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.

Six Elements of a Quality Assurance Program

1. Quality Control by Contractor
2. Acceptance by Caltrans
3. Independent Assurance
4. Dispute Resolution Process
5. Authorized Laboratories
6. Qualified Personnel

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:

www.dot.ca.gov/dist1/d1lab/forms/2005_IA_Maunal.pdf

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*.

An overview of the dispute resolution process, including detailed procedures and reporting requirements, is presented in Section 2.5, "Dispute Resolution," of the *Independent Assurance Manual*. Additional details are presented in Chapter 6, "Sampling and Testing," of the *Construction Manual*.

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.

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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

Advantages	Disadvantages
• Method specifications are well established, easily understood, and applicable to a wide range of topic areas. • Caltrans can exert significant control over the work (although this may come at the expense of increased Caltrans inspection efforts). • 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.	• 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. • Method specifications lack built-in incentives for contractors to provide enhanced performance. • The prescribed procedures may prevent or discourage the contractor from using the most cost-effective or innovative procedures and equipment to perform the work. • Contractor payment is not tied to the performance or quality of the work. • Acceptance decisions based on test results of individual field samples can increase the potential for disputes.

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 2.2.2. Advantages and Disadvantages of Quality Assurance Specifications

Advantages	Disadvantages
• Quality assurance specifications promote contractor innovation. • The contractor assumes more performance risk. • Contractors have the flexibility to select techniques and procedures to improve the quality or economy, or both, of the product. • 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. • The potential for disputes is reduced.	• Caltrans has less control over the work. • Identifying all of the parameters critical to performance and establishing related thresholds is challenging. • Roles and responsibilities of the contractor and Caltrans often become blurred if not adequately defined in the specifications or contract documents.

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

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

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.

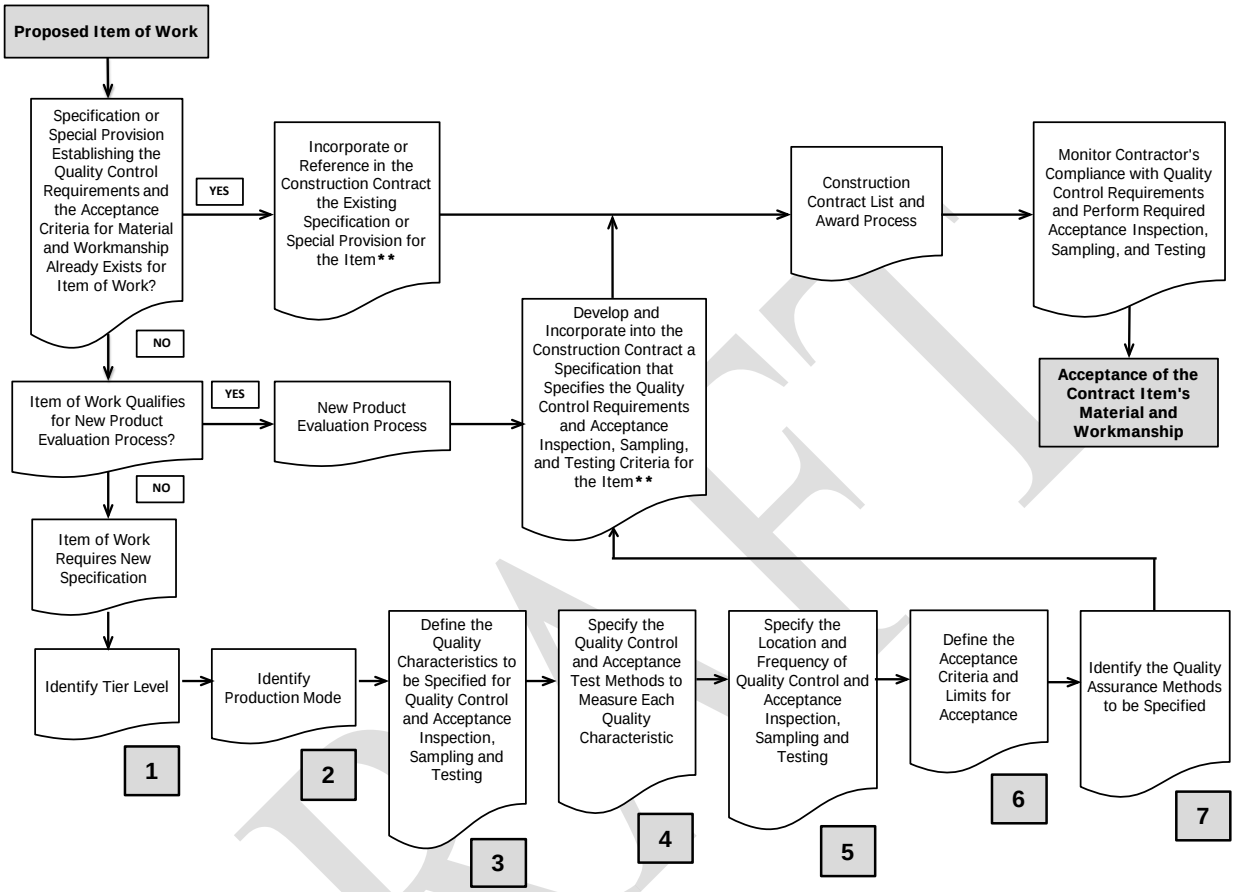
2.2.2 Specification Development Process

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.



** Note: Specified Quality Control Requirements and Acceptance Criteria Must Address Both Material and Workmanship

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

Tier Level	Failure Category	Consequence of Failure	Example Items	Quality Assurance Requirements
1	Catastrophic	Greatest consequence of failure. Failure is likely to cause loss of life or serious injury.	Typically, fabricated structural-type products, such as structural steel, precast girders, pre-stressing.	Quality assurance methods designed to provide the maximum level of confidence in the quality control efforts of both the contractor and the producer.
2	Safety	Although not catastrophic, failure creates a safety hazard for employees or the public.	Manufactured and fabricated safety-related products, such as delineation, safety barriers, lighting, signal controllers.	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.
3	Interrupt Service	Failure or repair may cause an interruption in service, or environmental impact.	Job site-produced base and pavement structure, embankment, and drainage items; and environmental items, including stormwater pollution prevention plan best management practice devices.	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.
4	Monetary	Monetary loss only. Consequence of failure is considered minimal in terms of project performance.	Grass seed, drainage and irrigation products, fencing.	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.

Table 2-2.6. *Standard Specifications* Sections with Associated Tier Levels

Section	Description	Tier 1	Tier 2	Tier 3	Tier 4
12	Temporary Traffic Control		X		
15	Existing Facilities		X		
16	Clearing And Grubbing			X	
17	Watering				X
18	Dust Palliative				X
19	Earthwork			X	
20	Landscape				X
21	Erosion Control				X
22	Finishing Roadway				X
24	Stabilized Soils				X
25	Aggregate Subbases			X	
26	Aggregate Bases			X	
27	Cement Treated Bases			X	
28	Concrete Bases			X	
29	Treated Permeable Bases			X	X
37	Bituminous Seals			X	
39	Hot Mix Asphalt			X	
40	Concrete Pavement			X	
41	Concrete Pavement Repair			X	
42	Groove and Grind Concrete		X		
46	Ground Anchors and Soil Nails	X			
47	Earth Retaining Structures	X			
48	Temporary Structures	X			
49	Piling	X		X	
50	Prestressing Concrete	X		X	
51	Concrete Structures	X	X	X	X
52	Reinforcement	X			
53	Shotcrete			X	X
53-2	Structural Shotcrete	X			
54	Waterproofing				X
55	Steel Structures	X	X		X

Table 2-2.6. *Standard Specifications* Sections with Associated Tier Levels (continued)

Section	Description	Tier 1	Tier 2	Tier 3	Tier 4
56-3	Overhead Sign Structures	X			
56	Signs		X		
57	Wood and Plastic Lumber Structures	X	X		X
58	Sound Walls	X			
59	Painting			X	X
61	Culvert and Drainage Pipe Joints			X	
62	Alternative Culverts			X	
64	Plastic Pipe			X	
65	Concrete Pipe			X	
66	Corrugated Metal Pipe			X	
67	Structural Plate Culverts			X	
68	Subsurface Drains			X	X
69	Overside Drains			X	
70	Miscellaneous Drainage Facilities			X	
72	Slope Protection				X
73	Concrete Curbs and Sidewalks				X
74	Pumping Equipment and Controls				X
75	Miscellaneous Metal		X		
80	Fences				X
81	Monuments				X
82	Markers and Delineators		X		
83	Railings and Barriers		X		
84	Traffic Stripes and Pavement Markings		X		
85	Pavement Markers		X	X	X
86	Electrical Systems		X	X	X

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:
  - 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.
  - Listed in an industry-wide catalog and available for timely delivery.
  - 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 2.2.7. Typical Quality Characteristics for Quality Control and Acceptance

Material Type	Quality Characteristics Typically Measured for Quality Control	Quality Characteristics Typically Measured for Acceptance
Soils and embankment	Moisture content and compaction	Moisture content and compaction
Aggregate base and subbase	Gradation, compaction, and moisture content	Gradation and compaction
Hot mix asphalt	Asphalt content, gradation and compaction	Asphalt content, gradation, compaction, and ride quality
Concrete pavement	Air content, gradation, and slump	Air content and thickness
Concrete structures	Gradation, slump, air content and compressive strength	Gradation, slump, air content, and compressive strength

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.

Table 2.2.8. Quality Assurance Method Application Matrix

Specification Section Heading	Quality Assurance Methods	Job Site	Manufactured	Fabricated	Tier 1	Tier 2	Tier 3	Tier 4	Method Spec	QA Spec	Structures	Roadway
Materials	Authorized Material List		X	X	X	X	X	X	X	X	X	X
	Authorized Material Source List	X	X	X	X	X	X	X	X	X	X	X
	Authorized to Deliver List		X			X	X		X		X	X
	Manufactured to National Quality Standard		X		X	X	X	X	X		X	X
	Proprietary Product or Process		X			X	X		X		X	X
	Commercial Quality		X					X	X			X
	Department-Furnished Materials		X	X	X	X	X	X	X		X	X
Qualifications	Authorized Facility Audit Listing			X	X	X			X	X	X	
	Prefabrication Audit			X	X				X	X	X	
	Authorized Laboratory	X	X	X	X	X	X	X		X	X	X
	Authorized Laboratory List		X		X	X				X	X	X
	Contractor	X	X	X	X	X	X	X	X	X	X	X
	Installer/Applicator/Erector Personnel	X		X	X	X	X			X	X	X
	Fabricator			X	X	X				X	X	
	Fabricator Personnel			X	X	X				X	X	
	Plant (MPQP)	X			X	X	X	X		X	X	X
	Sampling/Testing Personnel	X		X	X	X	X	X		X	X	X
Meetings	Pre-Production Meeting											
Warranty	Warranty (Materials and Workmanship)	X	X		X	X	X	X	X		X	X
	Warranty (Performance)	X				X	X				X	X
Mock-ups	Pre-Production Trial (Mock-up)	X	X	X	X	X	X	X	X	X	X	X
Quality Control	Inspection, Sampling & Testing (Job Site)	X	X	X	X	X	X	X	X	X	X	X
	Inspection, Sampling & Testing (Source)											
	Pre-Production Sampling & Testing (Initial, Stock)	X			X	X	X		X	X	X	X
	Sampling & Testing for Acceptance	X			X		X			X	X	X

Table 2.2.8. Quality Assurance Method Application Matrix (continued)

Specification Section Heading	Quality Assurance Methods	Job Site	Manufactured	Fabricated	Tier 1	Tier 2	Tier 3	Tier 4	Method Spec	QA Spec	Structures	Roadway
Department Acceptance	Certificate of Compliance w/ Test Results	X	X		X	X	X	X	X	X	X	X
	Inspection (Engineering)	X	X	X	X	X	X	X	X	X	X	X
	Inspection, Sampling & Testing (Job Site)	X	X	X	X	X	X	X	X	X	X	X
	Inspection, Sampling & Testing (Source)			X	X	X			X	X	X	
	Inspection, Sampling & Testing (Verification)	X			X	X	X			X	X	X
	Payment Based on Quality Factor	X			X		X			X	X	X
	Test Samples	X	X	X	X	X	X	X	X	X	X	X
Submittals	Construction Method – Design	X		X	X	X	X		X	X	X	X
	Construction Procedures – Engineer	X		X	X	X	X		X	X	X	X
	Fabrication Method – Design			X	X	X			X	X	X	
	Fabrication Procedures – Engineer			X	X	X			X	X	X	
	Mix Design/Job Mix Formula – Engineer	X		X	X	X	X		X	X	X	X
	Product Data	X	X	X	X	X	X	X	X	X	X	X
	Quality Control Plan – Engineer	X		X	X	X	X			X	X	X

Section 6, "Special Provisions," of the *Ready to List and Construction Contract Award Guide* provides guidance for preparing project special provisions. Use the latest version of the special provision template available at the DES-OE website for creating NSSPs. The *Specification Style Guide, 2010/2015* also provides instructions for specification writers contributing to Caltrans' construction specifications.

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:

http://www.fhwa.dot.gov/publications/research/infrastructure/pavements/pccp/02095/02095.pdf

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 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 t 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:

http://www.dot.ca.gov/hq/esc/Translab/OSM/documents/smdocuments/OSMPP.pdf

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:

http://onramp.dot.ca.gov/hq/esc/mets/structure_materials/restrictedosm/admaterials.php

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.

Table 2-3.1. Laboratory Authorization Matrix

		Test Categories										
		CTM*	Non-CTM	Pre-Production	Process Control	JMF/Mix Design	JMF Verify	Quality Control	Quality Control (for Acceptance)	Verification	Acceptance	Dispute Resolution
		Y= Must be Caltrans Authorized to Perform Test										
Laboratory Categories	Contractor	X	X	X		X		X	X			
	Contractor Fabricator/Manufacturer	X	X	X		X		X	X			
	Contractor Independent Third Party	X	X			X			X			
	Contractor Plant	X	X	X		X		X	X			
	Contractor Supplier	X	X	X				X				
	Department Central Laboratory (TransLab)	X	X				X			X	X	X
	Department Designated Agent	X	X				X			X	X	X
	Department District/Region	X	X				X			X	X	X
	Department Field Laboratory	X	X				X			X	X	X
	Independent Third Party (Dispute Resolution)	X	X				X					X
	Local Agency	X	X				X		X	X	X	

* Note: CTM = California Test Method

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

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.

Table 2.3.2. Sampling and Testing Personnel Authorization Matrix

		Test Categories										
		CTM*	Non-CTM	Pre-Production	Process Control	JMF/Mix Design	JMF Verify	Quality Control	Quality Control (for Acceptance)	Verification	Acceptance	Dispute Resolution
		Y= Must be Caltrans Authorized to Perform Test										
Personnel Categories	Contractor Fabricator	X	X	X		X		X	X			
	Contractor Jobsite	X	X	X		X		X	X			
	Contractor Laboratory	X	X	X		X		X	X			
	Contractor Plant	X	X	X		X		X	X			
	Contractor Supplier	X	X	X				X	X			
	Department Central Laboratory (TransLab)	X	X				X			X	X	X
	Department Designated Agent	X	X				X			X	X	X
	Department District/Region Laboratory	X	X				X			X	X	X
	Department Field Laboratory	X	X				X			X	X	X
	Department Jobsite	X	X							X	X	
	Independent Third Party (Dispute Resolution)	X	X									X
	Independent Third Party (Modified Emulsion)	X	X					X	X			
	Local Agency	X	X				X			X	X	

* Note: CTM= California Test Method

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.