures</td>
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<td>48</td>
<td>Temporary Structures</td>
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<td>Piling</td>
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<td>Prestressing Concrete</td>
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<td>X</td>
<td>X</td>
</tr>
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<td>Concrete Structures</td>
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<td></td>
<td>X</td>
<td>X</td>
</tr>
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<td>52</td>
<td>Reinforcement</td>
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<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>53</td>
<td>Shotcrete</td>
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<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>53-2</td>
<td>Structural Shotcrete</td>
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<td>Markers and Delineators</td>
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<td>86</td>
<td>Electrical Systems</td>
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</tbody>
</table>

Contact METS for assistance in determining the appropriate tier level for any item.

2.2.2.b Step 2—Identify Production Mode

The production mode is classified as jobsite, fabricated, or manufactured, as discussed below.

- **Job Site**—Products that are constructed, made, or produced at the project and subsequently subject to operations such as transport, mixing, placement, compaction, and curing that can substantively impact quality. Examples include pavement placement, cast-in-drilled-hole piles, batched concrete, imported borrow, and embankment fill.
• Fabricated—Custom made under controlled conditions to Caltrans specification at a fabrication facility off the job site. Fabricated items include those produced to meet specific requirements of Caltrans plans and specifications and all material, such as paint, produced to meet a state specification. Other examples include structural steel, and precast, prestressed concrete members.

• Manufactured—Items mass-produced under controlled conditions to standard industry specifications at a production facility off the job site. These products are not unique to Caltrans. Manufactured items include those that are:
  o Produced to meet the specifications of such industry-wide organizations as AASHTO, ASTM, the American Wood-Preservers’ Association, the American Institute of Steel Construction, and the United States Department of Agriculture, among others.
  o Listed in an industry-wide catalog and available for timely delivery.
  o Shelf items available for purchase at supply houses.

Examples include PVC pipe, cement, fly ash, electrical wire, and corrugated metal pipe.

2.2.2.c Step 3—Define the Quality Characteristics for Quality Control and Acceptance

The two critical aspects of developing quality assurance specifications are identifying the properties essential to ensure good performance over the design life of a product and translating each of those properties into some related measurable quality characteristic that can be specified and tested to determine conformance with the desired level of product quality.

The Transportation Research Board Circular Glossary of Highway Quality Assurance Terms defines quality characteristic as “that characteristic of a unit or product that is actually measured to determine conformance with a given requirement.”

In terms of acceptance, several decisions must be made concerning each quality characteristic. These decisions include establishing acceptance criteria (defining acceptable and rejectable quality levels; and determining sample size, lot size, and sample location. Specific knowledge of each quality characteristic is necessary to make these decisions.

Measuring quality characteristics of in-service performance is preferred because it indicates that the properties being measured are meaningful. It is also important to select quality characteristics that can be measured by well-established and reliable test methods. This improves credibility in the selection of the quality characteristic. When selecting quality characteristics, consider the following:

• What quality characteristics are considered critical to performance?
• To what degree does each quality characteristic influence performance?
• How can these quality characteristics be tested and measured?
• What price adjustment, if any, should be applied to these quality characteristics?
• Are all factors associated with the quality characteristics within the contractor's control? (For example, if the pavement contractor is not responsible for the subgrade conditions, there may be reluctance to accept responsibility for certain quality characteristics, such as structural deflection.)
If payment adjustments are made based on the test results for these quality characteristics, these performance–related results can be related to quality through some modeling process. This makes the payment adjustment process rational, and not arbitrary.

Article 625.4 (c) of 23 CFR 625, Design Standards for Highways, requires certain national reference standards be applied to transportation materials in the geometric and structural design process for highways. Reference standards are specifications prepared by recognized trade associations, professional societies, standards-writing organizations, or agencies that provide national standards of performance or measurement and that have been proven over time to provide the desired quality.

These reference standards typically identify the properties essential to good performance over the design life of a product and the measurable quality characteristics that can be specified and tested to determine conformance with the desired standard of performance and quality.

To incorporate reference standards into a specification, they should be referred to by number, title, or other designation. Cross-referencing in this manner makes the standard a part of the specification, as if it were included in its entirety.

National reference standards commonly used in transportation specifications include:

- AASHTO Standards for Materials and Methods of Sampling and Testing.
- ASTM standards for testing, materials and workmanship.
- American National Standards Institute (ANSI) product standards.
- Design standards from the American Concrete Institute (ACI) and the American Institute of Steel Construction (AISC).

Measuring some quality characteristics may be more ideally suited for the quality control function than for acceptance. For example, while it may provide useful information for Caltrans and the contractor, 28–day concrete cylinder strength is not a good quality control characteristic. By the time this quality characteristic is measured, too much production has occurred to make the strength results useful as a quality control tool.

Table 2.2.7 lists commonly used quality characteristics measured for the quality control and acceptance of various job site-produced items.

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Quality Characteristics Typically Measured for Quality Control</th>
<th>Quality Characteristics Typically Measured for Acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soils and embankment</td>
<td>Moisture content and compaction</td>
<td>Moisture content and compaction</td>
</tr>
<tr>
<td>Aggregate base and subbase</td>
<td>Gradation, compaction, and moisture content</td>
<td>Gradation and compaction</td>
</tr>
<tr>
<td>Hot mix asphalt</td>
<td>Asphalt content, gradation and compaction</td>
<td>Asphalt content, gradation, compaction, and ride quality</td>
</tr>
<tr>
<td>Concrete pavement</td>
<td>Air content, gradation, and slump</td>
<td>Air content and thickness</td>
</tr>
<tr>
<td>Concrete structures</td>
<td>Gradation, slump, air content and compressive strength</td>
<td>Gradation, slump, air content, and compressive strength</td>
</tr>
</tbody>
</table>
Throughout this manual, the term “quality characteristic” is used either to refer to a value measured for either quality control purposes or to assess acceptability of a material or product.

### 2.2.2.d Step 4—Specify the Quality Control and Acceptance Test Methods

The optimal material sampling and testing plan is driven by the criticality of the quality characteristic to be tested, the department’s resources, and the uniformity of the materials in question. The most desirable quality characteristics are measurable and testable. The specification must identify both a quality control testing method and an acceptance test method for each quality characteristic.

When selecting testing methods, consider the following:

- Are standardized tests available?
- Compared to other possible testing methods, is the sampling and testing economical, considering technician availability and the dollars per test multiplied by the number of tests required based on the uniformity of the material?
- Can the test data be processed in a timely manner?
- Do the sampling and testing techniques require a high skill level from technicians? Are special certifications necessary?
- Is specialized equipment necessary?

The combined cost of the specified sampling and testing effort per quality characteristic should be consistent with the criticality of the performance benefit sought and the criticality of the contract item.

Possible test method references include AASHTO and ASTM test methods, California Test Methods, and Office of Roadway Testing Lab Procedures.

California Test Methods and Office of Roadway Testing Lab Procedures can be viewed at the Caltrans Transportation Laboratory at:

http://www.dot.ca.gov/hq/esc/ctms/index.html

AASHTO, ASTM, and other test methods are available at IHS Standards Expert website (by clicking on “IHS Specs & Stds Search”), accessible by Caltrans staff at:

http://onramp.dot.ca.gov/hq/des/spi/

### 2.2.2.e Step 5—Specify the Location and Frequency of Sampling and Testing

The sampling and testing frequency specified for quality control and acceptance of each quality characteristic should be consistent with the criticality of the performance benefit sought and the criticality of the contract item. Section 6-107, “Materials Acceptance Sampling and Testing,” of the *Construction Manual* includes tables listing Caltrans’ minimum sampling and testing requirements for materials acceptance including the sampling location and frequency.
2.2.2.e (1) Location of Sampling and Testing

While there may be several choices for the point of sampling, the specific location in the construction or production operation at which sampling and testing are to be accomplished must be specified for each quality characteristic. Samples used in the acceptance decision should be taken as close as possible to where the material is incorporated into the project. Sampling and testing may be required prior to the production process, during the production process, upon completion of the production process, or a combination, depending on the quality characteristic being measured.

California Test Method 125, “Methods of Test for Sampling Highway Materials and Products Used in the Roadway Structural Sections,” describes the procedures for obtaining representative samples of various highway materials and products that are incorporated in roadway structural sections. This test method also addresses acceptable locations that are routinely used for sampling.

2.2.2.e (2) Quality Control Testing Frequency

A testing frequency must be established that creates a balance between enough tests to control the process but not so many tests as to be impractical. Operations with a history of quality control problems require more frequent sampling and testing than operations that typically have had few problems. Sampling and testing frequencies may vary as the quality and uniformity of the material varies.

A key to achieving a balance in testing frequency is to relate the testing frequency to the rate and consistency of production. If the production tends to be continuous and consistent, less frequent testing may be permissible than if there are many interruptions. The testing frequency may also be reduced for materials with a history of accurate, uniform test results that consistently meet specification requirements.

The rate of testing should be higher on newly developed material sources, sources that furnish materials only on an intermittent basis, sources with questionable quality, sources with a wide range of test results, and sources with failing test results.

2.2.2.e (3) Acceptance Testing Frequency

There are no universally accepted acceptance testing frequencies. Frequencies should be established from historical data obtained by a random sampling procedure, sampled and tested in a manner consistent with the new specification, derived from production and construction representative of different geographical areas of the state, different contractors with different operations, and projects of different sizes. If sufficient historical data does not exist, another data source involves gathering new data from ongoing projects on a statewide basis. Whichever method is used to determine the acceptance testing frequencies, the process should not be considered finished once the new testing frequencies are implemented. Data from projects should continue to be collected and monitored to verify that the assumptions made when developing the testing frequencies were appropriate.

Like any statistical procedure, the ability to determine with a low degree of risk the quality levels that the contractor is providing depends on several factors. One major factor is the amount of sampling and testing being performed—the greater the amount of sampling and testing, the greater the ability of the procedure to identify statistically valid quality levels. A minimum agency rate of 10 to 20 percent of the testing rate of the contractor has been commonly used.
2.2.2.f Step 6—Define the Acceptance Criteria and Acceptance Limits

Considerations involved in determining the acceptance criteria include the following.

2.2.2.f (1) Quality Measures

In quality assurance specifications, measure of quality refers to any one of several mathematical tools used to quantify the quality level of an individual quality characteristic. The measure of quality may quantify the average quality, the variability, or both. Percent within limits is the measure of quality that is most often recommended for use in quality assurance specifications.

2.2.2.f (2) Specification Limits

Specification limits refer to the limiting values (upper and lower specification limits) placed on a quality characteristic, established preferably by statistical analysis, for evaluating material or construction within the specification requirements. For each quality characteristic, establish what the specification limits should be within which the material or work can be produced to ensure good performance over the product’s design life. Selection of the limits relates to determining the risks. The risk for the contractor or producer is the probability that good quality construction will be rejected. The risk for Caltrans is the probability that poor quality construction will be accepted. A well-written QAP considers these risks in a manner fair to both the contractor and Caltrans. Since too large a risk for either party undermines credibility, the risks should be both reasonably balanced and reasonably small.

2.2.2.f (3) Payment Adjustment Schedule

The payment adjustment schedule, in either tabular or equation form, is used to assign pay factors associated with estimated quality levels of a given characteristic for a submitted lot of material or construction. The pay factors are usually expressed as percentages of the contractor’s bid price per unit of work. One of the primary purposes of the schedule is to provide payment commensurate with the quality provided. Often this includes sufficient incentive to produce the desired level of quality at the time of initial construction. A secondary purpose of the payment adjustment schedule is to recoup at least part of the anticipated future costs that are likely to occur when poor quality is received. Effective payment schedules encourage contractors to apply appropriate quality control measures to ensure that the finished product will equal or exceed the desired level of quality a high percentage of the time.

Additional details related to acceptance criteria are presented in Chapter 6, “Sampling and Testing,” of the Construction Manual.

2.2.2.g Step 7—Identify the Quality Assurance Methods to be Specified

Section 3 of this chapter details the seven categories of quality assurance methods Caltrans uses to ensure the quality of material and workmanship. The listed methods can be used singularly but are generally used in combination or series to achieve the desired level of quality assurance. Decisions on the quality assurance level required are based on the use or application of the item and the severity of the consequences of its failure.

Table 2.2.8, “Quality Assurance Method Application Matrix,” relates the use of each listed quality assurance method to the production mode, tier level, specification type, and type of construction of any proposed item or item component. The “X” on the matrix indicates the specification owner
should consider including the associated quality assurance method in the specification for the item or component.

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<thead>
<tr>
<th>Specification Section Heading</th>
<th>Quality Assurance Methods</th>
<th>Job Site</th>
<th>Manufactured</th>
<th>Fabricated</th>
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<th>Tier 2</th>
<th>Tier 3</th>
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<th>QA Spec</th>
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<td>Sampling &amp; Testing for Acceptance</td>
<td>X</td>
<td>X</td>
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Table 2.2.8. Quality Assurance Method Application Matrix (continued)

<table>
<thead>
<tr>
<th>Specification Section Heading</th>
<th>Quality Assurance Methods</th>
<th>Job Site</th>
<th>Manufactured</th>
<th>Tier 1</th>
<th>Tier 2</th>
<th>Tier 3</th>
<th>Tier 4</th>
<th>Method Spec</th>
<th>QA Spec</th>
<th>Structures</th>
<th>Roadway</th>
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<tr>
<td>Department Acceptance</td>
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<tr>
<td>Certificate of Compliance w/ Test Results</td>
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<td>X</td>
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<td>Inspection (Engineering)</td>
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<tr>
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<td>Mix Design/Job Mix Formula – Engineer</td>
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<tr>
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Information on developing quality assurance specifications is also available from a state planning and research pooled fund study SPR-2 (199) “Optimal Acceptance Procedures for Statistical Construction Specifications,” conducted to investigate the use of quality assurance specifications and provide recommendations for statistically sound quality assurance procedures and balancing of risks. The pooled fund study was administered by the FHWA and the results provided in FHWA-RD-02-095, “Optimal Procedures for Quality Assurance Specifications.” This publication provides a how-to guide for developing new or modifying existing quality assurance specifications and is available at:

Section 3
Quality Assurance Methods

Caltrans uses a spectrum of quality assurance methods to ensure the quality of material and workmanship depending on the material and construction activity. At one end of the spectrum are quality assurance methods that rely primarily on materials and methods provisions (soils and embankment items). At the other end are quality assurance methods that use contractor test results as part of the acceptance decision (hot-mix asphalt items). In between are various combinations of quality control and acceptance provisions. These methods can be as simple as reliance on a certificate of compliance for a manufactured product, or as complex as a series of measures including audit, quality control plan, certification, and inspection.

The quality assurance methods are grouped into seven categories: material prequalification, qualification requirements for facilities and personnel, submittal requirements, materials sampling and testing, certificate of compliance, material and engineering inspection, and warranty. The methods can be used alone, but are generally used in combination or series to achieve the level of quality assurance desired. Decisions on the quality assurance level required are based on the use or application of the item and the severity of the consequences of its failure.

2.3.1 Material Prequalification

2.3.1.a Authorized Materials List

The listed materials are pre-qualified and authorized for use on Caltrans projects. These materials cannot be evaluated or tested within typical construction project timeframes and require extensive prequalification testing not practical to repeat for every job. The strategy developed to ensure quality for these types of products involves the manufacturer submitting prequalification samples and Caltrans or a certified independent laboratory testing to ensure specification requirements are met prior to entry of the material onto a web-based authorized materials list. Although pre-qualified, periodic testing and field performance evaluations of the materials are performed at a prescribed frequency to ensure continued specified quality. Example materials include cementitious materials for use in concrete, concrete anchorage devices, safety, signing and delineation materials, post-tensioning systems, and noise barrier systems. Materials from the Authorized Materials List should be specified for use whenever possible.

Refer to Table 6-2.2, “Materials Acceptance Based on Authorized Materials List,” of the Construction Manual for materials accepted on the basis of the Authorized Materials List.

Material lists are located at:

http://www.dot.ca.gov/hq/esc/approved_products_list/

2.3.1.b Authorized Material Source List

The listed material sources are pre-qualified and authorized for use on Caltrans projects. The strategy developed to ensure quality for these sources involves the source submitting prequalification samples and Caltrans or a certified independent laboratory testing to ensure specification requirements are met prior to entry of the source onto a web-based authorized
materials source list. Although pre-qualified, periodic testing and field performance evaluations of the material from the source are performed at a prescribed frequency to ensure continued receipt of specified quality material. Example materials include lime materials for use in soil stabilization. Materials from the Authorized Materials Source List should be specified for use whenever possible.

2.3.1.c Authorized to Deliver Materials List

The materials listed are manufactured materials for which source inspection is deemed necessary but not necessarily on a per project basis. Source inspection for these materials includes a recurring audit with material sampling and testing at a prescribed frequency.

Materials from the Authorized to Deliver Materials List should be specified for use whenever possible. Example items include signal and lighting poles, sign structures, epoxy coated rebar, and elastomeric bearing pads.

Further information on the authorization to deliver program is in the OSMPP manual at:


Currently, the authorization to deliver program is used for Tier 2 and Tier 3 manufactured (non-fabricated) items only. The authorization to deliver material listing is password-protected and available at:


2.3.1.d Proprietary Product or Process

Specifications that identify the desired products or processes by manufacturer's name, brand name, model number, or other unique characteristic are considered proprietary. Trade names are generally the key to identifying patented or proprietary materials. Generally, products identified by their brand or trade name are not to be specified without an “or equal” phrase, and, if trade names are used, a minimum of three acceptable "equal" materials or products should be listed.

Use of specific brand or trade name items should be limited to applications in which the consequence of failure is low. See Public Contract Code Section 3400 and 23 CFR 635.411 for specifics governing the use of proprietary products, specifications, or processes. Refer to Section 6-3.02, “Specific Brand or Trade Name and Substitution,” of the Standard Specifications and Section 6.10, “Proprietary Products,” of the Ready to List Guide for further details.

2.3.1.e Products Manufactured to National Quality Standard

These products are manufactured to meet the specifications of such industry-wide organizations as AASHTO, ASTM, the American Wood-Preservers’ Association, the American Institute of Steel Construction (AISC), and the United States Department of Agriculture (USDA), among others.

These industry-standard specifications typically include end-result requirements, criteria, and tests to meet national standards of quality. They are prepared by recognized trade associations, professional societies, standards-writing organizations, or agencies that provide national standards of performance or measurement. They have been proven over time to provide desired quality, and can be readily incorporated into the Caltrans specifications by referencing the number, title, or other industry-assigned designation for the product specification.
These types of products should be specified for all manufactured items whenever possible because the capability of incorporating time-tested and proven product specifications by reference provides a cost-effective alternative to the process of developing Caltrans-specific contract item specifications and test methods for manufactured items.

2.3.1.f Commercial Quality Products

Commercial quality products are products defined in the *Standard Specifications* as having “quality meeting the best general practices.” These items are available for purchase at local supply houses and are typically referred to as “off-the-shelf items.” Use of commercial quality items should be limited to Tier 4 items in which the consequence of failure is low.

2.3.1.g Caltrans-Furnished Materials

On all highway construction projects, the contractor must furnish all materials to be incorporated in the work, and is permitted to select the sources from which the materials are to be obtained. Caltrans may make exceptions to this requirement on Federal-aid highway projects when there is a definite finding by Caltrans with FHWA concurrence that it is in the public interest to require the contractor to use materials furnished by Caltrans or from sources designated by Caltrans. Refer to 23 CFR 635.407 for specific guidelines pertaining to the use of Caltrans-owned, -furnished, or -designated materials.

Examples of Caltrans-furnished materials include monument discs, traffic signal controller assemblies, changeable message signs and assemblies, and salvaged (recycled) materials such as temporary traffic signals and flashing beacons. If the item is a Caltrans-furnished material, quality assurance requirements for that material are not provided in the specifications.

2.3.2 Qualification Requirements for Facilities, Contractors, and Personnel

2.3.2.a Qualification Requirements for Facilities

2.3.2.a (1) Prefabrication Audit

Caltrans performs a prefabrication audit to evaluate if a fabricator has the processes and the resources to fabricate products to the quality indicated in the specifications. This applies only to custom-fabricated materials where adherence to specifications is critical and field rejection costly to all parties. The onsite production facility audit provides a measure of assurance that the producer has the capability to perform. The contractor’s fabricator must demonstrate adherence to prescribed standards of operation. By knowing that a periodic audit is required to supply certain materials to Caltrans, contractors and fabricators are more cognizant of their responsibility for quality control. Further details on the application of this audit are available at:

http://www.dot.ca.gov/hq/esc/Translab/OSM/smbresources.htm

2.3.2.a (2) Authorized Facility Audit Listing

Caltrans audits the facilities listed on the Authorized Facility Audit Listing (AFAL) using a system-based approach to evaluate the fabricator’s quality control process. The AFAL is available for items such as structural precast concrete, welded steel for overhead sign structures, welded steel poles for lighting and signal structures, and steel pipe piling. The audit process evaluates if the fabricator has
the processes and the resources to fabricate the structural products to the quality specified in the contract documents. The AFAL is maintained by METS. Further information on the AFAL can be found at:

http://www.dot.ca.gov/hq/esc/Translab/OSM/

2.3.2.a. (3) Authorized Laboratory List

Caltrans maintains the list of independent laboratories authorized to perform testing on reinforcing steel splices. Example items requiring testing by laboratories on the Authorized Laboratory List include production tests for bar reinforcement splices and tensile tests for headed bar reinforcement. Further details on the qualification requirements for the Authorized Laboratory List are available at:

http://www.dot.ca.gov/hq/esc/Translab/authorized_laboratories_list/

2.3.2.a (4) Authorized Laboratory

An authorized laboratory must meet at least one of the following requirements:

- Be currently accredited by the AASHTO Accreditation Program, the Caltrans Independent Assurance Laboratory Accreditation Program, or by a comparable accreditation body recognized by the National Cooperation for Laboratory Accreditation (NACLA). According to 23 CFR 637.209, the laboratory accreditation must indicate that the laboratory was assessed according to the requirements in National Institute of Standards and Technology Interagency Report 7012 (NISTIR 7012), “Technical Requirements for Construction Materials Testing.”

- Participate in laboratory assessment and proficiency sample services provided by the AASHTO Materials Reference Laboratory, the Cement and Concrete Reference Laboratory, American Association for Laboratory Accreditation, or other recognized agency providing comparable services for construction materials testing laboratories.

- Be recognized and accepted product safety testing and certification organization such as Underwriters Laboratories or other recognized agency providing comparable product testing and certification services.

- Be a method for specialized testing developed by Caltrans.

A matrix relating authorization requirements for each category of laboratory to each test category is presented in Table 2-3.1.
Any commercial laboratory seeking Caltrans’ authorization to perform a specific test method on manufactured or fabricated construction materials must provide technical documentation to prove that the laboratory has the following:

- Proper facilities and necessary testing equipment capable of performing the test method.
- Competence in performing the test method as demonstrated by the following:
  1. Supervisors of testing personnel have a minimum of 3 years’ experience in testing highway construction materials.
  2. Laboratory assessments routinely made on a 3 to 5 year cycle
  3. Current training records and certifications that show testing personnel are properly trained, are routinely evaluated by observations and proficiency samples, and are qualified to perform the test method.
  4. Actual test results that show previous experience in performing the test method.
  5. A formal reporting procedure for test results including published test report forms.
- Two years of annual calibration records for required testing equipment. The calibration must be performed by an independent third party that has testing standards traceable to the National Institute of Standards and Technology.

The documentation detailed above must also be submitted by laboratories seeking authorization for specialized test methods for which neither a recognized laboratory accreditation nor certification currently exists.
The use of an authorized laboratory is typically specified for Tier 1 and Tier 2 fabricated items, Tier 1 and Tier 2 complex or critical manufactured items, and for all job site-produced items. Example items include aggregate bases and subbases, asphalt and concrete pavement, and structural concrete.

2.3.2.a (5) **Authorized Plant**

An authorized facility or plant must be certified to a recognized standard. An example is plant authorization under the Caltrans Material Plant Quality Program covering inspection, calibration, dynamic testing, and acceptance for material plant weighing and measuring devices. All hot mix asphalt plants must be authorized prior to production. Specific details about the Caltrans Material Plant Quality Program requirements are available at:

[www.dot.ca.gov/hq/construc/hma/MPQP.pdf](http://www.dot.ca.gov/hq/construc/hma/MPQP.pdf)

2.3.2.b **Qualification Requirements for Contractors**

Contractors are required to be certified to a recognized standard to ensure that work performed is executed by qualified contractors. An example is the Society for Protective Coatings certifications (SSPC-QP1, SSPC-QP2, and SSPC-QP3) required for structural steel painting contractors.

2.3.2.c **Qualification Requirements for Personnel**

2.3.2.c (1) **Sampling, Testing, and Inspection Personnel**

Sampling, testing, and inspection personnel must be certified to a recognized standard so that all contractor, vendor, and Caltrans sampling, testing, and inspection data used in the acceptance decision is executed by sampling and testing personnel qualified through experience and technical training. Example certifications include American Welding Society Certified Weld Inspector, Precast Concrete Institute Quality Control Inspector Certification, Caltrans Independent Assurance Program Qualification, American Society for Nondestructive Testing certification for non-destructive testing personnel, and American Concrete Institute.

Table 2.3.2 relates the authorization requirements for each category of sampling and testing personnel to each test category.
Qualifications for sampling, testing, and inspection personnel are typically required for Tier 1 and Tier 2 fabricated items, Tier 1 and Tier 2 complex or critical manufactured items, and for all job site-produced items (Tier 3). Example items include aggregate bases and subbases, asphalt and concrete pavement, and structural concrete.

2.3.2.c (2) Installer/Applicator/Erector Personnel

Production personnel must be certified to a recognized standard to ensure that work performed by contractors and fabricators is executed by personnel qualified through experience and technical training. Required qualification examples include American Welding Society certification for construction and inspection personnel, and ASNT certification for non-destructive testing personnel.

Qualifications for production personnel at the fabrication facility and for construction personnel at the jobsite are typically specified for:

- Tier 1 and Tier 2 fabricated item.
- Tier 1 and Tier 2 complex or critical manufactured item.
- Items having a prior history of quality or workmanship issue.
- Items having a personnel qualification requirement mandated by building codes or state statutes.
2.3.3 Submittal Requirements

Submittals requiring the department’s response such as written and graphic information or samples are action submittals. Action submittals include shop drawings demonstrating design adequacy, product data, test samples, quality control plans, work plans, and material source data. Submittals that are written information and not requiring the department’s response are informational submittals. Informational submittals include certificates of compliance and manufacturer instructions not associated with drawing submittals. Any submittal not specified as an informational submittal is considered an action submittal.

2.3.3.a Designer Review of Construction and Fabrication Working Drawings/Plans

Prior to the start of construction or fabrication, required drawings and plans submittals from the contractor that provide details on proposed methods of construction or fabrication are reviewed by project designers to assure conformance with design requirements. Typical drawing and plan features reviewed include weld details, nondestructive testing requirements, and constructability. Submittals detailing proposed methods of construction or fabrication are typically required for Tier 1 and Tier 2 fabricated items, and Tier 1 and Tier 2 complex or critical manufactured items. Examples include steel fabrication shop drawings, working drawings for mechanically stabilized earth structures, and working drawings for alternate piling systems.

2.3.3.b Resident Engineer Review of Construction and Fabrication Process Submittals

Required submittals from the contractor detailing proposed procedures for the construction or fabrication of an item are authorized by the resident engineer or representative prior to the start of construction or fabrication.

Submittals detailing proposed procedures for construction or fabrication are typically required for Tier 1 and Tier 2 fabricated items, Tier 1 and Tier 2 complex or critical manufactured items, and Tier 3 job site-produced items. Examples include proposed methods for construction of falsework, cast-in-drilled-hole piles, and proposed welding procedures.

2.3.3.c Resident Engineer Review of Proposed Job Mix Formulas/Mix Designs

Required submittals from the contractor detailing planned mix proportioning are reviewed by the resident engineer or representative prior to the start of construction or fabrication.

Submittals detailing planned mix proportioning are typically required for Tier 1 and Tier 2 fabricated items, Tier 1 and Tier 2 complex or critical manufactured items, and for all Tier 3 job site-produced items. Examples include hot mix asphalt pavement job mix formulas, and mix designs for structure concrete and pavement concrete.

2.3.3.d Resident Engineer Review of Proposed Quality Control Procedures

Required submittals from the contractor detailing planned quality control procedures are reviewed by the resident engineer or representative prior to the start of construction or fabrication.

Submittals detailing planned quality control procedures are typically required for Tier 1 and Tier 2 fabricated items, Tier 1 and Tier 2 complex or critical manufactured items, and for all Tier 3 job site-produced items. Examples include quality control plan submittals for precast, structural, and pavement concrete, welding, paint, hot mix asphalt pavement, and sign panels.
2.3.3.e Engineer Review of Product Data

Required submittals from the contractor demonstrate the compliance of a manufactured product with contract requirements and may include the manufacturer’s recommended installation or application instructions for the product. Examples of required product data submittals include the manufacturer’s catalog cut sheets, performance data, and installation instructions for pumping equipment and controls.

2.3.3.f Contractor Submittal of Test Samples

Required test sample submittals from the contractor are used for quality verification testing by Caltrans prior to authorizing incorporation of the represented material into the project. Examples of required test sample submittals include epoxy coated reinforcement bars, bonding materials and chemical adhesives for concrete structures, and fasteners for electrical systems.

2.3.4 Material Sampling and Testing

The optimal material sampling and testing plan is driven by the criticality of the quality characteristic to be tested, Caltrans’ resources, and the uniformity of the materials in question.

2.3.4.a Pre-Production (Initial or Stockpile)

Pre-production sampling and testing is performed by the contractor prior to job startup to determine whether proposed materials sources, proposed local materials, and products meet the specifications. Initial testing is typically specified for Tier 3 and Tier 4 items. Example items include the initial sampling and testing of borrow material sites and micro-surfacing aggregate.

Stockpile testing is typically specified for Tier 2, Tier 3, and Tier 4 manufactured and fabricated products that are identifiable by means of a serial number or other unique identifier. An example item is corrugated metal pipe.

2.3.4.b Quality Control Sampling and Testing

Quality control testing by the contractor, its representatives, or subcontractors is required during the production process to measure the quality characteristics that affect the production at a time when corrective action can be taken to prevent appreciable nonconforming material from being incorporated in the project.

Quality control testing at the point of production is typically specified for Tier 1, Tier 2, or Tier 3 fabricated or jobsite-produced items. Example items include aggregate bases and subbases, asphalt and concrete pavement, and structural concrete.

Quality control testing at the job site is typically specified for Tier 1, Tier 2, or Tier 3 job site-produced items whose quality is subject to change after production because of transporting or handling. Job site quality control testing may also be specified for manufactured or fabricated items whose quality is subject to change after production because of installation, placement, assembly, application, or storage. Examples of this include required testing of drilling slurry properties during construction of cast-in-drilled-hole piles, required testing for chemical composition of steel performed at a steel plant, and the non-destructive testing of welds by a steel fabricator.

2.3.4.b (1) Quality Control Sampling and Testing for Process Control
Process control refers to a method for keeping a process within boundaries or the act of minimizing the variation of a process. Process control activities may include sampling, testing, inspection, and corrective action performed by a contractor in addition to quality control requirements to improve the likelihood that the final product will meet the specified level of quality. Sampling and testing requirements for process control are not included in the specifications because process control, although beneficial to the contractor’s quality control efforts, is not essential to Caltrans’ evaluation of the finished work product for acceptance and payment purposes.

2.3.4.b (2) Quality Control Sampling and Testing for Acceptance

An important step in the evolution of quality assurance programs occurred when 23 CFR 637 allowed contractor test results to be used in the acceptance decision. Research indicates that, with the checks and balances required in the CFR, more testing in the acceptance function is being done using this alternative than would have been done solely by the agency under traditional acceptance testing.

In accordance with 23 CFR 637.207, contractor quality control sampling and testing results may be used as part of the acceptance decision provided that:

- The sampling and testing has been performed by qualified laboratories and qualified sampling and testing personnel.
- The quality of the material has been validated by the verification sampling and testing process. The verification testing must be performed on samples that are taken independently of the quality control samples.
- The quality control sampling and testing is evaluated by an independent assurance program.

Caltrans established a dispute resolution system that addresses the resolution of discrepancies between the verification sampling and testing and the quality control sampling and testing. The dispute resolution system is only applicable when the results from the contractor’s quality control sampling and testing are used in the acceptance program.

2.3.4.c Verification Sampling and Testing

This form of sampling and testing uses a statistically based number of tests that Caltrans performs to verify contractor-performed quality control testing results used by Caltrans in the acceptance decision. In this form, both the contractor’s and the department’s test results are used collectively to determine whether the material is acceptable.

Typically, the three sources of variability between contractor and Caltrans test results are derived from differences in the:

- Material quality.
- Testing procedures.
- Sampling procedures.

Variability between the contractor’s and Caltrans’ sampling and testing procedures is minimized by extending the laboratory and testing personnel qualification requirements and the independent assurance program requirements to the contractor if the contractor’s test results are to be used in the acceptance decision. Verification sampling and testing results are used to validate the quality of the material, thereby ensuring that all sources of differences between test results are measured.
The type and extent of verification that Caltrans performs as part of its acceptance program are outlined in the specifications. The frequency of verification sampling and testing depends on the risk implications from premature failures due to the acceptance of substandard or failing materials. For example, verification testing may be more frequent for structural concrete than for embankment materials.

Verification sampling and testing are applicable to all job-site-produced items for which the contractor’s quality control testing results are used in the Caltrans acceptance decision. Examples include hot mix asphalt (quality control/quality assurance process) and concrete pavement. In terms of the acceptance program, verification sampling and testing performed by Caltrans are not required when the contractor quality control testing results are not used in the Caltrans acceptance decision.

2.3.4.d Programmatic Quality Assurance Inspection and Testing at the Job Site

This periodic inspection and testing is performed by Caltrans on random “check” samples of manufactured products at the job site to confirm that a manufacturer continues to provide products meeting the desired standard of quality.

Inspection and testing requirements for programmatic quality assurance are not included in the specifications because, although an integral part of Caltrans’ periodic review of product quality, programmatic quality assurance is not essential to Caltrans’ evaluation of the finished work product for acceptance and payment purposes. This type of inspection and testing typically provides data to support continued use of a certificate of compliance and is not necessarily linked to specific projects.

2.3.4.e Programmatic Assessment

Caltrans evaluates Tier 3 and Tier 4 manufactured items to determine the reliability of the manufacturer’s quality control process.

Requirements for programmatic assessment procedures are not included in the specifications because the procedures are not essential to Caltrans’ evaluation of the manufactured product for acceptance and payment purposes.

2.3.4.f Acceptance Sampling and Testing

Sampling and testing are typically performed at either the point of production or the job site. Samples used in the acceptance decision should be taken as close as possible to where the material is incorporated into the project.

Sampling and testing responsibilities and requirements for the acceptance of job site-produced and miscellaneous materials are included in Chapter 6, Section 1, “Sample Types and Frequencies,” of the Construction Manual.

Sampling and testing responsibilities and requirements for the acceptance of manufactured or fabricated materials are included in Chapter 6, Section 2, “Acceptance of Manufactured or Fabricated Materials and Products,” of the Construction Manual.

Acceptance testing at the point of production is typically specified for Tier 1 and Tier 2 fabricated items, Tier 1 and Tier 2 complex or critical manufactured items, and any off-site production facilities for job site-produced items. Acceptance testing at the point of production does not
preclude acceptance by the resident engineer at the job site. Example items include overhead sign
structures.

Acceptance testing at the job site is typically specified for Tier 1, Tier 2, or Tier 3 job site-produced
items whose quality is subject to change after production because of transporting or handling.
Example items include hot mix asphalt and structural concrete.

Job site acceptance testing may also be applied to complex or critical manufactured or fabricated
items whose quality is subject to change after production because of installation, placement,
assembly, application, or storage. Example items include electrical systems, ground anchors, and
soil nails.

### 2.3.5 Certificate of Compliance

Certificates of compliance are used for acceptance of products for which the industry has
demonstrated a high degree of reliability in meeting contract specifications. The certificate of
compliance is submitted before the material is incorporated into the work, for each batch or lot of
the material (batch or lot must be identified on the certificate), and signed by the producer of the
material stating that the material complies with the contract. The certificate of compliance informs
Caltrans that the contractor has accepted the material and is confident that the material complies
with the contract specifications.

#### 2.3.5.a Certificate of Compliance from Producer

This written statement submitted by a producer affirms a product meets specification requirements.

#### 2.3.5.b Certificate of Compliance from Producer with Test Results

This written statement accompanied by field or laboratory test data from a producer affirms a
product meets specification requirements. Examples of field or laboratory data to be provided
include mill test reports for steel, pressure treating reports for timber, and concrete test reports. The
field or laboratory test data provided must:

- Address each of the product quality characteristics specified for measurement.
- Represent the same lot of material as the material to be incorporated in the work.
- For Tier 3 items, represent a test performed within the past 6 months.
- For Tier 4 items, represent a test performed within the past year.

Refer to Table 6-2.3, “Materials Accepted by Certificate of Compliance,” in the Construction
Manual for listing of applicable materials.

All materials and products accepted by certificate of compliance require periodic programmatic
quality assurance testing of random “check” samples with results that support the reliability of the
certificate provider.

A certificate of compliance is not required for off-the-shelf commercial quality items, Caltrans-
furnished materials, items subject to contract warranty provisions, and items for which material
tests are not specified or feasible.

A certificate of compliance with test results is required prior to the incorporation of the following:

- Products manufactured off-site but not inspected at point of production.
• Products included on the Authorized Materials List.
• Products included on the Authorized to Deliver List.
• Products specified to national quality standards.
• Products specified in the contract by brand name or trade name.

2.3.6 Material and Engineering Inspection

Inspection is one of the most important aspects of construction work. Inspection consists of careful reviews and critical examination of all the factors entering into the construction of transportation projects to ensure the proper combination of materials and details of construction. The construction of any transportation project consists of a number of operations that must be integrated to produce a quality-finished product. Each operation has an effect on the quality of the final product.

2.3.6.a Material Inspection

2.3.6.a (1) Quality Control Inspection

Quality control inspection is required to be performed by the contractor, its representatives, or subcontractors during the production process to ensure that a material or product meets the contract requirements.

Quality control inspection at the point of production is typically required for Tier 1 and Tier 2 fabricated items, Tier 1 and Tier 2 complex or critical manufactured items, and for any off-site production facilities associated with job site-produced items.

Quality control inspection at the job site is required for all remaining project items. Examples include the required documentation of concrete placement during the contractor’s construction of cast-in-drilled-hole piles, and required welding inspection for structural steel erected by the contractor.

2.3.6.a (2) Verification Inspection

Material and workmanship inspection is performed by Caltrans as part of an independent assurance program (to verify the contractor quality control process complies with specified requirements) or part of an acceptance program (to verify the contractor provided product meets the specified workmanship-related requirements). Verification inspection and acceptance inspection have the same underlying function—to validate the quality of the product.

2.3.6.a (3) Acceptance Inspection

Acceptance inspection is performed by Caltrans to ensure that a product is acceptable in terms of the specifications for a specific project. According to 23 CFR 637, acceptance inspection includes inspection of the component materials at the time of placement or installation, as well as quality of the finished product. As part of their acceptance responsibilities, Caltrans technicians and inspectors must monitor the contractor's quality control activities while retaining responsibility for acceptance sampling, testing, and inspection. The inspection is typically performed at either the point of production or the job site.
Material acceptance inspection at the point of production is typically required for Tier 1 and Tier 2 fabricated items, Tier 1 and Tier 2 complex or critical manufactured items, and for any off-site production facilities associated with job site-produced items. Material acceptance inspection at the point of production does not preclude acceptance by the resident engineer at the job site.

All remaining project materials require acceptance inspection at the jobsite by Caltrans personnel. Example items requiring job site acceptance inspection include aggregate bases and subbases, asphalt and concrete pavement, and structural concrete.

2.3.6.a (4)  Pre-Production Meetings

To ensure the contractor’s means and methods produce the desired product having the specified quality, Caltrans may require meetings to discuss and familiarize those responsible for performing, controlling, and managing the work with the quality control and workmanship requirements in advance of the work beginning. Example items include required pregrouting meetings before the start of grouting operations and required prepainting meetings before the start of structural steel painting operations.

2.3.6.a (5)  Pre-Production Trial (Mock-up)

To ensure the contractor’s means and methods produce the desired product with the specified quality or to use as a standard of comparison for accepting the finished product, Caltrans may require the functionality of items to be demonstrated, or prequalified, prior to use. Example items include test panels for structural concrete, shotcrete, textured or colored concrete surfaces, and prefabricated detectable warning surfaces; test strips for concrete pavement; mockups for self-consolidating concrete; and trial slabs for concrete pavement replacement.

2.3.6.b  Engineering Inspection

Engineering inspection involves monitoring the contractor’s construction processes to ensure that the construction quality and workmanship are in compliance with the plans and specifications. The resident engineers, structures representatives, and field engineers exercise engineering judgment and evaluate fitness for purpose when inspecting for workmanship quality.

Various Caltrans manuals including the Construction Manual, Bridge Construction Records and Procedures manual, Bridge Deck Construction Manual, Foundation Manual, and Concrete Technology Manual, provide guidelines for inspecting, measuring, and paying for contract item work. (For a listing of quality assurance documents refer to Appendix B, Caltrans Quality Assurance Documents.) These guidelines describe the construction details and associated inspection requirements necessary to ensure that product workmanship is acceptable.

The level of engineering inspection varies dependent on the type of work being performed and is categorized into three basic levels:

- Continuous Inspection—Inspect 80 to 100 percent of the time work is in progress with assistant(s) assigned only to one operation. Continuous inspection is typically required for Tier 1 and Tier 2 fabricated items, and Tier 1 and Tier 2 complex or critical manufactured items.

- Intermittent Inspection—Inspect 30 to 80 percent of the time work is in progress with assistant(s) assigned to two or three operations simultaneously. Intermittent inspection is typically required for Tier 2 items that are non-complex and non-critical and for Tier 3 items.
• Benchmark Inspection—Inspect up to 30 percent of the time work is in progress. Construction operations can proceed without inspection until a predetermined critical activity point has been achieved. Benchmark inspection is typically required for Tier 4 items.

Critical activity points are hold points established in the contract documents to ensure that the proper inspection and testing have been performed prior to starting, or before proceeding to the next phase or stage of that particular construction activity. No work can proceed beyond each critical activity point until approved by the department.

2.3.7 Warranty Provisions

Warranty is a guarantee of the integrity of a product and the maker’s responsibility for the repair or replacement of the deficiencies. A warranty specifies the desired performance characteristics of a particular product over a specified period and defines who is responsible for the product. Products that are good candidates have clearly definable, self-evident failure modes, are produced and designed by industries with proven quality control capabilities, are easily traceable through serial numbers or other identifying features, and can prematurely fail without dire consequences. The use of warranties allows Caltrans to shift some of the post-construction performance risk of the warranted product to the contractor.

2.3.7.a Material and Workmanship Warranty

A material and workmanship warranty holds the contractor responsible for correcting defects in work elements within the contractor’s control during the warranty period. The contractor or manufacturer warrants that material complies with specifications, and agrees to repair or replace if, during the period of the warranty, the material fails and tests prove it does not comply with the specifications. Material and workmanship warranties may be specified for Tier 3 and Tier 4 manufactured items. Example items include LED lights, prefabricated detectable warning surface for Americans with Disabilities Act (ADA) ramps (required by state statute), batteries for electrical systems backup, materials for pumping equipment, and permanent pavement marking tape.

2.3.7.b Performance Warranty

A performance warranty holds the contractor fully responsible for product performance during the warranty period. The contractor or manufacturer warrants that material will perform to pre-defined standards or will be repaired or replaced if, during the period of the warranty, the material’s performance falls below the standard. Contract language should specify the warranty period and the enforcement process, including a detailed description of the measures that will be used to determine warranty compliance. The requirements for warranties used on design-build projects are covered under 23 CFR 635.413, “Construction and Maintenance.”

An example warranty provision is the 5-year manufacturer's warranty of replacement for defects in dome shape, color fastness, sound-on-cane acoustic quality, resilience, and attachment specified for prefabricated detectable warning surfaces.

2.3.7.c Guarantee

According to Section 6-3.06, “Guarantee,” of the Standard Specifications, the contractor must guarantee that work remains free from substantial defects for 1 year after contract acceptance except for work portions relieved of maintenance and protection, which must be guaranteed for 1
year after the relief date. The guarantee excludes damage or displacement caused by an event outside the contractor’s control, including normal wear and tear and improper operation. Refer to Section 3-611A, “Guarantee,” of the Construction Manual for the resident engineer’s duties related to guarantees.
Chapter 3
Construction Quality Assurance Long-Range Plan

Overview

The following sections lay out a potential long-range plan for changes to the Caltrans Construction Quality Assurance Program. The objectives are in order of highest priority and include the following: establish a construction quality assurance database; adopt a system-based acceptance process; implement performance specifications; and adopt risk-based acceptance criteria.
Section 1
Long-Range Objective—
Integrated Construction Quality Assurance Database

Construction quality assurance databases are a key element of any construction quality assurance program because they enable highway departments to make sound, data-based decisions that lead to cost-effective construction. These databases improve data processing efficiency, minimize errors, unify data administration, and provide data security. They also provide the data source for a variety of analyses, such as construction quality monitoring, developing pay adjustments, and detailed statistical analyses.

A quality assurance database facilitates assessing the quality of materials production and placement and establishing pay factors, as defined by specifications. It also enables detailed analyses of quality, performance, and cost data that can help guide future improvements to standards and specifications (such as materials, techniques, and design strategies to use; quality characteristics and levels to use in acceptance; incentive/disincentive plan).

While most highway departments have established and maintained construction-related databases for many years, only within the last decade have they realized the need for more integrated systems to accommodate the requirements of new quality assurance programs.

Caltrans has a number of database and software systems that serve specific quality assurance functions for different groups. However, these individual databases are not integrated. They were established with different architecture, purpose, and data collection and access procedures, leaving limited means to match all the collected data. While Caltrans may be able to calculate pay factors and make acceptance decisions from one database, data from that database cannot easily be linked to other databases to monitor effectiveness of specifications, correlate construction quality to field performance, or to perform life-cycle cost analysis. The result is that by continuing to focus primarily on entering data and not necessarily on retrieving data to draw valuable conclusions, Caltrans may become “data rich and information poor.”

While individual databases may address current needs of the multiple functional groups, a more efficient, comprehensive, user-friendly database system is needed that can link existing individual databases. Such a system would allow the more efficient analysis required to develop or refine system-based and risk-based acceptance processes, performance specifications, warranty specifications, and innovative contracting procedures.

3.1.1 Construction Quality Assurance Database Requirements

Caltrans’ existing databases and software systems need to be integrated and updated to a web-based construction quality assurance database with client/server architecture having the following features and capabilities:
• User-friendly interface and configuration.
• Access by multiple users and functional groups (such as materials testing lab, construction engineers, field inspectors, designers, management, contractors, subcontractors, material suppliers and producers, and researchers) who most likely operate from different locations.
• Different levels of access security and operational privileges (such as viewing, entering, modifying, and analyzing data and generating output) depending on role in the department or project (inspector versus contractor).
• Ability to make “user group” assignments; users can belong to multiple groups.
• Audit and tracking information to trace users and their activities.
• Offline use of input modules or linkage to wireless hand-held devices to aid in timely data entry and subsequent uploading to the server.
• System for logging and tracking of material samples, related tests, and results.
• Capability to store construction details and contractor activities for each lot, including portland cement concrete (PCC) curing practices, thickness of hot mix asphalt lift in each paving operation, and traffic opening time.
• Aid in decision-making for quality assurance, performance-related, and warranty projects.
• Ability to perform fundamental and routine analysis for quality assurance operations, including pay factor calculations.
• Ability to generate system outputs and ad hoc or standardized reports that can be electronically distributed or published online.
• Ability to interface/link with other agency systems such as the pavement management system (PaveM) database and financial/cost accounting system.
• Capability to perform advanced analysis to correlate construction and material test data with performance (pavement management) and cost (bids, maintenance) databases.
• Common referencing across other key databases to perform analyses.
• Flexibility to customize the analysis for specific cases when required.
• Overall system stability (such as, backups and disaster recovery) and security (such as, firewall protection on machines accessing central database).

3.1.2 Potential Benefits of Construction Quality Assurance Database

A construction quality assurance database with well-integrated components (or individual databases) that can be linked with each other using a common reference system has benefits ranging across technical, administrative, and legislative levels for improving the quality of construction and enhancing Caltrans’ operations overall. The more data contained in this database, the more potential there is to use and analyze the data and thereby benefit from it. A well-developed construction quality assurance database offers the following potential benefits:

• Automates data entry across various Caltrans functional units having to do with materials, construction, and specifications in the Division of Engineering Services and the Division of Construction.
• Provides entry and storage of testing data and contract documents in an electronic format that is easily accessible by headquarters, region or district offices, project field offices, and other department personnel.

• Provides possibility for hierarchical data access.

• Provides ability to securely upload or import quality control test data and independent assurance data from external sources (such as, vendors, contractors, consultants).

• Provides electronic approvals.

• Automates calculating pay factors and make acceptance decisions.

• Provides ability to highlight specification non-conformance in real-time (such as during construction) and the opportunity to take timely remedial actions.

• Aids in developing performance measures for the overall quality assurance program.

• Generates ad-hoc and standardized reports in a manner that can be easily incorporated into documents. Reports that could be generated for a specific project or on a program-wide basis include:
  1. Measuring turnaround time between material testing and availability of the test results.
  2. Assessing compliance with minimum acceptance testing requirements.
  3. Monitoring conformance with Certificate of Compliance submittal requirements.

• Provides ability to perform various engineering analyses including:
  1. Rating asphalt and concrete plants based on quality they produce, which would be assessed from quality control records in the database.
  2. Pre-qualifying material suppliers and producers resulting in cost savings in quality assurance programs.
  3. Testing the effectiveness of current specifications or quality assurance processes and revising them as necessary based on performance or cost analysis.
  5. Tracking overall system performance and the performance of new and innovative materials, construction, and testing technologies.
  6. Forensic evaluation of pavements using lot specific materials, construction, and climatic data.
  7. Aiding in improving pavement design and pavement management processes.

3.1.3 Construction Quality Assurance Database Architecture

The recommended database is a web-based system with client/server architecture that permits the use of a standalone machine or a hand-held device for field data collection and subsequent
uploading to the server. As illustrated in Figure 3.1.1, the recommended database consists of three main modules:

- **Database server module**—is the core of the architecture storing all system data information and is the module that all client machines connect to through the internet.

- **Database input module**—provides the framework and format to make data inputs in several categories including general contract information, materials and design, quality control testing, acceptance testing, construction records, and independent assurance testing.

- **Database management module**—provides necessary specification information for each material for comparison with quality-of-construction data (from database input module) to calculate pay factors, establish acceptance or rejection decisions, generate reports, and perform quality data queries and engineering analyses. This module also provides the required communication links and tools to permit the interchange of data between the construction quality database and other Caltrans databases.

![Figure 3.1.1. Construction Quality Assurance Database Architecture](image)
### 3.1.4 Construction Quality Assurance Database Input Software

The recommended software application for providing the interface to input construction quality-related data is known as AASHTOWare Project Construction & Materials.

The American Association of State Highway and Transportation Officials (AASHTO) is a nonprofit, nonpartisan association whose primary goal is to foster the development, operation, and maintenance of an integrated national transportation system. AASHTO was established in 1914 and now serves highway and transportation departments in the 50 states, the District of Columbia, and Puerto Rico. An increasingly important part of this service is to provide a construction contract management solution known as AASHTOWare Project™ (Project™).

Project™ is a modular approach to software that encompasses the lifecycle of construction contract management prevalent in transportation agencies throughout the United States. Currently, more than 48 state transportation agencies, several hundred cities and counties, several hundred engineering consulting firms, and several thousand highway-contracting firms now use at least one Project™ module. Applications include a range of functions, from project estimation, to contract proposal preparation, to electronic bidding, to pre-award analysis, and construction contract management.

The Project™ module categories include: estimation, projects & proposals, bid lettings, and construction. estimation, projects & proposals, and bid lettings categories are preconstruction functions and are distinguished from post-award or construction functions. The Project™ module with construction and materials functionality, known as AASHTOWare Project Construction & Materials, is currently in development with production release scheduled for late in calendar year 2014.

The web-based AASHTOWare Project Construction & Materials software is designed to be a comprehensive construction management tool providing:

- Capabilities for electronic data entry, tracking, reporting, and analysis of contract data from contract award through finalization eliminating the need for paper records and duplication of efforts in entering field test data.
- Capabilities for recording, tracking, and reporting of material samples and test results from job sites, plants, and test labs.
- Multi-tier web architecture allowing for easy integration and data exchange with other databases.
- Access by all levels of construction and materials personnel, such as field inspectors, technicians, project managers, clerks, auditors, lab personnel, management, producers, suppliers, contractors, and the FHWA.

By adopting software that has been proven in multiple transportation agencies and is supported through shared investment, Caltrans can avoid risk that is often associated with custom software development and implementation. Additionally, since on-going maintenance costs for a custom solution typically run 17 to 20 percent of the initial system cost, this financial burden will be significantly reduced by sharing these expenses with the other AASHTO software licensees. Also
of importance, all base software upgrades and standard customer support are included in the AASHTOWare licensing fees.

DES-Office Engineers currently license AASHTOWare Project Expedite (the de facto national standard electronic bidding system) and BAMS/DSS (a client/server historical database and bid analysis software). Caltrans is also in the Feasibility Study Report (FSR) phase to procure AASHTOWare Preconstruction (web-based software for proposals and bid letting) and AASHTOWare Civil Rights & Labor.

Additional information about AASHTOWare software is available in the AASHTOWare catalog available for download at:

http://www.aashtoware.org/Pages/default.aspx

3.1.5 Implementation of Construction Quality Assurance Database

The first step in implementing a construction quality assurance database has already been accomplished with the approval of an Information Technology (IT) Concept Statement Form on June 26, 2009 (see Appendix E). The next step would be to develop an FSR. It is anticipated that FSR development and approval would take 12 months with an additional 4 to 6 months to obtain consultant services should Caltrans outsource FSR preparation. Caltrans would also need to prepare and approve a budget change proposal for costs and staffing necessary for the project.

The time and costs for implementing the database can vary depending on whether available software is purchased and modified or new Caltrans-specific software is to be developed (not recommended).

System acquisition could take 2 to 5 years after FSR approval. After system acquisition, collecting data, developing the needed correlations between as-built and design life, and verifying those correlations could take 2 to 10 years. Reallocation of staff would be required for implementation. For example, engineers would be relocated from field-testing to perform data analysis and evaluation to develop the needed correlations.
Section 2  
Long-Range Objective—System-Based Acceptance Process

Caltrans needs a system-based materials management system that monitors material quality on a statewide basis to facilitate more efficient use of testing and sampling resources.

System-based acceptance is the process by which a department of transportation performs tests and inspections on a system-wide basis, rather than on a project-specific basis. For example, in a system-based process only one verification sample would be tested for a particular heat of steel, whereas on a project-based system, several samples might be taken and tested for steel from the same heat delivered to multiple projects. System-based acceptance is most beneficial for off-site produced items, but can be advantageous for on-site produced materials on a more limited basis.

The advantages of a system-based acceptance process include improved quality because problem areas can be more readily identified and corrected, and more efficient resource use due to eliminating duplicate tests and inspections.

The following subsections discuss the system-based acceptance process.

3.2.1 Pre-Approved Source

Certain material sources consistently demonstrate the ability to supply acceptable products. Caltrans would periodically sample and test products from selected material sources and, if acceptable, would designate the source as approved and certified. Materials from such sources would be accepted for use upon delivery to the project site with proper documentation and no further sampling or testing would be required.

Pre-approved sources would be shown on a Caltrans approved list of sources for a specific time until a renewed approval was established by Division of Engineering Services – Materials Engineering and Testing Services/Office of Structural Materials (OSM). The current list would be available online.

3.2.2 Unapproved Source

If a source listed on the Contractor’s Form CEM-3101, “Notice of Materials to Be Used,” was not pre-approved by Caltrans, OSM would contact the source and arrange for source approval or for the testing of a specific “lot” of material. A “lot” generally refers to an isolated quantity of specified material from a single source. The variability of the material to be supplied would become the determining factor for source approval. Lot approval would only apply to the defined quantity of material. Source and lot approvals for unapproved sources are as follows:

- Lot Approval—Sampling of a specific lot would be arranged and, in most instances, would be submitted with a sampling report to Caltrans laboratories for testing and approval. The sampling report is essential, since it would be used to enter necessary information into the construction quality assurance database (QAD) for project-level documentation and to support the project materials certification when the pay item is completed.
• Source Approval—Source approval would work like lot approval except the data used for approval would often include manufacturer quality control data and site inspection results by Caltrans materials personnel. A report for source approval would be issued similarly to the report issued for the sampling of a specific lot. Lot and source approval reports would be essential to the QAD because they initiate tracking of the material approval process through project implementation and project materials certification.

3.2.3 Laboratory Testing

Material samples for projects throughout the state would be routinely routed to the Transportation Laboratory, district/region, or field laboratories. The laboratory would assign a number for tracking purposes, and enter basic information from the sample report into the QAD, including source identification, material identification, and, if applicable, project identification. As each laboratory completes the required testing, the results of the test data would be entered, cross-referenced, and tracked using the QAD. QAD data would be available to all Caltrans district/regions and their respective project personnel, who would track the material sample from the time it was received at a laboratory until the time project materials certification was needed for the item. The QAD would also track the approval of components for such items as PCC. For a PCC item, the QAD would maintain data on components (for example, cement, aggregates, admixtures, water) as well as the resulting PCC. If the resident engineer, contractor, producer, or manufacturer requested test status on a particular sample, Caltrans personnel could quickly access and provide the information.

3.2.4 Material Approval and Delivery

After materials were tested at a Caltrans laboratory, Caltrans personnel would evaluate the results in accordance with contract or standard specifications. If the material source or lot were approved, OSM would notify the manufacturer or producer. Upon delivery, the manufacturer or producer would be required to provide shipping documents as minimum evidence of inspection to demonstrate delivered materials are from an approved lot or approved source. The resident engineer would verify that a copy of the shipping document is forwarded to the district/region materials engineer. Upon receipt, the district/region would enter the source identification, destination identification, material type, lot identification (the lot number at the time of approval), and the quantity delivered into the QAD. The QAD would allow Caltrans to verify the status of each shipment and the remaining balance in an approved lot of material.

3.2.5 Field Release of Manufactured Items

The QAD would also identify and track manufactured items that OSM had released from a facility to be field inspected for acceptance. Field staff would be able to identify from the QAD the items required to be inspected at site.

3.2.6 Project-Level Documentation

With few exceptions, all off-site materials used in Caltrans construction would be pre-inspected (tested and approved to meet the contract specifications) before they were delivered to the project. The resident engineer would ensure project materials were delivered to the site with the proper shipping documents, which include the laboratory number as evidence of inspection. In addition,
some materials would have additional inspection requirements and additional indicators for evidence of inspection.

OSM should develop and maintain an “Evidence of Inspection Documentation,” listing the minimum evidence of inspection documentation required for the acceptance of all applicable materials at the project site. OSM should also distribute a copy of this list to the contractor, resident engineer, and assistant resident engineer at each pre-construction meeting. Material without evidence of inspection would not be incorporated into the work.

The resident engineer has the final opportunity to observe project materials to detect any problems before they are incorporated in the project. If evidence of inspection were lacking or less than minimum or if there were any doubt as to a material’s acceptability, the district/region materials engineer would be immediately contacted before the material was accepted. When materials were shipped to projects from intermediate suppliers, the supplier’s shipping document would be required to reference the laboratory number and the original manufacturer’s shipping document number. The original manufacturer (point of sampling) would be required to submit the proper documentation to OSM. The resident engineer would forward a copy of all shipping documents to the district/region materials engineer.

The assistant resident engineer or office engineer would be responsible for recording, on the Daily Report, the quantity of material delivered and placed and the acceptability of the material. If a manufacturer or producer delivered material to the site, the assistant resident engineer or office engineer would again be required to verify the shipping document referenced the appropriate laboratory numbers. Caltrans project personnel would enter the laboratory number and additional information from the shipping document into the QAD and request verification of acceptability. The QAD would assign the request a tracking number and the data would be uploaded from the computerized project record system to the QAD, which, in turn, would verify the data entered against the data previously entered by OSM on the status of the approved lot of material. The QAD would verify the lot identification, delivery date, project identification, and quantity. At the time the data were uploaded, the QAD would immediately notify project-level personnel of any deviations in acceptance criteria. All deviations would require resolution prior to OSM performing the final review and audit; otherwise, acceptance criteria would be met and the QAD would document completion and acceptance of the pay item.

All data entered at the project level would be required to match the data in the QAD for that particular material. If the data matches, the QAD would generate a verification report for the resident engineer documenting the quantity shipped from the approved lot. As part of the tracking and auditing system, the QAD would then adjust the balance of the quantity remaining in the approved lot.

### 3.2.7 Final Materials Certification

The primary objective of the QAD is to track and document materials certification for all project pay items during project construction. The QAD would use project level materials data from the computerized project record system and from Caltrans laboratories to document the acceptability of pay items (that is, validity of samples and test results comply with specifications, lot and source approvals properly documented, shipments properly documented and traceable to source). If
material discrepancies were encountered during the project, the QAD would immediately alert Caltrans personnel to resolve the issue. The system would also be tied to the project pay system and would calculate pay adjustments as indicated by test results. Project materials certification, in essence, would occur as the project was being constructed. At the time project materials certification was required for project finalization, the QAD would provide Caltrans personnel with an efficient and relatively routine method of validating project pay items. After project completion, Caltrans would generate the materials certification for the project. The resident engineer would use the QAD to generate a report documenting the acceptability of each pay item in the project. The final report would be signed and dated by the resident engineer, and the project records of the QAD would be locked to protect against unauthorized modification.
Section 3
Long-Range Objective—Performance Specifications

Performance specifications reflect the values for materials characteristics or engineering properties used in the design process to predict the design performance life of a facility. The as-built values of those properties are used to predict the as-built performance life. Comparing the as-built performance life to design life is used to calculate the change in life-cycle cost (LCC). The LCC analysis is used to adjust the payment to the contractor. When the as-built life exceeds the design life, the payment would be increased by the decrease in LCC. Conversely, the payment would be decreased by the increase in LCC, when the expected life is less than the design. The advantage to using performance specifications is that the compensation paid to the contractor is adjusted based upon any additional calculated cost or savings to the owner. These types of specifications provide the opportunity for maximum fairness by sharing either savings or cost due to respective good or poor performance.

Performance specifications are either performance-related (calculations of performance life are related to materials quality characteristics) or performance-based (calculations of performance life are based on engineering properties).

Implementing performance specifications would be most feasible in coordination with development of a new construction quality database system, such as that described in Section 1 of this chapter, in which to collect and analyze data to correlate performance with selected materials characteristics or engineering properties.

Examples of needed data include:

- As-constructed values for the designated material characteristics or engineering properties.
- Type, magnitude, and time of observed distresses.
- Correlation between as-built and design life.
- Costs associated with correcting the distresses (LCC).

3.3.1 Performance-Related Specifications

Performance-related specifications (PRS) are “specifications that use quantified quality characteristics and life-cycle cost analysis (LCCA) relationships that are correlated to product performance.” (AASHTO Highway Subcommittee on Construction Quality Construction Task Force, Major Types of Transportation Construction Specifications, draft of August 2003).

PRS identifies and quantifies the particular technical factors that influence product performance. It uses empirical data, engineering judgment, mechanistic modeling, and life-cycle costing as the basis for determining the potential for performance. Like quality assurance specifications, PRS only specifies quality characteristics that lend themselves to acceptance testing at the time of construction. It does not specify the desired long-term product performance.

PRS uses mathematical models to predict future performance, maintenance requirements, and life-cycle costs. Construction quality characteristics, such as initial smoothness, slab thickness, air voids
in asphaltic pavements, and strength of concrete cores, have been found to correlate with
fundamental engineering properties that can predict performance. Conceptually, designs are
developed based on these models to achieve predetermined service lives for specific conditions of
load and environment. Because they are based on data, PRS models present a clear and realistic
picture of what influences a constructed product’s performance. These models are also the means
through which enhanced or diminished life is estimated from results of acceptance tests and, when
combined with appropriate economic principles, how rational payment factors are determined.
Implementation of PRS depends on the development and validation of such models. Correctly
applied, PRS could enable identifying the level of quality that provides the best balance between
cost and performance and assure the attaining that level in the constructed work. Refer to
Appendix F, “Features of Performance-Related Specifications,” for more detailed information
about PRS.

3.3.1. Advantages and Requirements of Performance-Related Specifications

The advantages of using PRS include:

- Design relates performance to quality characteristics.
- Testing and inspections measure characteristics that directly influence performance.
- Payment to the contractor is based upon performance determined from the measured as-built
  quality characteristics.

PRS includes specifications for key materials and construction quality characteristics that have been
demonstrated to correlate significantly with long-term performance of the finished work. These
specifications are based on quantified relationships between such characteristics measured at the
time of construction and subsequent performance. They include sampling and testing procedures,
quality levels and tolerances, and acceptance (or rejection) criteria. Typically, PRS also includes
payment schedules with positive and/or negative adjustments that are directly related through the
performance models to changes anticipated in worth of the finished work as a result of departure
from the quality level defined as acceptable.

Performance-related specifications require:

- A design method that can predict performance based upon material characteristics.
- An information system to register the values of the material characteristics of the constructed
  facility.
- An information system to register performance data of the constructed facility.
- A system for correlating the as-designed to the as-built of the constructed facility.

Performance-related specifications for pavement, as an example, require four major elements:

1. Pavement management system.
2. Mechanistic/empirical (M/E) design.
3. Life-cycle cost analysis.
4. Material management system.

Performance-related specifications for pavement rely upon inter-relationships among these major
elements:
• A pavement management system that tracks pavement performance.
• The M/E formulation for pavement design relates material quality characteristics to pavement performance.
• The pavement management system data is used to calibrate the M/E formulation for the local materials.
• Field measurement data entered in QAD, for material quality characteristics for each project, is compared to those used in the M/E design formulation.
• The differences between the material quality characteristics used in the M/E design formulation and those measured in the field are used in the life-cycle cost data to determine pay factors.
• Pay factors increase or decrease the payment to the contractor based upon predicted performance. (For example, M/E is used to develop the parameters for a 20-year pavement life, and the actual field production results show that the pavement would only have a life of 15 years, the LCCA would be used to calculate the cost for 5 years, and this would be the amount deducted from payment to the contractor.)

3.3.1.b Status of Performance-Related Specifications

Caltrans is already working to implement three of the four numbered elements listed above. In 2013, the Caltrans pavement management system (PaveM) became functional. The M/E design for flexible pavement was required for all designs beginning January 2014. Caltrans is conducting experimental work for rigid pavement M/E. LCCA has been performed since 2007. The QAD still needs to be planned and implemented.

3.3.2 Performance-Based Specifications

Performance-based specifications (PBS) are quality assurance specifications that describe the desired levels of the actual fundamental engineering properties (not the key quality characteristics) that are predictors of performance. The fundamental engineering properties in PBS (for example, resilient modulus, creep properties, and fatigue properties) are used in performance prediction relationships (mathematical models). In turn, these models can be used to predict stress, distress, or performance from combinations of predictors that represent traffic, environmental, and structural conditions. In the true sense, PBS is concerned with the performance of the final in-place product, not how it was built.

3.3.2.a Distinguishing Features of Performance-Based Specifications

• Acceptance based on measurement of the finished product’s fundamental engineering properties that predict performance.
• Acceptance limits that are developed on a statistical basis.
• Mathematical models used to quantify the relationship between the fundamental engineering properties measured and product performance. Price adjustments that are based on the expected LCC of the constructed transportation facility.
3.3.2.b Status of Performance-Based Specifications

Complete performance-based specifications do not yet exist. Specifications, in *Superpave Performance Graded Asphalt Binder Specifications and Testing*, which were developed through the Strategic Highway Research Program, are an example of a partial performance-based specification. However, a performance-graded asphalt binder is only one component of the final product. All of a product’s constituent materials and their related fundamental engineering properties must be included to have complete models to predict performance of that product. Other performance-based test methods have not been fully developed. Performance-based test methods have yet to be developed to a user-friendly level that would permit timely acceptance testing. Further development and validation of performance-based tests are currently underway through research programs.

In addition, true PBS will require good PaveM data to generate and validate the models required to determine price adjustments based on expected LCCA. As discussed previously, most agency management systems do not presently collect and evaluate all of the data necessary to develop the required performance and cost models. Accordingly, PBS has not yet emerged as a viable tool in highway construction.

3.3.3 Quality Assurance Program Changes

As performance specifications are implemented, it will be necessary to make changes to the QAP, primarily in the sampling and testing requirements, in the pavement specifications, and the *Construction Manual*. For example, if fatigue and stiffness are chosen as the performance measure for hot mix asphalt, testing requirements will need to be included in those documents.
Section 4
Long-Range Objective—Risk-Based Acceptance Criteria

Caltrans should analyze the uniformity and quality of materials produced and, based on the results of those analyses, adjust the quality verification program accordingly.

Risk-based acceptance is a statistical method for establishing the level of risk to each party by calculating the likelihood of accepting materials that do not meet specification and, conversely, rejecting acceptable material. The benefit of using risk-based acceptance is that variances of materials and of testing and sampling are recognized and accounted for, which helps minimize the use of erroneous test results.

Risk-based acceptance criteria assume these governing specifications:

- Incorporate material quality characteristics that are consistent with design requirements.
- Include acceptance limits that consider the normal variability associated with products, sampling and testing processes, contractors, and producers.
- Acknowledge the inherent risk that measurements made to determine compliance with statistically based requirements may result in the acceptance of “bad” material or rejection of “good” material. Include specification limits based on historical data. (This data would be stored in the QAD. See Appendix F, Materials Management System Objective.)

3.4.1 Analysis Acceptance Limits

Overall product variability can be classified into two main categories:

- Material and construction variability that are mainly the sole responsibility of the contractor.
- Sampling, testing, and performance prediction error, plus any other error sources over which the contractor has no control.

If the specification limits of acceptance do not include reasonable allowances for material and construction variances, sampling variances, and testing variances that are all inherent in the construction process, specification conformity levels will always be low.

A classic example of this situation can occur in the measurement of slump to determine the consistency of plastic concrete. Research has shown that for a reasonably well-controlled process, the overall standard deviation can be expected to be about 1/2 inch. With specification tolerance limits of ±1/2 inch imposed, research has shown that, over a period of time, one could expect to have approximately 32 percent of the test results out of specification if the process is producing concrete with normal variability and the average slump is equal to the specified target value.

To allow for normal variability due to sampling, testing, and inherent materials variations, the tolerance limits in this example should be set at ±1 inch (equal to two standard deviations) when judging conformity on the basis of one test. With these tolerance limits, approximately 95 percent conformity can be expected over a period of time. This will avoid having changes made when the
process is really under control. Only when the precision of sampling and testing methods and normal production processes are improved would it be practical to tighten these tolerances.

The following are required to confirm statistically based limits of acceptance:

- The materials and construction quality levels from appropriate contractors and producers to determine representative inherent local variability for each quality characteristic.
- Data collected using multiple random field samples under controlled conditions that reflects the known variability of the materials produced for each quality characteristic.

If conformity with the specification limits of acceptance is consistently high and the specifications are deemed adequate to produce the performance desired, sampling frequencies specified in the quality verification program should be reduced on a project basis. Conversely, if the specification conformance is low, increased sampling frequencies should be considered to reduce the risk of accepting non-specification material.

### 3.4.2 Analysis to Confirm Acceptance Plan Risks

Establishing the limits to be used for acceptance is an important part of a quality assurance program. Making the limits too restrictive deprives the contractor of a reasonable opportunity to meet the specification. Making them not sufficiently restrictive makes them ineffective in controlling quality. Selection of the limits relates to the determination of risks. The two types of risk encountered are the seller’s (or contractor’s) risk, alpha, and the buyer’s (or Caltrans’) risk, beta.

The seller’s risk is the probability that an acceptance plan will erroneously reject acceptable quality level material or construction with respect to a single acceptance quality characteristic. The contractor or producer takes the risk of having acceptable quality level material or construction rejected.

The buyer’s risk is the probability that an acceptance plan will erroneously fully accept rejectable quality level material or construction with respect to a single acceptance quality characteristic. Caltrans takes the risk of having rejectable quality level material or construction fully accepted.

To evaluate how the acceptance plan will perform over a wide range of possible quality levels, it is necessary to construct an operating characteristic curve that is a graphic representation of an acceptance plan. This would show the relationship between the quality of a lot and either (1) the probability of its acceptance (for accept/reject acceptance plans), or (2) the probability of its acceptance at various pay levels (for acceptance plans that include pay adjustment provisions).

Acceptance plans must consider these risk in a manner that is fair to both the contractor and Caltrans. Too large a risk for either party undermines credibility; therefore, the risks should be both reasonably balanced and reasonably small.

The seller and buyer risk levels that may be appropriate vary, depending on the material or construction process involved. While setting the acceptance risk levels is a Caltrans decision, Section 9, “Risks and Risk Analysis,” of AASHTO’s Standard Practice for Acceptance Sampling Plans for Highway Construction (AASHTO R 9-05 [2009], page R9-19) presents the following guidance:
The appropriate risk level is a subjective decision that can vary from agency to agency. However, as an economic decision, typical practice limits risks to no more than five percent. The more critical the application, the lower should be the buyer’s risk. But only under rare circumstances should the buyer’s risk be lower than the seller’s risk.

If the acceptance plan risks are considered acceptable in terms of being low and the specifications are deemed adequate to produce the performance desired, consideration should be given to reducing sampling frequencies set forth in the quality verification program on a project basis. However, if the risks are considered unacceptable in terms of being too high, a reassessment of the quality verification plan and possible increased sampling frequencies should be considered to reduce the risk of accepting non-specification material.

In summary, the opportunity exists for Caltrans to use existing quality verification program resources more effectively by including risk-based acceptance criteria provisions in the governing specifications.
## Appendices

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<th>Title</th>
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<td>Quality Assurance Support Services Available to Resident Engineer</td>
</tr>
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<td>C</td>
<td>Contract Administration Process Evaluation (CAPE)</td>
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<td>D</td>
<td>Quality Assurance Program Bulletin</td>
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<td>E</td>
<td>IT Concept Statement Form</td>
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<td>Features of Performance-Related Specifications</td>
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CONSTRUCTION QUALITY ASSURANCE PROGRAM MANUAL
Appendix C—Contract Administration Process Evaluation

Caltrans Division of Construction
CHARTER: Contract Administration Process Evaluation (CAPE)

BACKGROUND:
In 2000, the Caltrans Division of Construction (Construction) initiated its first process evaluation of contract administration guidance and practices. Construction’s executive management meets each year to compile a list of potential contract administration topics for evaluation. Typically, these topics are areas of concern where there may be a lack of contract enforcement, a lack of understanding by resident engineers, or contractor disputes. Each year, Construction chooses approximately three to four topics for evaluation.

Once topics are selected, a CAPE evaluation plan is developed. The plan consists of the problem statements, objectives, estimates of resources needed, and identifies the managers and team leaders. The team leaders are typically Construction’s subject matter experts. The plan is used as a scoping document to help guide the investigating team members in performing the CAPE. Each district and region provides team members for each CAPE topic. The teams investigate and evaluate the effectiveness of current contract administration processes by interviewing resident engineers in each district and region. The information and findings are collected and compiled into the CAPE report, which identifies strengths, weaknesses and suggested improvements provided for each district and region. Construction also uses the findings as an opportunity to improve policies, guidance and develop needed training. The CAPE report and the associated findings for each topic are shared with the Deputy District Directors and Region Division Chiefs of Construction. Each district and region then prepares an action plan that contains planned managerial or training actions and proposed corrections for the suggested improvements. After two years, a self-evaluation or look back is prepared by each district and region to evaluate the effectiveness of the implemented training or corrective actions taken to improve the contract administration processes.

OBJECTIVE:
Evaluate the current state of contract administration methods, guidance material and processes to identify strengths, weaknesses and suggested improvements. This periodic review of current business practices improves the construction and project delivery process. The proposed changes and process improvements help streamline construction processes and achieve success in the delivery of construction projects.

DESIRED DELIVERABLES:
1. Evaluate each CAPE topic for each district and region. Identify strengths, weaknesses and suggested improvements for each CAPE topic. Compile the results in the annual CAPE report.
2. Develop district and region action plans to address suggested improvements identified in the CAPE. Monitor and implement the action plans.
3. Where appropriate, improve contract administration policy, processes, guidance material, specifications and administration by field staff.

RESOURCES:
Individual CAPE teams are made up of Caltrans staff from headquarters and supporting team members from the districts and regions. Consultants may participate in each topic team to aid in collecting data and then preparing the final CAPE report. Travel is authorized as needed to conduct the interviews.

SPONSORS:

SCOTT JARVIS  DATE  MARK LEJA  DATE
Assistant Chief, Division of Construction  Chief, Division of Construction

December 6, 2012
Quality Assurance Program Bulletin

QAPB YY-nn Quality Assurance Program Bulletin Style Sheet
The QAPB title should fit on one line and clearly describe the contents.
When possible, list references in the order they appear in the body of the QAPB.

References:
- Reference titles here Cite the number and section title of the reference. If the information wraps to the next line, indent 1/4 inch.
- Additional reference titles here Stack information about additional references here. If the information wraps, indent 1/4 in.

(Example):
- Standard Specifications Section 6-3.04, “Quality Control”
  Section 15-2.02B, “Quality Control, Inspection and Testing”
  Section 1-7 “Inspection and Testing”

Effective Date: Day after the approval date Approved: XXXX XXXX
Chief
Division of Construction

Approval Date: Seven to ten days in the future

Background
In the “Background” section, introduce the subject and provide summary information. Help the reader understand that the Division of Construction is changing an existing process or implementing a new one. The summary usually provides two or more of the following:
- Information about circumstances, such as changes in the law, that led to the creation of the QAPB.
- A description of problems or common errors that required the QAPB.
- A brief explanation of how the new procedure improves the old procedure or what impact the new procedure will have.

The “Background” section rarely contains as much information as the “New Procedure” section.

Existing Procedure
This section cites references to existing procedures and provides summary information being changed or replaced.

“Provide a safe, sustainable, integrated and efficient transportation system to enhance California’s economy and livability”
Avoid providing details about existing procedures. Readers can check the references you provide if they want to see details.

**New Procedure**

The “New Procedure” section begins with an introduction to the procedure. It provides details about each function that must be performed in the new procedure, identifies the titles of the persons responsible for performing the function(s), and frequently provides timeline information.

- Provide the information the reader will need to perform the new procedure but not more information than necessary. Remember the reader is in the field with limited access to reference materials.
- Write the QAPB as it should read in the *Construction Quality Assurance Manual*. Doing so now will reduce the time spent in the future to update the manual.

Provide a closing statement that includes the contact person’s name, “Division of Construction,” email address, and telephone number.

*“Provide a safe, sustainable, integrated and efficient transportation system to enhance California’s economy and livability”*
Appendix E—IT Concept Statement Form

IT Concept Statement Form

A. Naming, Contact, and Approval Information

A.1 Proposed project name, submitter, and contact

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>Materials Certification and QCQA System</th>
<th>Date:</th>
<th>June 26, 2009</th>
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<tbody>
<tr>
<td>Submitted By:</td>
<td>Division of Construction</td>
<td>Phone:</td>
<td></td>
</tr>
<tr>
<td>Office:</td>
<td>Division of Construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact Name:</td>
<td>Chuck Suzko</td>
<td>Phone:</td>
<td>916-227-7314</td>
</tr>
</tbody>
</table>

A.2 Approvals

The following personnel have reviewed and approved the contents of this concept proposal and ensure that the business and financial information is consistent with the program area business objectives/charter.

<table>
<thead>
<tr>
<th>FSR Sponsor signature(s) and date</th>
<th>1. Mark Leja</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deputy Director signature and date</td>
<td>Richard Land</td>
</tr>
</tbody>
</table>

Information Technology Management Committee (ITMC) | Approved | Denied | Date |

| ITMC Chair signature and date | Not currently required |

Caltrans Organization:  Page 1
IT Concept Statement Form

B. Concept Description (see instructions)

B.1 Business Problem or Opportunity

Certain materials incorporated into construction projects must be certified or tested to ensure that they meet contract requirements. A log of material certifications is to be kept on file with each project. These logs have not always been kept up to date or are not readily available during audits. The Federal Highway Administration has requested that such logs be made available to them.

Additionally, the Department is heading to a Quality Control/Quality Assurance process on materials where the contract must establish control mechanism to ensure quality products and the Department assures that the contractor is performing quality work. This process requires frequent and lengthy data transfers to ensure a statistical correlation between the tests. This is currently done with paper forms the often require re-entering data. This leads to errors and, sometimes, lengthy and expensive disputes.

B.2 Solution Research Methodology

The goal would be to develop a web-based application that would allow both the contractor and the Caltrans field staff to enter data onto an electronic form specific to each project. The application would perform the necessary calculations to arrive at the applicable adjustment or notify the parties when correlation cannot be achieved. The process would result in more efficient data entry and calculations and allow for the logging of the results. This automatic logging would also solve the first issue identified above.

B.3 Success Factors

Success would be:
- Quicker comparisons of QC and QA to allow corrections while materials are still being placed, which allows for improved material quality instead of penalties for poor products.
- Fewer disputes over entered information
- More accurate data
- Automatic tracking of data

B.4 Strategic Information

Please answer the following questions by marking “Yes” or “No” and provide narrative as appropriate.

Is the project consistent with Caltrans and/or program area Strategic Plan? [ ] Yes [ ] No

Briefly explain: Material testing and quality are essential to long-life infrastructure. Accurate and responsive testing will allow for better quality material and lower expenditure of resources.

Is the project identified in the Caltrans and/or program area IT tactical and/or strategic plans? [ ] Yes [ ] No

The need for automating testing and record keeping has been known for some time. The addition of QC/QA is accentuating this problem by increasing the amount and detail of data being developed.

Caltrans Organization:
B.5 Constraints

- System must allow for tracking materials on approximately 700 contracts.
- System must be able to be accessed by both external personnel/entities as well as department staff.

C. Concept Scope

C.1 Integration Information

Please answer the following questions by marking “Yes” or “No” and provide narrative as appropriate.

- Will this project upgrade or enhance an existing system (s)?
  - Yes ☐ No ☒
  - If so, provide name of system (s):

- Will this project replace an existing system (s)?
  - Yes ☐ No ☒
  - If so, provide name of system (s):

- Will this project exchange data (i.e. interface) with an existing system (s)?
  - Yes ☒ No ☐
  - If so, provide name of system (s): CMS – necessary to pull project specific data and, possibly, to allow pay factors to be included.

C.2 Business Processes Impacted

This section describes the high-level business functions that this system supports. Check all appropriate functions.

- [ ] Plan Transportation Solutions
- [ ] Specify Transportation Solutions
- [ ] Implement Transportation Solutions
- [ ] Manage Transportation systems
- [ ] Maintain Transportation Systems
- [ ] Manage Transportation Information
- [ ] Manage Human Resources
- [ ] Manage Finances
- [ ] Manage IT
- [ ] Manage Stakeholders
- [ ] Manage Departmental Assets
- [ ] Manage Procurements
- [ ] Manage the Enterprise
- [ ] Manage Projects
- [ ] Manage Operational Requirements
- [ ] Manage Contracts
IT Concept Statement Form

C.3 Cost estimates

Please check the appropriate cost estimate:

- Will the cost, excluding operations and maintenance, of the project be between $50,001 and $500,000? [x]
- Will the cost, excluding operations and maintenance, of the project be between $500,001 and $5,000,000? [ ]
- Will the cost, excluding operations and maintenance, of the project be between $5,000,001 and $10,000,000? [ ]
- Will the cost, excluding operations and maintenance, of the project be over $10,000,000? [ ]
- Unable to provide cost estimates at this time [ ]

C.4 Funding (see instructions)

The creation and establishment of the system is funded through the cost report. The maintenance will be funded through the Capital and Maintenance operational expenditures.

C.5 Organizational Sizing

Estimate number of users per area.

<table>
<thead>
<tr>
<th>AREA</th>
<th>DISTRICT</th>
<th>HQ</th>
<th>STATEWIDE</th>
</tr>
</thead>
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<tr>
<td>Engineering Services - A&amp;E</td>
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<td>Maintenance</td>
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Caltrans Organization: Page 4
## IT Concept Statement Form

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<td>Permits</td>
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<td>TMC</td>
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<td>Traffic Operations</td>
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<tr>
<td>Other:</td>
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</tbody>
</table>

### D. FSR Development and Planning Information

Who will lead the FSR Study team if this concept is approved?

**Chuck Suszko**

Who will participate in the FSR study team?

**TBD**

Please describe the FSR effort in quantitative terms. Ex. Do you expect three people to work on it for a quarter of their time for 3 months? Two people working half time for 5 months?

Three people working on the FSR for a quarter of their time for 6 months.

When do you estimate the FSR being completed?

**March, 2010**
1.1. **Distinguishing Features of Performance-related Specifications**

1.1.1. Acceptance based on key quality characteristics that have been found to correlate with fundamental engineering properties that predict performance.

1.1.2. Mathematical models used to quantify the relationship between key materials and construction quality characteristics and product performance.

1.1.3. Price adjustments related to the expected life-cycle cost (LCC) of the constructed transportation facility.

1.2. **Components of Performance-related Specifications**

1.2.1. Identification of owner's needs or goals

   In the application of PRS, the owner defines its needs at the highest possible level. For example, for pavements such goals are safety, comfort, accessibility, and capacity. Lower level requirements, such as material or manufacturing properties, are included only when necessary and where definitions for desired performance cannot otherwise be expressed in clear and unambiguous terms.

1.2.2. Performance parameters

   Performance parameters are functional requirements that can be measured or tested to ensure that the owner's project goals are satisfied. For example, possible performance parameters for an asphalt pavement include smoothness, in-place density, and asphalt content.

1.2.3. Measurement or testing technique

   PRS identifies a measurement strategy for each performance parameter. For example, pavement smoothness could be measured using a high-speed profilograph. The most desirable performance parameters are measurable.

1.2.4. Performance value or threshold

   For each performance parameter, PRS sets a performance value, expressed in terms of ranges (minimum/maximum), thresholds, or a rating system. For example, a performance value associated with pavement smoothness could be expressed as a maximum International Roughness Index (IRI) in inches/mile.
1.2.5. Verification tests or inspection

PRS requires the contractor to develop, submit, and implement a plan to control the quality of materials and construction. Even though the contractor may assume more responsibility for inspection and testing under PRS, this in no way relieves Caltrans of its responsibility to perform its own oversight and independent verification to ensure that the product meets or exceeds the stated objective or standard.

1.2.6. Price adjustment

Unlike method specifications, PRS allows the parties to acknowledge a range of acceptable work quality through the use of price adjustments that reflect the value of the work received. Pay adjustments are based upon the analysis of both As-Designed and As-Constructed life-cycle costs (LCC).

As-Designed LCC is determined by using the target values of the specified quality characteristics as inputs to the Models. As-Constructed LCC is determined by using the actual measured values of a construction project's quality characteristics as input. The difference between As-Designed LCC and As-Constructed LCC is the basis for any pay adjustment. Since price adjustments are based on a lifecycle cost analysis, a negative pay adjustment covers the cost of future maintenance and rehabilitation due to the construction not meeting the designed level of quality while a positive adjustment reflects the savings in maintenance and rehabilitation due to the higher level of initial quality.

1.3. Development of Performance-related Specifications

Basic requirements for development of PRS include:

1.3.1 Products that are viable candidates for PRS are identified. The use of PRS is considered for those products for which the end product performance is measurable; the specified testing is rapid, available, and economical; and for those which the contractors are willing to assume performance risk because they are in a position to control the risk or are attracted to the possibility of increased profit.

1.3.2 In-service performance requirements are organized and prioritized for each of the identified products.

1.3.3 Specification language is developed or existing specifications modified to accommodate the use of PRS for those products that have performance clearly identified.
1.3.4. Mechanistic-empirical models are developed and/or actual performance data is assembled that clearly link design factors to performance. Factors that are under the direct control of the designer and those that are under the direct control of the contractor are identified.

1.3.5. Non-destructive tests are developed and implemented that link more directly to performance and focus on 100 percent sampling and/or continuous sampling of the in situ product.

1.3.6. Critical quality characteristics should be readily measurable and clearly tied to product performance. Construction contractors should be held accountable only for those quality characteristics under their control.

1.3.7. Prediction tools, including modeling and databases, are verified, calibrated, validated, and otherwise made appropriate for local conditions.

1.3.8. Life cycle cost analyses (LCCA) are used to compare the as-designed product section to the as-built section. The LCCA is based on a clear, well-documented, and realistic preservation, rehabilitation, and maintenance decision process. User costs are considered in developing appropriate pay factors.

1.3.9. Acceptance plans are statistically based with clearly defined risks. If necessary, pay determinations are completed in a timely fashion to allow for prompt corrective action. Sampling and testing plans properly address material, operator, and testing variability and improve confidence in the results.

1.3.10. Performance-related specifications are written simply, clearly, and concisely.

1.3.11. As PRS end-result criteria are added to a contract for a specific quality characteristic, they are accompanied by a corresponding reduction in prescriptive or method elements, giving the contractor more freedom to innovate, improve quality, and clarify roles and responsibilities.

1.3.12. Testing requirements incorporate standardized tests using nondestructive techniques to measure the product in situ, better quantifying the quality characteristics and enhancing 24 to 48-hour, if not instant, turnaround of information through the use of computer technology.

1.3.13. The contractor is given reasonable latitude to develop and implement a quality control plan that can be verified by Caltrans, especially for those quality characteristics included in the acceptance plan.
1.3.14 Performance prediction techniques used in PRS are based on mechanistic models and are the same models used in the design process. Asset management systems track the same assumptions used in both the design and construction process.

1.4. Implementation of Performance-related Specifications

The ability to both develop and implement PRS is dependent upon Caltrans having reasonable Performance-Prediction Models and Maintenance-cost Models. Performance-Prediction Models predict when and to what extent a construction product (such as a pavement) will exhibit a given type of distress, such as fatigue cracking or joint spalling. Maintenance-cost Models estimate the post-construction life-cycle cost (LCC), which is the cost of maintenance and rehabilitation necessary throughout the projected life of the product. Inputs for these models include design variables such as traffic loading, climatic factors, drainage, and soil factors and quality characteristics such as asphalt binder content and air voids, concrete permeability and strength, and ride smoothness. These models can only be developed and validated through good quality data, including pavement and bridge performance, construction quality, construction cost, and maintenance cost.

Construction and Engineering Information Management Systems (Pavement, Bridge and Maintenance) are used to collect this data and generate the required Performance-Prediction Models and Maintenance-cost Models.

1.5. Advantages of Performance-related Specifications

1.5.1. PRS directly connects design requirements with construction, provides a critical link between the construction and engineering management systems, and improves overall design-to-construction communication.

1.5.2. PRS uses a more rational and defensible approach in developing pay factors for adjusting contractor pay when quality is above or below desired levels.

1.5.3. Testing requirements focus more on those characteristics that relate to performance giving Caltrans the capability to target and economize inspection programs.

1.5.4. Performance, quality, and costs are uniquely connected through modeling and life cycle cost analyses providing an improved way to analyze tradeoffs.

1.5.5. Improved understanding of those quality characteristics that relate more directly to product performance and more accurately translate design intent into construction requirements.
1.5.6. Improvement in the focus on the overall quality of the product in areas that caused problems previously.

1.5.7. PRS clarifies changes in roles and responsibilities between Caltrans and the contractor and, at the same time, defines the levels of risk for each party. By being less prescriptive, PRS creates an environment that encourages contractor innovation. Contractors have the flexibility to select materials, techniques, and procedures to improve the quality or economy, or both, of the end product.