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Development of Risk-Based Protocol for KDOT Construction Inspection

Dan Tran, Ph.D., P.E.
Mamdouh Mohamed, M.S.

The University of Kansas

Kansas Department of Transportation

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16 Abstract

State Departments of Transportation (DOTs) have been facing a challenge of shrinking budgets and substantial reductions in both the numbers and experience levels of inspectors over the last decade. Many state DOTs, including the Kansas Department of Transportation (KDOT), have lost experienced construction inspection staff while the numbers of projects and required levels of inspection have increased. To address these challenges, DOTs often rely on contractors' quality control and outsource to a third party for testing and inspection. This strategy, however, is not always a cost-effective approach.

The objective of this project was to develop a risk-based protocol for KDOT to optimize resource allocation for inspection of transportation construction projects. A comprehensive list of 302 testing and inspection activities were retrieved from KDOT's Construction Manual, construction checklists, Standard Specifications, quality assurance guides, and Bridge Construction Manual. Based on the survey responses and interviews with subject matter experts from KDOT and the Kansas Division of the Federal Highway Administration (FHWA), this list was narrowed down to a core list of 108 activities. The risk associated with each core inspection activity was assessed based on the probability of failure and the consequences of failure, measuring in three main dimensions: safety reduction, service interruption, and the effect on long-term performance, expressed as cost of repair. A composite risk index was developed to assess the overall risk impact and prioritization of the 108 core inspection activities. Based on the risk index, a KDOT risk-based inspection protocol was proposed. The risk-based inspection protocol could assist KDOT in efficient allocation of inspection resources.

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Final Report

Prepared by

Dan Tran, Ph.D., P.E.
Mamdouh Mohamed, M.S.

The University of Kansas

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THE KANSAS DEPARTMENT OF TRANSPORTATION
TOPEKA, KANSAS

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THE UNIVERSITY OF KANSAS
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PREFACE

The Kansas Department of Transportation's (KDOT) Kansas Transportation Research and New-Developments (K-TRAN) Research Program funded this research project. It is an ongoing, cooperative and comprehensive research program addressing transportation needs of the state of Kansas utilizing academic and research resources from KDOT, Kansas State University and the University of Kansas. Transportation professionals in KDOT and the universities jointly develop the projects included in the research program.

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Abstract

State Departments of Transportation (DOTs) have been facing a challenge of shrinking budgets and substantial reductions in both the numbers and experience levels of inspectors over the last decade. Many state DOTs, including the Kansas Department of Transportation (KDOT), have lost experienced construction inspection staff while the numbers of projects and required levels of inspection have increased. To address these challenges, DOTs often rely on contractors' quality control and outsource to a third party for testing and inspection. This strategy, however, is not always a cost-effective approach.

The objective of this project was to develop a risk-based protocol for KDOT to optimize resource allocation for inspection of transportation construction projects. A comprehensive list of 302 testing and inspection activities were retrieved from KDOT's Construction Manual, construction checklists, Standard Specifications, quality assurance guides, and Bridge Construction Manual. Based on the survey responses and interviews with subject matter experts from KDOT and the Kansas Division of the Federal Highway Administration (FHWA), this list was narrowed down to a core list of 108 activities. The risk associated with each core inspection activity was assessed based on the probability of failure and the consequences of failure, measuring in three main dimensions: safety reduction, service interruption, and the effect on long-term performance, expressed as cost of repair. A composite risk index was developed to assess the overall risk impact and prioritization of the 108 core inspection activities. Based on the risk index, a KDOT risk-based inspection protocol was proposed. The risk-based inspection protocol could assist KDOT in efficient allocation of inspection resources.

Acknowledgments

This project was made possible by the sponsorship of Kansas Transportation Research and New-Developments (K-TRAN) Research Program and the Kansas Department of Transportation (KDOT). The authors of this report would like to thank project monitor, Greg Schieber, for his guidance and suggestions. The authors also acknowledge the valuable assistance and technical guidance from the members of the K-TRAN Research Committee in the course of performing this study.

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Chapter 1: Introduction

1.1 Background

Inspection of highway construction is fundamental to meet the missions of state Departments of Transportation (DOTs) and the Federal Highway Administration (FHWA) to provide high-quality products and facilities that meet or exceed specified quality standards. State DOTs have historically specified quality standards based on detailed instructions describing the required materials and construction methods. Primary inspection areas typically include interpretation of contract plans and specifications; project recordkeeping and reporting; construction surveying; field inspection and testing procedures, techniques, and equipment; and supervisory techniques.

Federal regulation 23 CFR 637 (2011), subpart B: "Quality Assurance Procedures for Construction" requires that a comprehensive construction quality assurance (QA) program (including inspection and testing) should consist of the following six core elements: quality control (QC), acceptance, independent assurance (IA), dispute resolution, personnel qualification, and laboratory accreditation/qualification. According to an FHWA program evaluation report (FHWA, 2009) and various QA stewardship reviews for 2003–2008, the risks of accepting non-conforming work are high. The FHWA recommended that risk-based evaluation tools should be developed to address risks for materials and workmanship; and 23 CFR 637 should be updated to address alternative delivery methods, to more formally address construction inspection and processes for acceptance of manufactured products, and to be more applicable to all federal-aid projects regardless of system, class, or type.

1.2 Research Problem

Although these national standards and engineering experience and judgment have provided an adequate and qualified DOT in-house inspection staff, funding constraints have caused the highway construction industry to reduce in-house staff and outsource inspection responsibilities while overseeing ever-larger construction programs. State DOTs are also faced with shrinking budgets and substantial reductions in both the numbers and experience levels of inspectors over the last decade. Many state DOTs, including the Kansas Department of Transportation (KDOT), have lost experienced construction inspection staff while the numbers of projects and required levels of inspection have increased. To address these challenges, DOTs often rely on contractors' QC and outsource to a third party for testing and inspection. This strategy, however, is not always a cost-effective approach. Further, previous studies have confirmed that, due to the current reality of reduced funds and resources, DOTs have sought to optimize QA processes to do more with less (NCHRP, 2017). There is an immediate and compelling need for KDOT to incorporate risk-based approaches into current practices for construction inspection.

1.3 Objectives

The objective of this project was to develop a risk-based protocol for KDOT to optimize resource allocation for inspection of transportation construction projects. The proposed protocol provides KDOT with a list of prioritized key inspection items and construction activities that drive long-term project performance. This prioritized list helps KDOT project and program managers effectively and efficiently allocate their limited resources while mitigating risk impact. The sub-objectives included the following:

- Conducting a comprehensive review of existing QA literature and practices, focusing on the FHWA manual and specifications and current KDOT inspection practices,
- Developing a core list of inspection items associated with construction processes,
- Evaluating the current inspection practices of KDOT corresponding to the core list of inspection items using survey questionnaires and interviewing experts from KDOT and the Kansas Division of the Federal Highway Administration (FHWA),
- Conducting risk assessment and prioritizing inspection activities to facilitate efficient allocation of available resources, and
- Documenting the results of this research in a concise and comprehensive research report.

1.4 Report Organization

This report is composed of six chapters. Chapter 1 introduces the subject area and covers the scope and objectives. Chapter 2 provides a literature review to support the understanding of existing risk-based inspection methodologies and the most relevant issues to construction inspections. Further, this chapter briefly discusses state-of-practice by examining current state DOT inspection strategies with a focus on the KDOT QA program. Chapter 3 presents study methodology. The data used in the methodology implementation were collected based on interviews with a panel of experts and a questionnaire survey. Chapter 4 includes study results and presents key findings related to prioritization of QA inspections. Chapter 5 includes research findings and deliverables. Finally, Chapter 6 briefly summarizes the information presented in previous chapters and offers conclusions and suggestions for future research.

Chapter 2: Literature Review

2.1 Introduction

This literature review focuses on risk-based inspection methodologies and practices. Many reference materials related to current QA processes and risk assessment techniques were reviewed, with research articles and DOT manuals and guidance (e.g., QA programs, standard specifications, or construction manuals) being the two primary sources of information. Literature searches were conducted using academic search engines such as Engineering Village and Google Scholar, as well as research institutions such as the Transportation Research Board (TRB), the FHWA library, several state DOT websites, and general internet search engines. The literature searches specifically focused on obtaining documents that would support the development of risk-based inspection for highway construction activities. Typical keywords and terms for these searches included inspection, risk and uncertainty, material testing, QC/QA processes, risk-based inspection, qualitative assessment, quantitative assessment, and risk impact and consequences. The research team reviewed and synthesized each document to obtain relevant information, including key summaries of past research efforts in risk-based inspection practices, and attempted to obtain original work rather than rely on summaries. Cross-referencing the literature helped identify essential advances in the domain. Findings from the literature review were categorized as federal regulations related to construction QA (including inspection processes), risk-based inspection methodology, and the current state of practices of materials QA and construction inspection from seven DOTs that have implemented risk-based inspection (Appendix A).

2.2 Federal Regulations

The Code of Federal Regulations (CFR), title 23, part 637, a baseline document related to materials acceptance procedures, requires each state DOT to develop and implement a QA program to ensure that the materials and workmanship incorporated into federal-aid highway construction projects conform to requirements of the approved plans and specifications (23 CFR 637, 2011). The six core elements of a construction QA program include QC, acceptance, IA, dispute resolution, personnel qualifications, and laboratory accreditation/qualification (FHWA, 2012). Subpart B of 23 CFR 637 defines these six core elements as follows:

- *QC*: All operational techniques and activities performed by the contractor vendor to fulfill contract requirements.
- *Acceptance*: All factors that comprise state DOT's determination of product quality as specified in the contract requirements, including verification sampling, testing, inspection, and possibly QC sampling and testing results.
- *Independent Assurance (IA):* Activities that are an unbiased and independent evaluation of all sampling and testing procedures used in the acceptance program (Test procedures that are performed in the state DOT's central laboratory are not covered by an independent assurance program.)
- *Dispute resolution:* A system administered entirely within the DOT that addresses the resolution of discrepancies between the verification sampling and testing and the QC sampling and testing.
- *Personnel qualifications:* Personnel capability defined by appropriate programs established by the DOT with sampling and testing by qualified personnel.
- *Laboratory accreditation/qualification:* Laboratory capability defined by appropriate programs established by the DOT, minimally including provisions for checking test equipment and records of calibration checks. (Definitions of other key terms related to this study are provided in Appendix D.)

The requirement in 23 CFR 637 applies only to project-produced materials, not manufactured items. The non-regulatory supplement, NS 23 CFR 637, part B, encourages state DOTs to perform risk analysis using the historical quality of the product, safety, and cost to develop an acceptance program for manufactured items.

Apart from these six fundamental components, QA practices can vary widely between state DOTs. For example, for fabricated or manufactured materials such as structural steel and precast concrete, some DOTs base acceptance on inspection conducted at the plant, whereas others rely on certification programs. For project-produced materials such as pavements and earthwork, some DOTs allow adjustments to the standard frequency of inspection, sampling, and testing based on the quantity of materials, project delivery method, or criticality of materials, whereas others do not. Therefore, 23 CFR 637 was revised in 1995 to allow use of contractor QC test results in a DOT's acceptance decision if the following conditions are met:

- Sampling and testing are performed by qualified laboratories using qualified sampling personnel.
- The DOT, or its designated agent (i.e., consultant under direct contract with the DOT), validates the contractor's test results by performing independent verification sampling and testing. Use of a third-party testing and inspection firm hired by the contractor does not relieve the agency of its responsibility for verification; likewise, splits of contractor-obtained samples cannot be used for verification.
- QC sampling and testing is evaluated under an IA program.
- The DOT has a dispute resolution system in place to resolve possible discrepancies between the contractor's QC and the agency's verification data.

2.3 Overview of Risk-Based Inspection

Although risk-based inspection is commonly used to inspect oil and gas fields, refineries, petrochemical industry, and the power and energy industry, it is still relatively new in the highway construction industry. Risk-based inspection represents the next generation of inspection approaches to provide safe, reliable operating facilities (API, 2016). Previous studies indicated that risk-based inspection offers practical implementation of an inspection process (Bai & Bai, 2014; Kamsu-Foguem, 2016) and provides a method of assessing the probability and consequence of failure (or risk), evaluating risk level, and creating relevant actions that can help develop required risk management policies. Risk-based inspection practices are promising because they change reactive inspections to proactive inspections in various domains (Kamsu-Foguem, 2016).

Figure 2.1 shows a typical risk-based inspection process adapted from the American Petroleum Institute (API, 2016) Recommended Practice 580. This approach systematically reduces inspection risk and improves inspection practices.

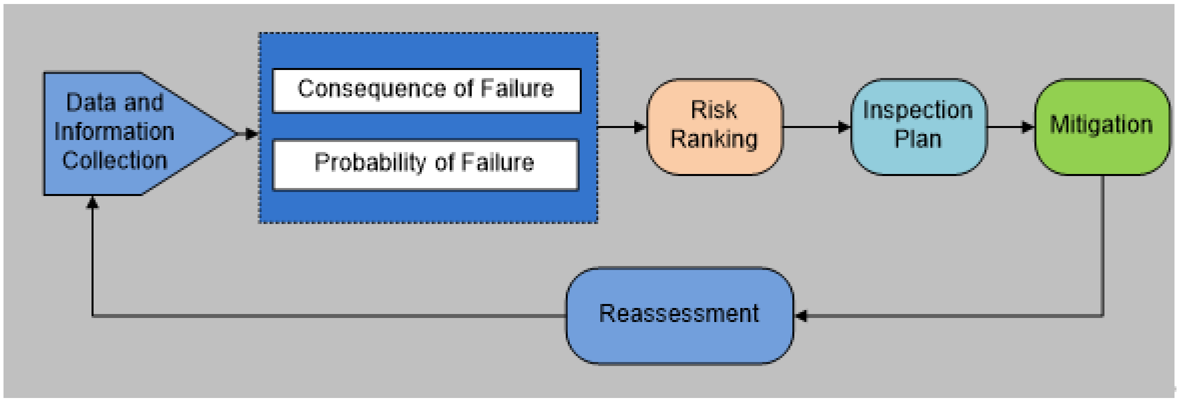

Figure 2.1: Typical Risk-Based Inspection Process
Source: API (2016)

As shown in the figure, risk-based inspection methodology requires the assessment and evaluation of data and information collection, risk assessment process (including probability of failure and consequence of failure), risk ranking, inspection plan, mitigation (if needed), and reassessment. The API identifies several benefits of using risk-based inspection, including identifying critical inspection and maintenance activities, facilitating the development of optimized inspection and mitigation plans, understanding the current risk and providing an overall risk reduction, allocating inspection resources properly, and generating cost savings (API, 2016).

Figure 2.1 also shows that risk-based inspection assessment involves two main components: consequence of failure/risk and probability of failure/risk. As shown in Equation 2.1, risk impact can be estimated based on the product of the probability of an event and associated consequences:

Risk Impact = Probability of Occurrence x Risk Consequences **Equation 2.1**

Where, *Probability of Occurrence* is the likelihood of an adverse event or failure occurring during a given time period, and *Risk Consequences* is a measure of the economic, social, safety, or environmental impact of the event.

The probability of risks and their possible consequences can be estimated quantitatively or qualitatively, depending on the project/system characteristics and the availability of inspection data. The quantitative estimating process often utilizes the probability of failure models and quantitative measures of consequences (e.g., cost impact of a risk event, service interruption, or safety), while the qualitative estimating process uses a risk matrix. For example, risk probability can be estimated based on whether the likelihood of a certain event is high, medium, or low. Similarly, risk consequences can be expressed qualitatively as high, medium, or low. Researchers have shown that presenting risk qualitatively is an effective approach for assessing and evaluating risk (NCHRP, 2014). Figure 2.2 shows a simple risk matrix that can be used for maintenance preparation, inspection programing, and ordering work orders (Kamsu-Foguem, 2016).

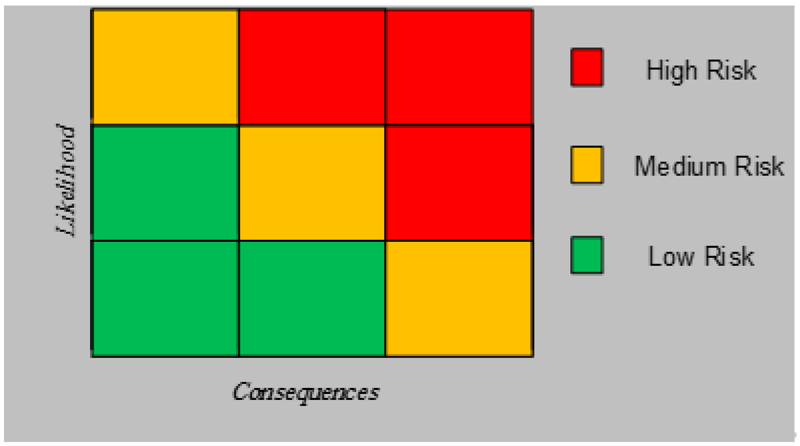

Figure 2.2: Typical Risk Matrix

The overall concept of risk assessment shown in Figure 2.2 can be defined as follows:

- *Red – High risk*: The upper right-hand corner of the figure shows a high likelihood (probability) of occurrence with a high consequence, resulting in high risk. Typically, high risk may not be acceptable, and actions are required to lower the risk by reducing the probability or the severity of consequences. For inspection strategies, high-risk items should be prioritized for frequent and intense inspections to monitor and control risk and uncertainty.
- *Green – Low risk:* The lower left-hand corner of the figure shows low risk resulting from low likelihood and low consequence. Low risk is typically acceptable and may require little or no action. Low-risk items may have less inspection frequencies or less intense inspection protocols.

- *Yellow – Medium risk:* The main concern of medium risk inspection activities is how much risk is acceptable and what strategies are appropriate to mitigate risk.

The risk level is determined by the likelihood and consequence of a risk event. For example, a risk event with high likelihood does not necessarily mean it is a high-risk item if the consequences are minor. Likewise, an item with high consequences may not be a high-risk item if the likelihood is small. The risk-based inspection approach considers the likelihood of failure and the associated consequences to focus on items whose failures are most important (NCHRP, 2014).

Figure 2.3 shows that faults of design, natural disasters, and human errors prevent risk from being reduced to zero. These factors cause residual risk that is usually not able to be inspected. Nevertheless, risk-based inspections aim to highlight risk drivers in order to prioritize inspection-related activities and minimize total risks, thereby motivating decision makers to understand risk-based inspection methodology (Soares, de Vasconcelos, & Rabello, 2015).

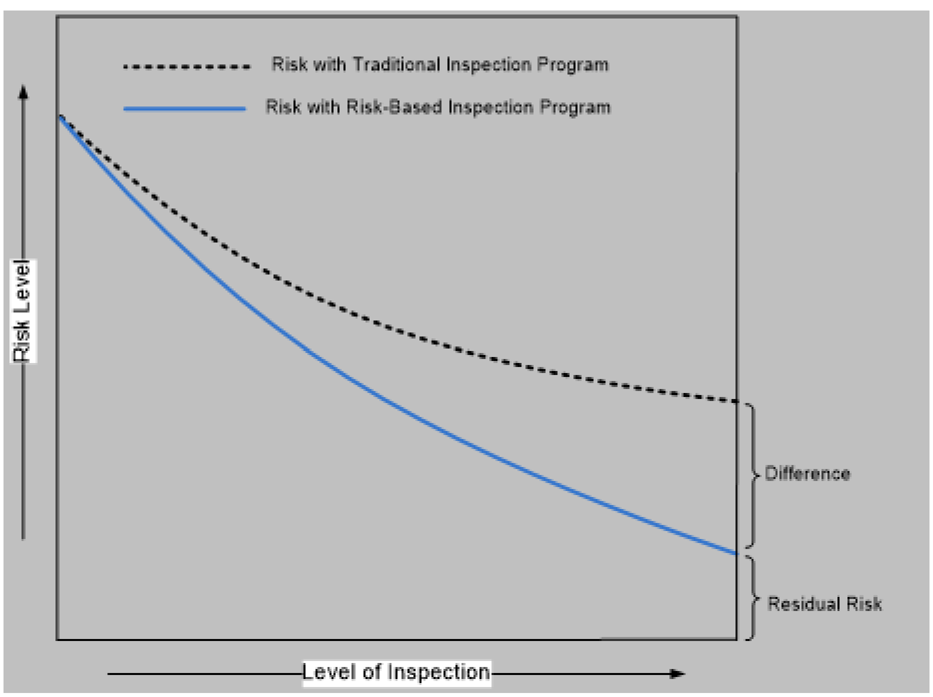

Figure 2.3: Traditional Inspection vs. Risk-Based Inspection
Source: Soares et al. (2015)

2.4 Key Elements of Risk-Based Inspection

The National Cooperative Highway Research Program (NCHRP) Report 782 includes three key elements for reliability-based bridge inspection practices that can also be applied to the inspection of highway projects: the occurrence factor, the consequence factor, and the assessment panel (NCHRP, 2014). This section briefly discusses these three key elements as they apply to risk-based inspection for highway construction projects.

2.4.1 Occurrence Factor

The occurrence factor is an estimate of the likelihood of severe damage occurring in an inspection period, identified by determining what could go wrong and how likely it is. All three risk assessment approaches (qualitative, quantitative, or semi-quantitative) can be used to estimate the expected performance of components. NCHRP Report 782 uses a four-level scale that ranges from "remote" when the likelihood is extremely small (e.g., unreasonable to expect failure) to "high" when the likelihood of the risk event increases (NCHRP, 2014). Table 2.1 summarizes the rating scale for estimating occurrence factors for risk-based inspections.

Table 2.1: Rating Scale for Occurrence Factor

Level	Category	Description
1	Remote	Remote likelihood of occurrence
2	Low	Low likelihood of occurrence
3	Moderate	Moderate likelihood of occurrence
4	High	High likelihood of occurrence

Source: NCHRP (2014)

2.4.2 Consequence Factor

The consequence factor categorizes the consequences of failure of an element(s) based on anticipated or expected outcomes (NCHRP, 2014). This factor can be estimated based on physical conditions, materials involved, service interruption, and safety issues. Like the occurrence factor, qualitative, quantitative, or semi-quantitative risk-assessment approaches can be used to evaluate the consequence factor. According to NCHRP Report 782, qualitative assessments based on engineering judgment and documented experience typically are sufficient for assessing the consequence factor. NCHRP Report 782 uses a four-level scale ranging from “low,” which describes scenarios in which failure is very unlikely to have a significant effect on safety (short-term consequences) and serviceability (long-term consequence), to “severe,” which describes the major consequences of safety or serviceability (NCHRP, 2014). Table 2.2 summarizes the rating scale for estimating consequence factors for the risk-based inspection practice.

Table 2.2: Rating Scale for Consequence Factor

Level	Category	Consequences		Summary Description
		Safety	Serviceability	
1	Low	None	Minor	No effect on highway safety, minor effect on serviceability
2	Moderate	Minor	Moderate	Minor effect on highway safety, moderate effect on serviceability
3	High	Moderate	Major	Moderate effect on highway safety, major effect on serviceability
4	Severe	Major	Major	Major effect on highway safety, major effect on serviceability

Source: NCHRP (2014)

2.5 Overview of QA Process in KDOT

In KDOT, the Bureau of Construction and Materials develops standards and specifications for materials, establishes sampling procedures and frequencies, and creates testing procedures that are used in the laboratory and the field to ensure specification compliance. Part V of the KDOT (2018) *Construction Manual* and the KDOT (2015) *Standard Specifications* include provision for KDOT’s QC/QA program. KDOT currently utilizes method specification and QC/QA specification processes to ensure the quality of project-produced materials (KDOT, 2018). The older Method Specs procedure uses KDOT test results as the basis of acceptance for project-produced materials, and the contractor is not required to conduct quality control testing. All inspection, sampling, and testing for acceptance must be performed by a KDOT authorized representative. The current QC/QA Specs procedure requires the contractor to conduct QC testing, and these test results can be used as a basis of acceptance if KDOT’s QA verifies the results. However, for each relevant test group, all technicians must demonstrate qualifications such as certificate types for the completion of a training program or a demonstration of test procedures and completion of written exams over the test methods (KDOT, 2014; KDOT, 2018). All contractors conducting QC/QA sampling and testing for KDOT projects are responsible for the annual calibration and verification of their equipment by the American Association of State Highway and Transportation Officials (AASHTO) accredited laboratory using the National Institute of Standards and Technology (NIST) traceable equipment (KDOT, 2018).

KDOT uses a systems-wide approach for IA sampling and testing of project-produced materials. Each test is categorized as aggregates, concrete, asphalt mixes, or soils, depending on the types of material. For IA, the technician must be observed properly conducting the test and splitting or replicating samples. KDOT requires that IA be conducted once per calendar year per technician per group of tests performed by that technician during that year (KDOT, 2018). Figure 2.5 illustrates KDOT QA acceptance systems.

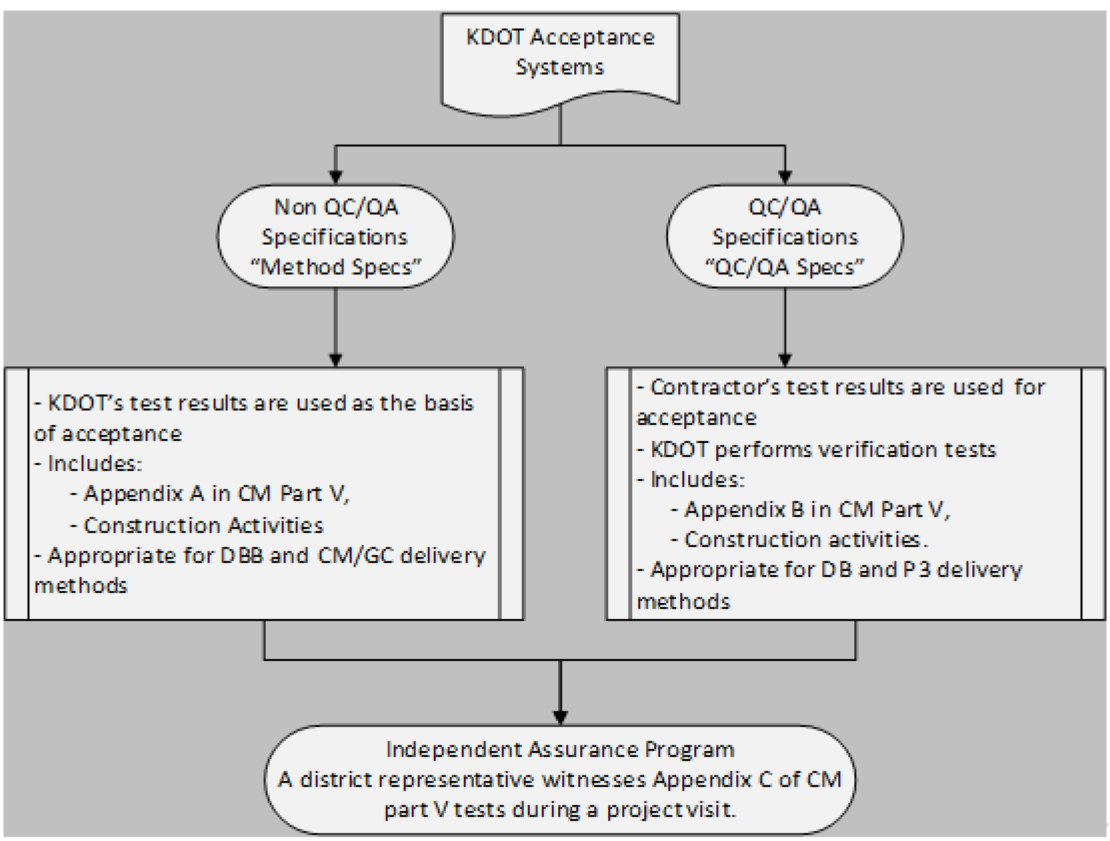

Figure 2.4: KDOT QA Acceptance Systems
Source: KDOT (2018)

To reduce the number of inspection staff, KDOT typically adopts more than one optimization strategy for QA acceptance. For example, KDOT often utilizes a preapproved list of materials and suppliers to minimize quantities, volumes, and numbers of inspection times, or the department uses a contractor's QC test results as a basis of acceptance and then uses its own assurance procedures to verify these results. KDOT also reduces the frequency of testing (non-QC/QA) by increasing lot size and large volumes. For non-QC/QA specifications, the district materials engineer may reduce project sampling and testing frequency based on continued satisfactory, uniform production. Figure 2.5 shows a multilevel sampling frequency chart for non-QC/QA specifications.

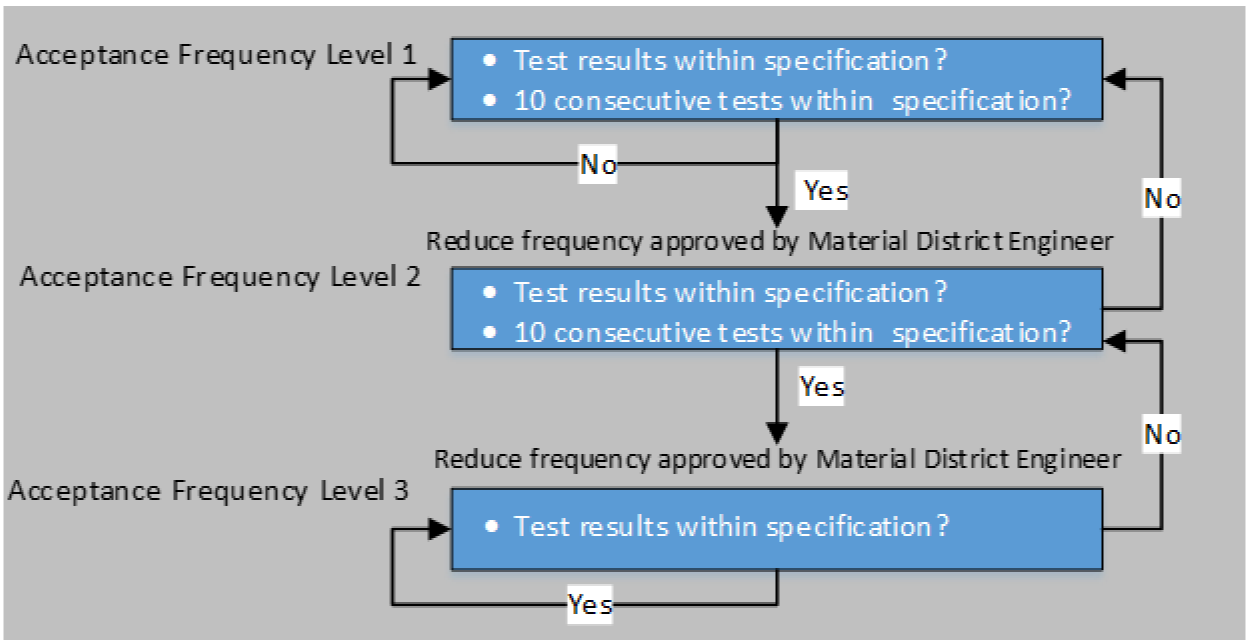

Figure 2.5: KDOT's Multi-Level Sampling Frequency Chart
Source: KDOT (2018)

2.6 State of Practice of Risk-Based Inspection

The authors conducted a comprehensive review of seven state DOTs that have implemented risk-based inspection: California, Florida, Indiana, New York, Texas, Virginia, and Washington state. A comprehensive analysis of construction manuals, specifications, and other related documents collected from DOT websites, the FHWA library, and other relevant publications was conducted. Table 2.3 summarizes the two main types of inspection, material risk-based inspection and construction risk-based inspection, and the salient findings from the seven state DOTs are detailed in Appendix A.

Table 2.3: Risk-Based Inspection Types by State DOTs

California	✓	✓
Florida	✓	
Texas	✓	
Virginia		✓
New York	✓	
Washington	✓	
Indiana	✓	✓

2.7 Summary

State DOTs have begun to consider the risks and impacts on QA practices. Current risk-based inspection approaches aim to evaluate material testing and workmanship inspection based on criticality, and the results can beneficially influence field inspection and laboratory tests by increasing construction quality, leading to lower overall life cycle costs. The typical risk-based inspection process identifies acceptance requirements as specified in project specifications, the risk assessment process (i.e., probability of inspection failure and consequences of element failure), and inspection protocol, which includes inspection activities prioritized based on criticality. The risk-based inspection plan shows when, where, and how to inspect.

Chapter 3: Methodology

3.1 Introduction

The primary objective of this research was to develop a risk-based protocol for KDOT to optimize resource allocation for inspection of transportation construction projects. The protocol provided KDOT with a list of prioritized key inspection activities that drives long-term project performance and helps KDOT project and program managers effectively and efficiently allocate limited resources while mitigating risk impact. The research team performed six integrated research tasks in three stages.

3.2 Research Approach

The research approach included three stages: (1) reviewing and assessing the literature on material QA programs; (2) developing core inspection items; and (3) performing risk assessment and prioritization of core inspection items. Figure 3.1 shows the main research activities associated with each stage.

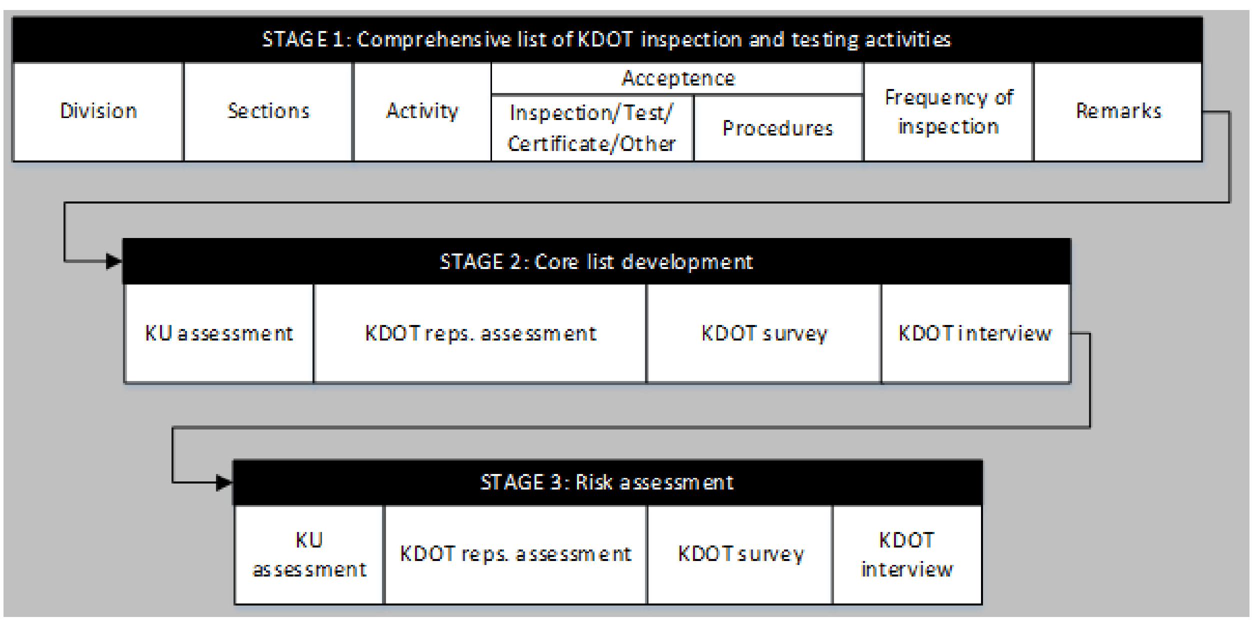

Figure 3.1: Overview of Research Approach

- **Stage 1: Review and Assess the Literature on Material QA Programs.** The purpose of this stage is to (1) examine the current state of practices related to risk-based inspection for highway construction projects, and (2) develop *a comprehensive list* of inspection items identified by retrieving information from KDOT. This stage includes three main tasks (Task 1, Task 2, and Task 3).
    - ***Task 1 – Literature Review:*** A literature review was used to identify and describe quality management systems, with emphasis on the FHWA manual and specifications, as well as current QC/QA practices of other state DOTs. The research team focused on methods of materials acceptance, QC practices, the impact of sample size, material certification, and the evaluation and assessment of agency and contractor risks.
    - ***Task 2 – Desk Scanning of KDOT Documentation:*** This task reviewed and analyzed the current state of QC/QA practices used by KDOT. The research team conducted a comprehensive review and synthesized KDOT's *Construction Manual* and *Standard Specifications*, the KDOT QA program, and a sample of KDOT projects.
    - ***Task 3 – Content Analysis:*** This analysis utilized a qualitative data analysis computer software package (NVivo) to develop a raw list of relevant inspection activities. NVivo is ideal for qualitative researchers working with rich text-based and/or multimedia information in which deep levels of analysis on small or large volumes of data are required. The research team used the following key words for the searching process: inspection, acceptance, certification, quality assurance, quality control, risk, uncertainty, and test.
- **Stage 2: Development of Core Inspection Items.** The purpose of this stage was to determine *a core list* of inspection items. Task 4 detailed below is the main focus of this stage.
    - ***Task 4 – Development of Core Inspection Items:*** Based on the referent lines and sources identified from NVivo in Stage 1, the research team performed

a rigorous analysis to conservatively determine *a comprehensive list* of QA inspection activities by removing repeated activities or adding relevant activities. To determine *a core list* of inspection items, the research team conducted both survey questionnaires and interviews with KDOT and FHWA experts. The survey was designed based on the key findings from Stage 1. The interviews were conducted in person and a group. The core list of inspection items was classified according to seven divisions of KDOT's construction manual and specification: (1) General clauses; (2) Equipment; (3) Earthwork; (4) Subgrade, base, and shoulders; (5) Concrete Bridge Deck; (6) Portland cement concrete pavement (PCCP); and (7) Hot-mix asphalt (HMA) pavement.

- **Stage 3: Risk Assessment and Prioritization of Inspection Items.** The purpose of this stage was to evaluate the risks associated with core inspection items determined from Stage 2. This stage includes two main tasks (Task 5 and Task 6).
    - ***Task 5* – Risk Assessment:** This task involved evaluating two components: (1) determining the likelihood of risk occurring (risk frequency), and (2) determining the impact (consequences) of risk. The risk assessment process involved a variety of KDOT and FHWA experts (e.g., state material engineer, geotechnical engineer, project manager, field engineer, and others). The result of this approach typically provides qualitative terms such as "low," "medium," or "high," or numerical values (e.g., using ordinal scale measurement such as a 1–5 scale).
    - ***Task 6* – Analysis and Prioritization:** This task involved analyzing the data collected from Task 5 using composite indexes that include both the likelihood and severity of an inspection failure. The risk-based inspection assessment includes two main components: (1) the probability (or likelihood) of risk occurred (e.g., material failing to meet specification), and (2) the impact (or consequence) of risk (e.g., increased maintenance or caused safety issues).

The completion of Stage 3 resulted in a prioritized list of critical inspection items associated with specific construction activities based on risk. Detailed risk assessment mythology and analysis are discussed in the next section.

3.3 Risk Assessment Methods

Risk assessment is the process of evaluating risk events. As mentioned previously, risk assessment involves evaluating two components: (1) determining the likelihood of risk occurring (risk frequency), and (2) determining the impact (consequences) of risk. Typically, risk assessment can be classified into three main categories: qualitative, quantitative, and mixed (e.g., semi-quantitative) approach. Figure 3.2 graphically summarizes these three approaches in terms of detail of analysis. The quantitative approach requires more details of analysis than the semi-quantitative or qualitative approach.

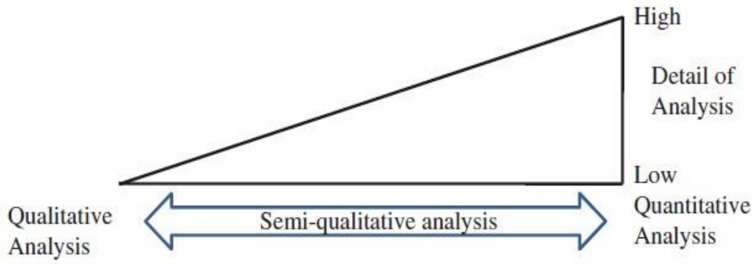

Figure 3.2: Risk Assessment Approach for Risk-Based Inspection
Source: API (2016)

Although all three risk assessment approaches identify areas of concern and associated risks, screen risks, and develop a prioritized list of inspection items for in depth analysis, selection of a suitable risk assessment method depends on factors such as the number of inspection items required, available resources, the nature and quality of available data, and the complexity of the inspection processes. Risk assessment in risk-based inspections results in knowledge needed to develop a prioritized list of inspection items (Ashley, Diekmann, & Molenaar, 2006). This prioritized list should be based on individual evaluation of the probability (likelihood) and consequence of risk (U.S. DOE, 2011).

3.3.1 Qualitative Approach

The qualitative risk assessment approach analyzes the probability and consequences of a risk event using descriptive information from engineering experts (API, 2016; Mostafavi & Abraham, 2012). The accuracy of this approach depends on the background, collective experience, expertise, and other defined quality of the participants. Andersen, Chouinard, Hover, and Cox (2001) determined that the level of detail in the assessment process should be limited to avoid the overestimation of risk consequences and their likelihood. Results of this approach are typically qualitative terms such as "low," "medium," or "high," or numerical values (e.g., using Likert scale measurement such as a 1–5 scale). It is important to note that although the qualitative approach is less precise than the quantitative approach, it is effective and useful for screening and prioritizing risks and for developing appropriate risk mitigation and allocation strategies (Ashley et al., 2006; API, 2016). The qualitative approach may be used for any aspect of inspection plan development (API, 2016), and qualitative analysis is often used to guide the quantitative risk assessment approach.

3.3.2 Quantitative Approach

The quantitative risk assessment approach relies on quantitative, or detailed, data developed from probabilities models, databases of failure, and past-performance data such as deterioration rate models. Quantitative analysis quantifies the probabilities and consequences of probable damage. For example, the likelihood of an inspection risk item can be assessed using the probability and effects of specific inspection or testing failure based on the history of failure probability for a type of testing or inspection items (Patel, 2005). The probability is expressed as a probability density function that represents the time-to-failure of an item as a generic distribution to find the probability of failure function (Montgomery & Runger, 2010; Ross, 2014).

Quantitative risk assessment is a numerical, objective analysis of the probability and consequence of risk events. A series of statistical modeling techniques (e.g., Monte Carlo simulation, sensitivity analysis, and other stochastic methodologies) can be used to determine the probabilities and impact of an inspection risk item. Event trees and fault trees also can be used to quantitatively model inspection risk items and inspection processes. An event tree, a graphical representation of probabilistic events, delineates initiating events and combinations of system successes or failures (API, 2016). A fault tree, a graphical representation of causes of a failure, depicts how the system failures represented in the event trees can occur (API, 2016). Additionally, a decision tree was proposed to use for quantifying the impact of risk on the inspection process.

It is important to note that although the quantitative assessment provides valuable insight and accurate and objective results, it has several limitations. In general, it is impractical to acquire the required data to be modeled effectively. For example, data on past performance are typically incomplete or inaccurate (Andersen et al., 2001). NCHRP 782 highlighted that "the effort required to collect and analyze the data may far outweigh the value of the data in estimating future performance, particularly when the data are sparse, include a large uncertainty, or design characteristics are evolving" (NCHRP, 2014).

3.3.3 Semi-Quantitative Approach

A semi-quantitative approach is referred to any approach that utilizes both qualitative and quantitative assessments. It aims at obtaining the main advantages of both approaches such as less available data required and level analysis (speed of qualitative assessment) and more rigor and accuracy of quantitative assessment (API, 2016). Additionally, the qualitative data can be augmented with quantitative data for any inspection activities when available (NCHRP, 2014).

It is recommended that the qualitative, quantitative, and semi-quantitative approaches should not be considered separately but rather as complementary (API, 2016). At the program level, qualitative may be the suitable approach to screen the highest risk for further analysis. At the project level, a semi-quantitative approach may be suitable for the higher risk items. At the activity level, if the data available with enough quality, a quantitative approach may be the best approach to analyzing the risk. NCHRP (2014) pointed out that quantitative analysis does not necessarily mean its results are more accurate than qualitative analysis unless the quality data supporting the analysis is available.

3.3.4 Risk Assessment Panel

The critical component of the risk-based inspection practice is to establish a proper risk assessment panel. The individuals in the panel should offer experience relevant to the types of risks related to the inspection process such as design features, construction specifications and practices, materials, and operational environment. The process to elicit expert judgement from the panel is relatively simple. The purpose of the elicitation process is to provide a systematic framework that allows efficient, objective analysis, and comprehensive gathering insight into the probability of failure and its associated consequences (NCHRP, 2014).

3.4 Summary

This chapter described the six integrated research tasks employed to develop a risk-based protocol for KDOT to optimize resource allocation for inspection of transportation construction projects. These six tasks were conducted in three research stages: (1) reviewing and assessing the literature on material QA programs; (2) developing core inspection items; and (3) performing risk assessment and prioritization of core inspection items. The chapter also detailed three risk assessment methods for risk-based inspection: qualitative, quantitative, and semi-quantitative approaches. Although the qualitative approach is less precise than the quantitative approach, it effectively screens and prioritizes risks to develop appropriate risk mitigation and allocation strategies for highway construction projects.

Chapter 4: Development of KDOT Inspection Activities

4.1 Introduction

This chapter summarizes the development of a comprehensive list and a core list of inspection activities for KDOT. The comprehensive list of KDOT inspection activities was developed based on reviewing, synthesizing, and evaluating a variety of KDOT documents. For each inspection activity in the comprehensive list, the research team rigorously analyzed the KDOT *Construction Manual*, KDOT *Bridge Construction Manual*, KDOT Specifications, QA Inspection Acceptance, and other relevant documents. The comprehensive list was verified by KDOT and FHWA experts and then used to develop the core list of KDOT inspection activities. The core list was based on discussions and meetings with KDOT and FHWA experts.

4.2 Development of a Comprehensive List of Inspection Activities

Proper design and satisfactory construction of construction elements such as earthwork and embankment, base course and subbase, bridge deck and structural concrete, bituminous pavement, and rigid pavement generally result in a product that will perform at the desired level of service (FHWA, 2017). Material QA tests, visual inspection, and a certification process are typically used to identify the risk of QA requirements for these elements. To compile a comprehensive list of construction inspection items/activities, this research team rigorously reviewed and evaluated KDOT QA documents, including KDOT's *Construction Manual*, construction checklists, QA guides, documentation manuals, specifications, design manuals, and relevant FHWA documents, such as standard specifications. These documents detail acceptable procedures and methods for the construction of KDOT highway projects. As shown in Figure 4.1, the task of compiling a comprehensive list of KDOT QA activities was carried out in two phases.

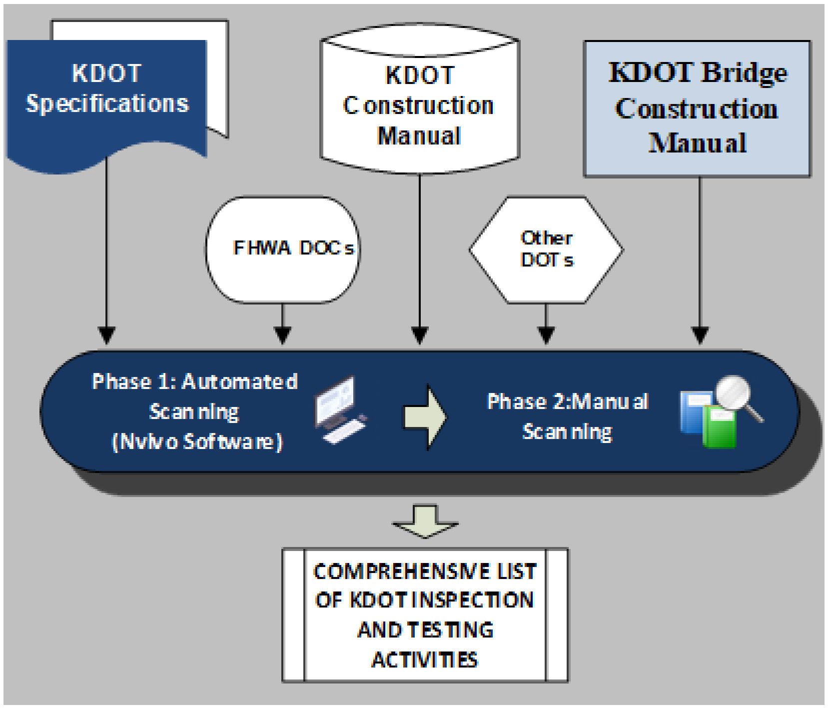

Figure 4.1: Two Phases of Scanning KDOT Documents

In Phase 1: Automated Scanning, the research team used a qualitative data analysis computer software package (NVivo) to analyze all e-documents collected from KDOT and FHWA. NVivo quickly identifies key topics and themes via a text search and word frequency queries. The key words used for input analysis included inspection, certificate, test, sampling, risk, QA, and acceptance. Figure 4.2 shows a sample of a search using NVivo. The outcomes were documented and included in Phase 2.

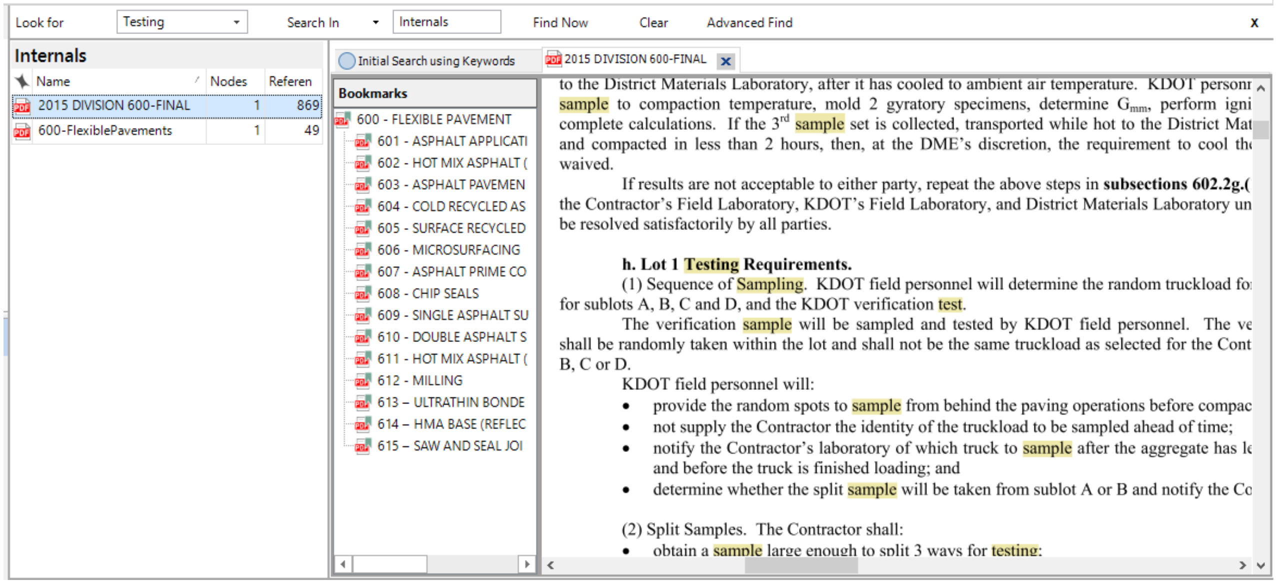

Figure 4.2: Sample Output of NVivo Search

The results from Phase 1 generated all-inclusive outcomes based on key words. The purpose of Phase 2: Manual Scanning was to analyze and evaluate these outcomes to ensure that activities did not overlap or were redundant. For example, any outcome (e.g., sentences, texts, or paragraphs) that focused on administration or management processes rather than QA inspection was removed. As a result, all outcomes obtained through Phase 1 were refined and validated by manual review. The research team conducted three independent rounds of reviews to confirm the resulting comprehensive list of QA inspection activities.

Figure 4.3 shows the four levels of the comprehensive list of QA activities. The first level, Divisions, identifies the division of the inspected construction element. The second level, Sections, includes relevant references for further examination of a QA activity. The third level, QA Activities, lists each QA activity, while the fourth level, Acceptance, focuses on the acceptance method used for each item.

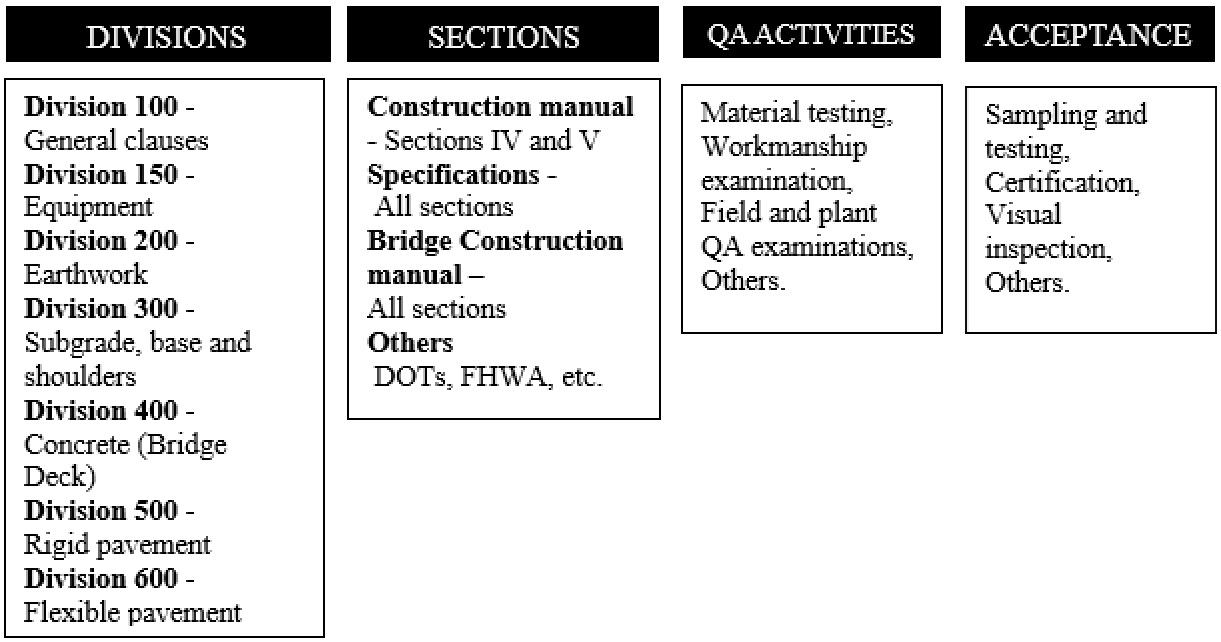

Figure 4.3: Levels of KDOT QA Data Collection

Figure 4.4 and Figure 4.5 show a hierarchy used to organize QA activities for two samples. Figure 4.4 displays a simple inspection activity (Check construction limits) from Division 100 and retrieved from Section 4.01.03 of the KDOT (2014) *Construction Manual* Part IV (CM-Part IV). This activity requires visual inspection, including having the contractor superintendent define the construction limits. Figure 4.5, however, lists a demanding inspection activity (HMA quality control plan approval) from Division 600 and retrieved from Section 5.2.7.1 of the KDOT (2018) *Construction Manual* Part V (CM-Part V) and KDOT (2015) *Standard Specifications* 602.2. This activity requires document reviews and approval for the contractor's HMA quality control plan.

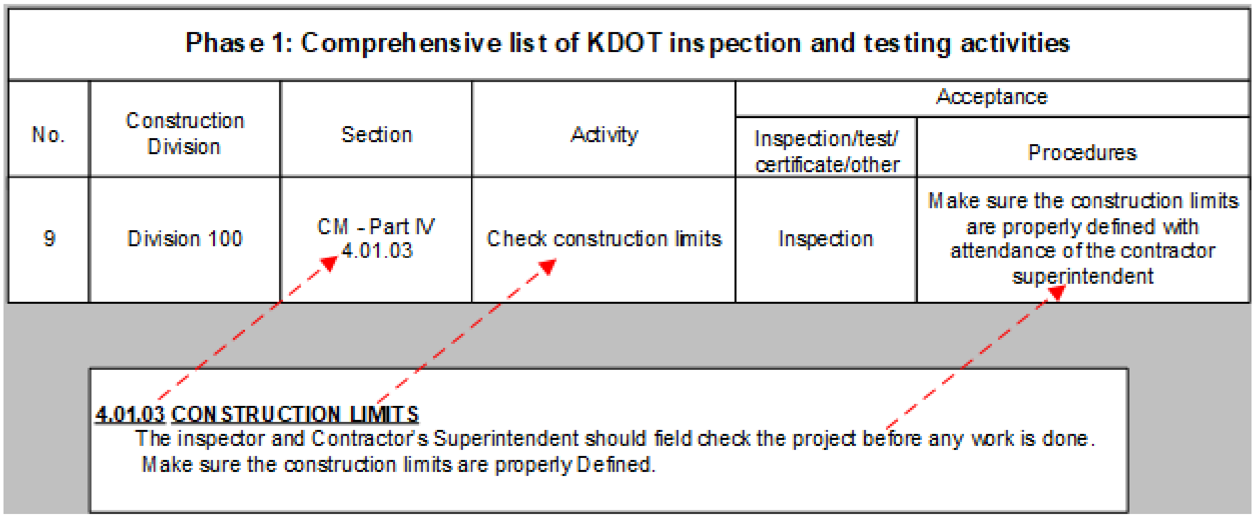

Figure 4.4: Summary of Developing QA Activities (Sample 1)

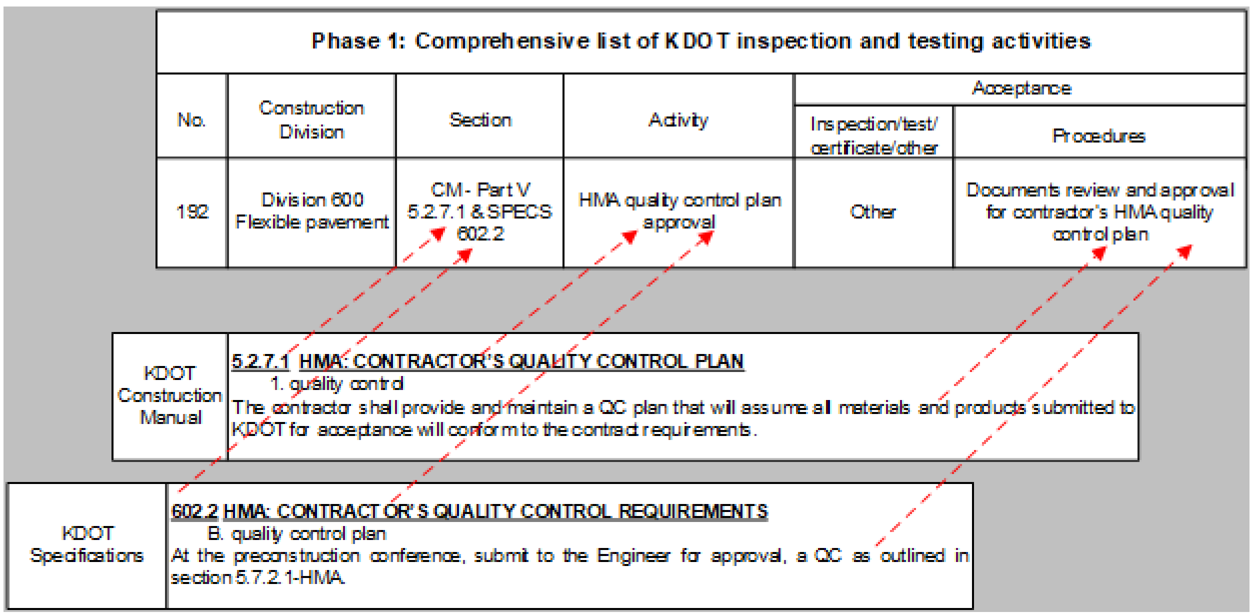

Figure 4.5: Summary of Developing QA Activities (Sample 2)

Table 4.1 summarizes the results of the comprehensive list for KDOT inspection activities from both phases. As shown in the table, Phase 1 resulted in 448 QA activities, and 302 QA activities after overlapped or redundant activities were removed from Phase 2. The 302 QA inspection activities were included for next steps of this study. Appendix B provides detailed descriptions of each activity.

Table 4.1: KDOT Comprehensive List of QA Inspection Activities

Division	Inspection Activities	
	From automated scanning (NVivo Software)	From manual reviewing and evaluating processes
100 - General clauses	49	23
150 - Equipment	38	16
200 - Earthwork compaction	55	27
300 - Subgrade, base, and shoulders	55	63
400 - Concrete (bridge deck)	42	39
500 - Rigid pavement (PCCP)	61	58
600 - Flexible pavement (HMA)	148	76
Total	448	302

4.3 Development of a Core List of Inspection Activities

To develop a core list of KDOT inspection activities, the research team employed a Delphi technique to analyze the 302 inspection activities identified in Phase 2. The Delphi technique is a communication technique designed to obtain the insights of a panel of experts through multiple rounds of surveys to achieve consensus. The results of each round of interviews were summarized and given to the experts in the next round. If an expert believed that the group median was incorrect, they were asked to explain why the true value differed. The Delphi process ended when 90% consensus was achieved. Because the Delphi process is prone to cognitive bias when raters are asked to use their experience, all participants remained anonymous to ensure minimal bias.

A panel of KDOT and FHWA experts in QA inspection and material testing was given two rounds of assessment. During the first round, seven of the experts analyzed the QA activities using criteria such as critical, noncritical, and maybe critical. The first round of criticality ranking was conducted individually with no discussion among the experts. Table 4.2 summarizes the results of the first round for the Delphi process. Tier 1 and Tier 2 in the table show activities with high and medium priority levels; the criticalities of these activities were rated by at least five out of seven experts. Tier 3 and Tier 4 show activities with low to medium priority levels; the criticalities of these activities were rated by a maximum of four experts.

Table 4.2: First-Round Criticality Ranking of QA Activities

No.	Description	Score (out of 7)	No. of Activities
Tier 1	High Priority	≥ 6	48
Tier 2	Medium-High Priority	5	76
Tier 3	Medium Priority	3 or 4	133
Tier 4	Low Priority	≤ 2	45
TOTAL			302

A second round of the Delphi process was conducted to determine the core list of inspection activities. The purpose of this round of data collection was to reach consensus among the experts regarding criticality ranking and assumptions made during the first round. The experts reviewed the differences in rankings in the first round across four tiers and discussed the rationale for their rankings. Activities in Tier 2 and Tier 3 were the primary focus in the second round, and the research team carefully documented this process. As a result, 194 activities were eliminated from the comprehensive list of 302 inspection activities, meaning the list of 108 activities was considered the core list of inspection activities for KDOT. Table 4.3 summarizes the core list of QA inspection activities across five divisions of construction processes.

Table 4.3: KDOT Core List of QA Inspection Activities

No.	Division	No. of Critical Activities
1	200 - Earthwork	7
2	300 - Subgrade, Base, and Shoulders	47
3	400 - Concrete (Bridge Deck)	9
4	500 - Rigid Pavement (PCCP)	12
5	600 - Flexible Pavement (HMA)	33
TOTAL		108

Table 4.4 through Table 4.8 list all core inspection activities associated with (1) Earthwork; (2) Subgrade, Base, and Shoulders; (3) Concrete (Bridge Deck); (4) Rigid Pavement (PCCP); and (5) Flexible Pavement (HMA) divisions, respectively.

Table 4.4: Core Inspection Activities for Earthwork (7 activities)

Activity ID	Description	Remarks/References
1.1	Field density for compacted earth works	KT-13 or KT-51: Measuring the density of compacted soil [CM - Part V 5.9.13, 5.9.51 & SPECS 204, 205, 208]
1.2	Field density of compacted backfilling works	KT-13 or KT-51: Measuring the density of soil backfilling around a structure [CM - Part V 5.9.13, 5.9.51 & SPECS 204, 205, 208]
1.3	Moisture content of earthwork	Determining the moisture content in accordance with KT-11 [CM - Part V 5.9.51 & SPECS 204, 205, 208]
1.4	Moisture content for structure backfilling	Determining the moisture content in accordance with KT-11 [CM - Part V 5.9.51 & SPECS 204, 205, 208]
1.5	Field density of foundation of MSE walls	KT-13 or KT-51: Measuring the density of compacted soil (foundation and retained soil) [SPECS 209]
1.6	Field density of mechanically stabilized earth fill	KT-13 or KT-51: Measuring the density of compacted soil [SPECS 214]
1.7	Check placement and compaction of granular drainage blanket	Check dimensions and locations according to contract documents [SPECS 215]

Table 4.5: Core Inspection Activities for Subgrade, Base, and Shoulders (47 activities)

Activity ID	Description	Remarks/References
2.1	Sieve analysis of aggregate for subgrade	KT-02: Determination of the particle size distribution of aggregates using standard sieves. [SPECS 301, 1110 & 1112]
2.2	Check the application rate of cement or fly ash (CTB)	The engineer will have the contractor blade a flat area in the path of the cement or fly ash application, place a planar surface with a minimum surface area of 1 square foot (e.g., A straight-sided pan) and of sufficient height to contain the admixture on the prepared area and allow the train to pass over the surface. [SPECS 303.3]
2.3	Material passing the no. 200 (75 µm) sieve by the wash method for subgrade aggregate	KT-03: Determining the quantity of material finer than the no. 200 (75µm) sieve in aggregate by the wash method. [CM Part V 5.9.03]
2.4	Plasticity of aggregate of subgrade	KT-10: Determining the liquid limit, plastic limit, and plastic index of soils and the minus no. 40 (425 µm) portions of aggregates. [CM Part V 5.9.10 - SPECS 301, 1110 & 1112]
2.5	Moisture content for lime treated subgrade	KT-11: Determination of the moisture content of soil [CM Part V 5.9.11 - SPECS 302, 2000 & 2400]
2.6	Sieve analysis for acceptance of lime treated subgrade	KT-42: Determining the amount of material retained on the 2, 1 ½ in. and the no. 4 sieves for lime treated soils. [CM Part V 5.9.42 - SPECS 302, 2000 & 2400]
2.7	Percent solids of lime slurry in lime treated subgrade	KT-62: Determining the amount of solids, by percent, contained in lime slurry. [CM Part V 5.9.62 - SPECS 302, 2000 & 2400]
2.8	Field density of lime treated subgrade	KT-13: Measuring the in-place density of soils. [CM Part V 5.9.13 - SPECS 302, 2000 & 2400]
2.9	Sample of subgrade hydrated lime and pebble quicklime	KT-29: sampling Portland cement, lime and fly ash in the field [CM Part V 5.9.29 - SPECS 302, 1103, 2002 & 2003]
2.10	Sieve analysis for acceptance of fly ash or cement treated subgrade	KT-42: Determining the amount of material retained on the 1 ½ in. and the ½ in. sieves for cement treated soils [CM Part V 5.9.42 - SPECS 303, 2000, & 2400]
2.11	Field density of cement or fly ash treated subgrade	KT-13 or KT-51: Measuring the in-place density of soils and granular base courses [CM Part V 5.9.13 - SPECS 303, 2000, & 2400]
2.12	Sample of stabilization and cold recycle fly ash	KT-29: sampling Portland cement, lime and fly ash in the field [CM Part V 5.9.29 - SPECS 303, 604, & 2005]
2.13	Field density of crushed stone subgrade	KT-41: Determining density in Portland cement treated bases, aggregate bases and aggregate shoulders [CM Part V 5.9.41 - SPECS 304, 1100, & 2400]
2.14	Relative density of crushed stone subgrade	KT-69: Determination of the maximum–index dry density/unit weight of soil using a vertically vibrating table [CM Part V 5.9.69 - SPECS 304, 1100, & 2400]
2.15	Sieve analysis for aggregate crushed stone of backfill	KT-02: Determination of the particle size distribution of aggregates using standard sieves [CM Part V 5.9.02 - SPECS 304, 1107, & 1115]
2.16	Sieve analysis for aggregate of base course	KT-02: Determination of the particle size distribution of aggregates using standard sieves [CM Part V 5.9.02 - SPECS 305 and 1104]

Table 4.5: Core Inspection Activities for Subgrade, Base, and Shoulders (47 activities) (Continued)

Activity ID	Description	Remarks/References
2.17	Sieve analysis for aggregate of binder material of base course	KT-02: Determination of the particle size distribution of aggregates using standard sieves [CM Part V 5.9.02 - SPECS 305 and 1104]
2.18	Plasticity for aggregate of binder material of base course	KT-10: Determining the liquid limit, plastic limit, and plastic index of soils and the minus no. 40 (425 μm) portions of aggregates. [CM Part V 5.9.10 - SPECS 305 and 1104]
2.19	Sieve analysis for combined aggregate of base course	KT-02: Determination of the particle size distribution of aggregates using standard sieves [CM Part V 5.9.02 - SPECS 305 and 1104]
2.20	Plasticity of combined aggregate of base course	KT-10: Determining the liquid limit, plastic limit, and plastic index of the minus no. 40 (425 μm) portions of aggregates. [CM Part V 5.9.10 - SPECS 305 and 1104]
2.21	Moisture test for combined aggregate of base course	KT-11: Determination of the moisture content of aggregate. [CM Part V 5.9.11 - SPECS 305 and 1104]
2.22	Field density of completed aggregate base course	KT-13: Measuring the in-place density of granular base courses [CM Part V 5.9.13 - SPECS 305 and 1104]
2.23	Sieve analysis for individual aggregate of shoulders (non HMA)	KT-02: Determination of the particle size distribution of aggregates using standard sieves [CM Part V 5.9.02 - SPECS 305 and 1113]
2.24	Plasticity of individual aggregate of shoulders (non HMA)	KT-10: Determining the liquid limit, plastic limit, and plastic index of the minus no. 40 (425 μm) portions of aggregates. [CM Part V 5.9.10 - SPECS 305 and 1113]
2.25	Sieve analysis for aggregate of binder material of shoulders (non HMA)	KT-02: Determination of the particle size distribution of aggregates using standard sieves [CM Part V 5.9.02 - SPECS 305 and 1113]
2.26	Plasticity of binder material of aggregate shoulders (non HMA)	KT-10: Determining the liquid limit, plastic limit, and plastic index. [CM Part V 5.9.10 - SPECS 305 and 1113]
2.27	Sieve analysis for combined aggregate of shoulders (non HMA)	KT-02: Determination of the particle size distribution of aggregates using standard sieves [CM Part V 5.9.02 - SPECS 305 and 1113]
2.28	Plasticity of combined aggregate of shoulders (non HMA)	KT-10: Determining the liquid limit, plastic limit, and plastic index. [CM Part V 5.9.10 - SPECS 305 and 1113]
2.29	Moisture of combined aggregate of shoulders (non HMA)	KT-11: Determination of the moisture content of aggregate. [CM Part V 5.9.11 - SPECS 305 and 1113]
2.30	Field density of completed aggregate shoulders (non HMA)	KT-13: Measuring the in-place density of aggregate shoulders [CM Part V 5.9.13 - SPECS 305 and 1113]
2.31	Moisture of completed aggregate shoulders (non HMA)	KT-11: Determination of the moisture content of completed aggregate shoulders. [CM Part V 5.9.11 - SPECS 305 and 1113]
2.32	Sieve analysis for aggregate of cement treated base (CTB)	KT-02: Determination of the particle size distribution of aggregates using standard sieves [CM Part V 5.9.02 - SPECS 306 and 1105]
2.33	Moisture of cement treated base (CTB)	KT-11 or KT-41: Determination of the moisture content of completed aggregate shoulders. [CM Part V 5.9.11 - SPECS 306 and 1105]

Table 4.5: Core Inspection Activities for Subgrade, Base, and Shoulders (47 activities) (Continued)

Activity ID	Description	Remarks/References
2.34	Density of cement treated base (CTB)	KT 37 or KT 20: Determining the mass per cubic foot. [CM Part V 5.9.11 - SPECS 306 and 1105]
2.35	Compressive strength of cement treated base (CTB)	KT 37 or KT 20: Determining the compressive strength. [SPECS 306 and 1105]
2.36	Field density of completed cement treated base (CTB)	KT-13 or KT-41: Measuring the in-place density of completed CTB [CM Part V 5.9.11 - SPECS 306 and 1105]
2.37	Moisture of completed cement treated base (CTB)	KT-11 or KT-41: Determination of the moisture content of completed CTB [CM Part V 5.9.11 - SPECS 306 and 1105]
2.38	Sieve analysis for aggregate of granular base	KT-02: Determination of the particle size distribution of aggregates using standard sieves [CM Part V 5.9.02 - SPECS 307 and 1106]
2.39	Plasticity of aggregate of granular base	KT-10: Determining the liquid limit, plastic limit, and plastic index of the minus no. 40 (425 μm) portions of aggregates. [CM Part V 5.9.10 - SPECS 307 and 1106]
2.40	Sieve analysis for aggregate of binder material of granular base	KT-02: Determination of the particle size distribution of aggregates using standard sieves [CM Part V 5.9.02 - SPECS 307 and 1106]
2.41	Plasticity of binder material of granular base	KT-10: Determining the liquid limit, plastic limit, and plastic index. [CM Part V 5.9.10 - SPECS 307 and 1106]
2.42	Sieve analysis for pulverized aggregate of granular base	KT-02: Determination of the particle size distribution of aggregates using standard sieves [CM Part V 5.9.02 - SPECS 307 and 1106]
2.43	Sieve analysis for combined aggregate of granular base	KT-02: Determination of the particle size distribution of aggregates using standard sieves [CM Part V 5.9.02 - SPECS 307 and 1106]
2.44	Plasticity of combined aggregate of granular base	KT-10: Determining the liquid limit, plastic limit, and plastic index. [CM Part V 5.9.10 - SPECS 307 and 1106]
2.45	Moisture of combined aggregate of granular base	KT-11: Determination of the moisture content of combined aggregate. [CM Part V 5.9.11 - SPECS 307 and 1106]
2.46	Field density of completed granular base	KT-13 or KT-41: Measuring the in-place density of completed granular base [CM Part V 5.9.13 - SPECS 307 and 1106]
2.47	Moisture of completed granular base	KT-11: Determination of the moisture content of granular base. [CM Part V 5.9.13 - SPECS 307 and 1106]

Table 4.6: Core Inspection Activities for Bridge Deck (9 activities)

Activity ID	Description	Remarks/References
3.1	Slump of concrete	KT-21: Determining the slump of freshly mixed concrete. [CM Part V 5.9.21 - SPECS 401, 402, 703, 710 and 717]
3.2	Portland cement approval for concrete	KT-29: sampling Portland cement in the field [CM Part V 5.9.29 - SPECS 2001, 2004, & 2005]
3.3	Concrete temperature measurement	KT-17: obtaining representative samples of freshly mixed concrete as delivered to the project site and determine conformance with quality requirements of the specifications [CM Part V 5.9.17 - SPECS 401, 402, 703, 710 and 717]
3.4	Concrete mass per cubic foot	KT-20: Determining the mass per cubic foot (meter) of freshly mixed concrete [CM Part V 5.9.20 - SPECS 401, 402, 703, 710 and 717]
3.5	Concrete air content	KT-18: Determining the air content of freshly mixed concrete by the pressure method [CM Part V 5.9.18 - SPECS 401, 402, 703, 710 and 717]
3.6	Moisture in aggregate	KT-24: Determining the free moisture or absorption of aggregates for use in concrete [CM Part V 5.9.24 - SPECS 401, 402, 703, 710 and 717]
3.7	Density of fresh concrete	KT-36: Determining the in-place density of freshly mixed concrete in bridge deck overlays using a nuclear density gauge [CM Part V 5.9.36 - SPECS 401, 402, 703, 710 and 717]
3.8	Permeability of concrete	KT-73: Determinations of percent volume of permeable voids in hardened concrete [CM Part V 5.9.73 - SPECS 401, 402, 703, 710 and 717]
3.9	Concrete strength (cylinders)	KT-22 and KT-76: Determining the compressive strength of molded cylindrical concrete specimens [CM Part V 5.9.73 - SPECS 401, 402, 703, 710 and 717]

Table 4.7: Core Inspection Activities for Rigid Pavement (12 activities)

Activity ID	Description	Remarks/References
4.1	Concrete mass per cubic foot - PCCP	KT-20: Determining the mass per cubic foot (meter) of freshly mixed concrete [CM Part V 5.9.20 - SPECS 401, 403, 502 and 503]
4.2	Sieve analysis of individual aggregates - PCCP	KT-02: Determination of the particle size distribution of aggregates using standard sieves. [SPECS 501 & 503]
4.3	Check vibrator frequencies before placing PCCP	Inspector Checks the required vibrator frequencies before placing PCCP
4.4	PCCP temperature	KT-17: obtaining representative samples of freshly mixed concrete as delivered to the project site and determine conformance with temperature quality requirements of the specifications [CM Part V 5.9.17 - SPECS 401, 403, 502 and 503]
4.5	PCCP slump	KT-21: Determining the slump of freshly mixed concrete. [CM Part V 5.9.21 - SPECS 401, 403, 502 and 503]
4.6	PCCP air content	KT-20: Determining the mass per cubic foot (meter) of freshly mixed concrete [CM Part V 5.9.20 - SPECS 401, 403, 502 and 503]
4.7	Moisture in PCCP aggregate	KT-24: Determining the free moisture or absorption of aggregates for use in PCCP [CM Part V 5.9.24 - SPECS 401, 403, 502 and 503]
4.8	Cored PCCP thickness	KT-49: obtaining and testing specimens to determine the compressive strength of in-place concrete in pavement and depth of concrete pavement [CM Part V 5.9.49 - SPECS 401, 403, 502 and 503]
4.9	Density of fresh PCCP	KT-38: Determining the in-place density of freshly mixed concrete in pavements using nuclear density gauge [CM Part V 5.9.38 - SPECS 401, 403, 502 and 503]
4.10	PCCP permeability	KT-73: Determinations of percent volume of permeable voids in hardened concrete [CM Part V 5.9.73 - SPECS 401, 403, 502 and 503]
4.11	PCCP vibrator frequency	KDOT standard specification 154.2e requirements for vibrators for rigid pavement. [SPECS 154.2e]
4.12	Unit weight of PCCP individual aggregate – lightweight aggregates only	KT-05: Determining the unit weight of fine, coarse, or mixed aggregates. The method is applicable to aggregates not exceeding 1 ½ in. (37.5 mm) in nominal maximum size. [SPECS 501 & 503]

Table 4.8: Core Inspection Activities for Flexible Pavement (33 activities)

Activity ID	Description	Remarks/References
5.1	Sieve analysis of HMA individual aggregate	KT-05: Determining the unit weight of fine, coarse, or mixed aggregates. The method is applicable to aggregates not exceeding 1 ½ in. (37.5 mm) in nominal maximum size. [SPECS 501 & 503]
5.2	Compaction of asphalt pavement layer - HMA	Inspector checks compaction of asphalt pavement layer with considering the required tests
5.3	HMA sampling and storage for testing	KT 26: sampling asphalt, cutback, and emulsifier materials, at the point of production and at destination.
5.4	Percentage of crushed particles in HMA crushed gravel (coarse aggregate angularity)	KT-31: Determining the percent, by mass, of particles, which by visual inspection, exhibit characteristics of crushed aggregate [CM Part V 5.9.31 - SPECS 603, 611, 1103 & 15-06001]
5.5	Uncompacted void content of HMA fine aggregate	KT-50: Determination of the uncompacted void content of a sample of HMA aggregate based on a given gradation. Measure of aggregate angularity, sphericity, and texture [CM Part V 5.9.35 - SPECS 603, 611, 1103 & 15-06001]
5.6	Sieve analysis for HMA aggregate of mineral filler supplement	KT-02: Determination of the particle size distribution of HMA aggregate of mineral filler supplement using standard sieves [CM Part V 5.9.02 - SPECS 603, 611, 1103 & 15-06001]
5.7	Plasticity of HMA mineral filler supplement	KT-10: Determining the liquid limit, plastic limit, and plastic index of HMA mineral filler supplement [CM Part V 5.9.10 - SPECS 603, 611, 1103 & 15-06001]
5.8	Sieve analysis of HMA combined aggregate	KT-02: Determination of the particle size distribution of HMA combined aggregate [CM Part V 5.9.02 - SPECS 603, 611, 1103 & 15-06001]
5.9	Coarse aggregate angularity for combined aggregate - HMA	KT-31: Determining the percent, by mass, of particles, which by visual inspection, exhibit characteristics of crushed aggregate [SPECS 602, 603, 611 & 1103]
5.10	Sand equivalent of HMA combined aggregate	KT-55: Determining the relative proportions of fine dust or claylike material in minus no. 4 (4.75 mm) HMA combined aggregates. [CM Part V 5.9.10 - SPECS 603, 611, 1103 & 15-06001]
5.11	Moisture content of HMA combined aggregate	KT-11: Determination of the moisture content of HMA combined aggregate [CM Part V 5.9.11 - SPECS 603, 611, 1103 & 15-06001]
5.12	Density of HMA mixtures (field lab)	KT-14: testing bituminous mixes to determine optimum asphalt content, density characteristics, and stability characteristics [CM Part V 5.9.14 - SPECS 603, 611, 1103 & 15-06001]
5.13	Voids of HMA mixtures (field lab)	KT-14: testing bituminous mixes to determine optimum asphalt content, density characteristics, and stability characteristics [CM Part V 5.9.14 - SPECS 603, 611, 1103 & 15-06001]
5.14	Moisture content of HMA mixtures (field lab)	KT-11: Determination of the moisture content of HMA mixtures in field lab [CM Part V 5.9.11 - SPECS 603, 611, 1103 & 15-06001]
5.15	HMA asphalt binder sampling for testing at plant	KT-26: sampling asphalt, cutback, and emulsifier materials, at the point of production and at destination [CM Part V 5.9.26 - SPECS 603, 611, 1103 & 15-06001]
5.16	Density of HMA mixtures (District lab)	KT-14: testing bituminous mixes to determine optimum asphalt content, density characteristics, and stability characteristics [CM Part V 5.9.14 - SPECS 603, 611, 1103 & 15-06001]
5.17	Gradation of HMA mixtures (District lab)	KT-34: Determination of the particle size distribution of aggregate extracted from asphalt mixtures [CM Part V 5.9.34 - SPECS 603, 611, 1103 & 15-06001]

Table 4.8: Core Inspection Activities for Flexible Pavement (33 activities) (Continued)

5.18	Asphalt content of HMA mixtures (District lab)	KT-57: Determination of asphalt content of hot mix paving mixtures by ignition of the asphalt cement at 932°f (500°c) in a furnace [CM Part V 5.9.57 - SPECS 603, 611, 1103 & 15-06001]
5.19	Maximum specific gravity of uncompacted plant mix asphalt (field lab)	KT-39: Determination of the theoretical maximum specific gravity of uncompacted asphalt paving mixtures. [CM Part V 5.9.39 - SPECS 603, 611, 1103 & 15-06001]
5.20	Moisture content of uncompacted plant mix asphalt (field lab)	KT-11: Determination of the moisture content of soil and aggregate [CM Part V 5.9.11 - SPECS 603, 611, 1103 & 15-06001]
5.21	Air voids of plant mix asphalt (District lab)	KT-15 and KT-58: the compaction of cylindrical specimens of hot mix asphalt (HMA) using the super pave gyratory compactor [CM Part V 5.9.15 - SPECS 603, 611, 1103 & 15-06001]
5.22	Maximum specific gravity of uncompacted plant mix asphalt (District lab)	KT-39: Determination of the theoretical maximum specific gravity of uncompacted asphalt paving mixtures. [CM Part V 5.9.39 - SPECS 603, 611, 1103 & 15-06001]
5.23	Gradation of plant mix asphalt (District lab)	KT-34: Determination of the particle size distribution of aggregate extracted from asphalt mixtures [CM Part V 5.9.34 - SPECS 603, 611, 1103 & 15-06001]
5.24	Asphalt content of plant mix asphalt (District lab)	KT-57: Determination of asphalt content of hot mix paving mixtures by ignition of the asphalt cement at 932°f (500°c) in a furnace [CM Part V 5.9.57 - SPECS 603, 611, 1103 & 15-06001]
5.25	Field density (cores or nuclear) of completed HMA road work	KT-15: Determining the bulk specific gravity of specimens of compacted asphalt mixtures. The specimens may have been molded in the laboratory or cut or cored form compacted pavement. None required if specified [plan] lift thickness is less than 1.5”. [CM Part V 5.9.15 - SPECS 603, 611, 1103 & 15-06001]
5.26	Voids in mineral aggregate (VMA)	KT-15 & KT-6: Determining the specific gravity and absorption of aggregates [SPECS 602]
5.27	Mix gradation	Testing mix gradation at field lab [SPECS 602]
5.28	Binder content	KT-57: conduct the tests for binder content on representative portions of the HMA, quartered from the larger sample of HMA. Take a random sample weighing a minimum of 55 pounds from behind the paver and transport it to the test facility, using a method to retain heat to facilitate sample-quartering procedures, record and document all test results and calculations on data sheets provided by KDOT. [SPECS 602]
5.29	Theoretical maximum specific gravity of asphalt paving mixtures- (field lab)	KT-39: Determination of the theoretical maximum specific gravity of uncompacted asphalt paving mixtures [CM Part V 5.9.39 - SPECS 602]
5.30	Voids filled with asphalt (VFA)	KT-15, KT-39, and KT-58 [SPECS 602]
5.31	Voids in mineral aggregate (VMA)	KT-15 & KT-6: Determining the specific gravity and absorption of aggregates [SPECS 602]
5.32	Dust to effective binder content (d/b) ratio	Examining dust to effective binder content (d/b) ratio in HMA [SPECS 602]
5.33	HMA construction joints control	Inspector review making and checking transverse and longitudinal joints, an acceptable surface texture and meet density requirements, apply a light coat of asphalt emulsion or asphalt binder if needed. Before placing the fresh HMA against a cut joint, spray or paint the contact surface with a coat or asphalt binder [SPECS 602]

4.4 Summary

This chapter presented a comprehensive list and a core list of inspection activities for KDOT. The comprehensive list included 302 inspection activities that were developed by synthesizing and evaluating a wide range of KDOT documents. These documents include KDOT's Construction Manual, KDOT's Bridge Construction Manual, KDOT's Specification, QA Inspection Acceptance, and others. The relevant information from these documents was extracted and associated with each activity. The four levels of a hierarchical structure (Divisions, Sections, QA Activities, and Acceptance) were used to connect each inspection activity with relevant KDOT documents. This hierarchical structure could be a beneficial reference for inspectors to efficiently implement inspection procedures and the acceptance process. Interviews with KDOT and FHWA experts led to the exclusion of 194 activities from the comprehensive list, resulting in a core list of 108 inspection activities, of which seven activities were in the Earthwork division; 47 activities were in the Subgrade, Base, and Shoulders division; nine activities were in the Concrete (Bridge Deck) division; 12 activities were in the Rigid Pavement (PCCP) division; and 33 activities were in the Flexible Pavement (HMA) division. Appendix B details all 302 inspection activities.

Chapter 5: Risk Assessment Results

5.1 Introduction

This chapter presents the results of the risk assessment process of 108 core inspection activities determined from Chapter 4. The risk assessment method used in this research is presented, followed by the risk assessment results of 108 core activities associated with the five divisions: Earthwork; Subgrade, Base, and Shoulders; Concrete (Bridge Deck); Rigid Pavement (PCCP); and Flexible Pavement (HMA). Finally, the chapter highlights the top risk inspection activities in each division.

5.2 Risk Assessment Method

A survey questionnaire was given to 16 KDOT and FHWA experts in the fields of construction materials and construction means and methods. These experts included material engineers, district engineers, construction engineers, a field engineer, and project managers within KDOT. Each participant was asked to rate the risks associated with 108 core inspection activities.

As discussed in Chapter 3, risk impact can be estimated based on a product of the probability of an event and its associated consequences. Table 5.1 summarizes the two risk assessment factors: (1) the probability of an inspection not meeting requirements, and (2) the consequences of an inspection not meeting requirements. Both probability and consequences of each core inspection activity were rated based on the five-point scale: (1) Very Low; (2) Low; (3) Moderate; (4) High; and (5) Very High. Three performance metrics (cost, safety, and service interruption) were used to evaluate the consequences of an inspection failing to meet requirements. For example, a “Very Low” probability means that the likelihood of an inspection not meeting KDOT requirements is remote. Similarly, the “Very Low” consequence for the cost impact of an inspection failing to meet KDOT requirements means a very minor effect to achieving the remaining service life of the element or structure. The “Very Low” consequence for safety means that only minor injuries may occur when an inspection does not meet requirements, and the “Very Low” consequence for service interruption means that only a minor slowdown of highway service occurs when an inspection does not meet requirements.

Table 5.1: Risk Assessment Factors

No.	Category	Probability of an inspection not meeting requirements	Consequence of an inspection not meeting the requirements		
			Cost	Safety	Service Interruption
0	N.A.	Not Applicable	Not Applicable		
1	Very Low	Remote likelihood	Very minor effect to achieve remaining service life	Very minor injuries	Minor slow-down of the highway service
2	Low	Low likelihood	Minor effect to achieve remaining service life	Minor injuries	Considerable slow-down of the highway service
3	Moderate	Moderate likelihood	Considerable effect to achieve remaining service life	Considerable injuries	Partial Close of the highway
4	High	High likelihood	Major effect to achieve remaining service life	Severe injuries	Major close of the highway for short time
5	Very High	Very high likelihood	Severe effect to achieve remaining service life	Loss of life	Full close of the highway for a long time

Based on the ranking system presented in Table 5.1, a 5 × 5 matrix was created to aggerate the two dimensions of the risks into one composite index (CI). Figure 5.1 shows the CI for the KDOT risk-based inspection assessment method.

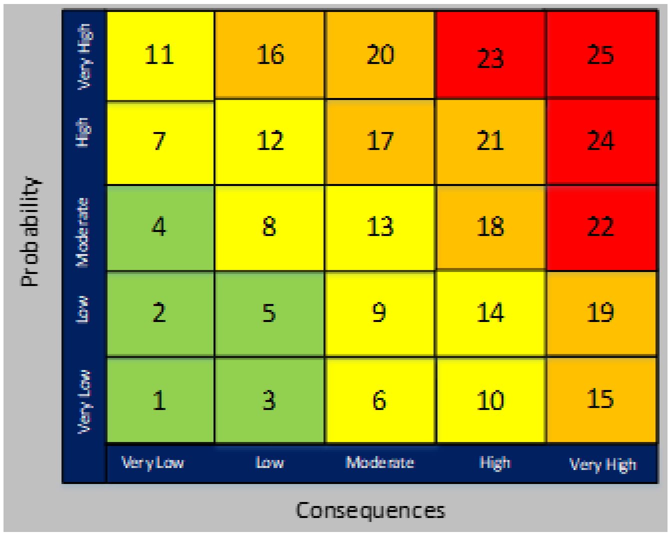

Figure 5.1: Risk Assessment Matrix

As shown in Figure 5.1, the vertical axis represents the likelihood, and the horizontal axis represents the consequence of the inspection not meeting the KDOT requirement. Figure 5.1 indicates that the composite index (CI) value ranges from "1" to "25." There are four risk zones (critical, high, moderate, and low) depending on the CI values. Specifically, the critical zone includes inspection activities with the CI value ranging from "22" to "25." For the inspection activities within the critical risk zone, a comprehensive set of actions is required immediately to address the risk. The high-risk zone includes inspection activities with the CI value ranging from "15" to "21." Under the high-risk zone, the risk impact would be severe but not critical. For the inspection activities within the high-risk zone, some immediate actions are required, including the development of a comprehensive action plan. The moderate-risk zone includes inspection activities with the CI value ranging from "6" to "14." The risk impact of inspection activities not meeting the KDOT requirement is not severe and can be managed using the established QA inspection process. It is important to note that the risk associated with the moderate-risk zone should be monitored regularly. Finally, the low-risk zone includes inspection activities with the CI value ranging from "1" to "5." Under this zone, the risk impact of inspection activities not meeting the KDOT requirement is relatively insignificant. Status of inspection activities within this zone should be reviewed periodically.

Table 5.1 and Figure 5.1 were used to assess and evaluate all 108 inspection activities in the core list based on the KDOT and FHWA experts. For example, for a given inspection activity if a respondent selects "High" for the probability and "High" for a consequence based on the rating system defined in Table 5.1, then this activity will receive a CI of "21" using Figure 5.1. The same process was repeated to all 108 core activities. The mean of the CI values was calculated based on all respondents to the survey. It is important to note that the consequences of the inspection not meeting the KDOT requirement included three aspects of cost, safety, and service interruption. In this study, the maximum rating value of these three aspects was used as the representative value to determine the critical inspection risk list. Appendix C provides a detailed result of risk assessment. Figure 5.2 graphically illustrates the risk assessment procedure and calculation process for the inspection activities in the Earthwork Division.

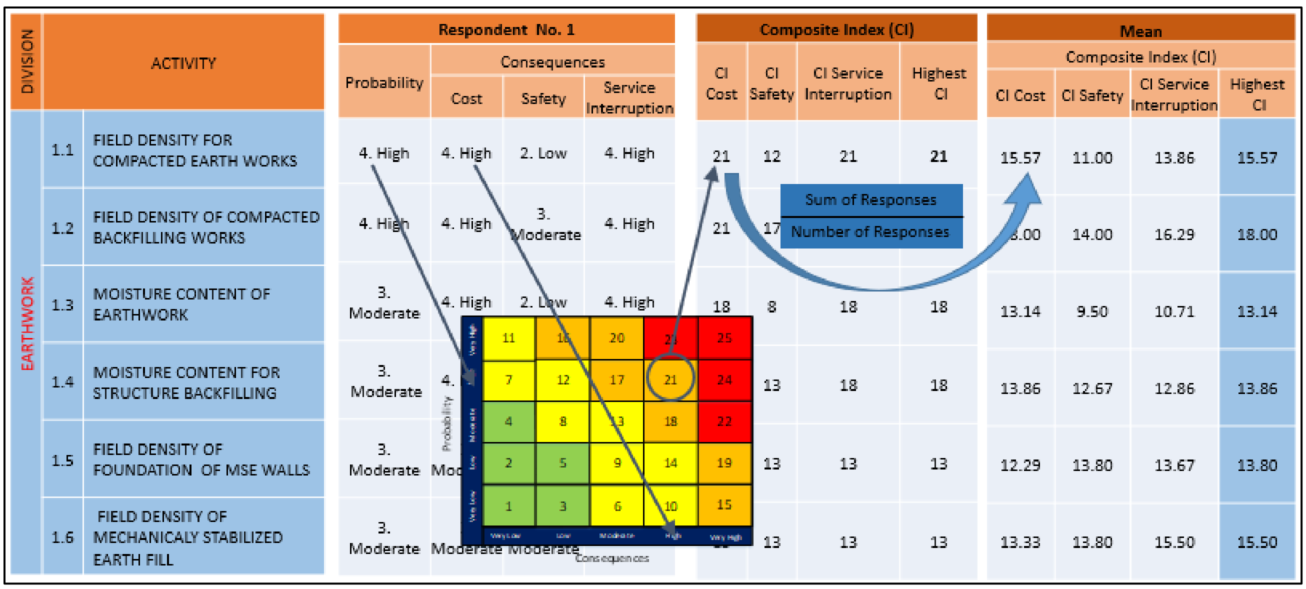

Figure 5.2: Sample of Calculating CI Mean

5.3 Risk Assessment Results

This section presents risk assessment results of all 108 core KDOT inspection activities associated with the five Divisions: (1) Earthwork; (2) Subgrade, Base, and Shoulders; (3) Concrete (Bridge Deck); (4) Rigid Pavement (PCCP); and (5) Flexible Pavement (HMA). As mentioned previously, the survey questionnaires were distributed to 16 KDOT and FHWA experts for risk assessment. It is noted that the KDOT and FHWA experts were asked to rate the risk impact of inspection items based on their expertise. As a result, the valid responses associated with each core inspection activity varied.

5.3.1 Risk Assessment Results for Earthwork Activities

Figure 5.3 summarizes the risk impact of seven inspection activities in the Earthwork division, designated by seven valid responses. As shown in Figure 5.3, the following three inspection activities are in the high-risk zone (i.e., CI value of 15–21):

- *Activity ID 1.1*: Field density for compacted earthwork;
- *Activity ID 1.2*: Field density of compacted backfilling work; and
- *Activity ID 1.6*: Field density of mechanically stabilized earth fill.

Figure 5.3 also shows that the remaining four inspection activities are in the moderate-risk zone (i.e., CI value of 6–14):

- *Activity ID 1.3*: Moisture content of earthwork;
- *Activity ID 1.4*: Moisture content for structure backfilling;
- *Activity ID 1.5*: Field density of foundation of MSE walls; and
- *Activity ID 1.7*: Check placement and compaction of granular drainage blanket.

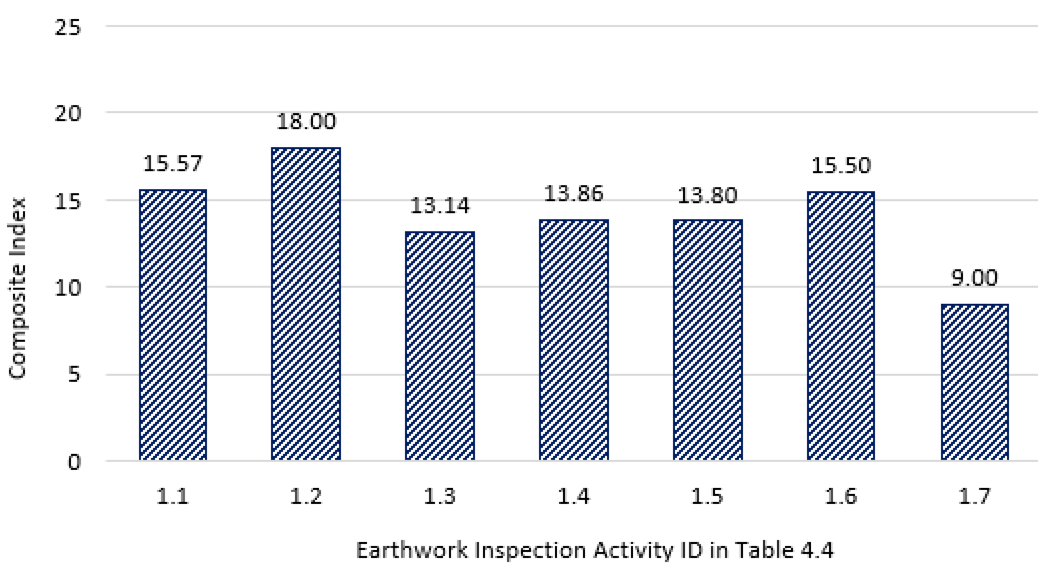

Figure 5.3: Risk Impact of Earthwork QA Activities (n = 7)

5.3.2 Risk Assessment Results for Subgrade, Base, and Shoulders Activities

Figure 5.4 summarizes the risk impact of 47 inspection activities in the Subgrade, Base, and Shoulders division, designated by six valid responses. As shown in the figure, only one inspection activity (*Activity ID 2.35*: Compressive strength of cement-treated base) is in the high-risk inspection zone (i.e., CI value of 15–21), and 38 of the 47 core inspection activities are in the moderate-risk zone (i.e., CI value of 6–14). The following top 10 inspection activities were in the moderate-risk zone:

- *Activity ID 2.5*: Moisture content for lime-treated subgrade;
- *Activity ID 2.8*: Field density of lime-treated subgrade;
- *Activity ID 2.11*: Field density of cement or fly ash-treated subgrade;
- *Activity ID 2.22*: Field density of completed aggregate base course;
- *Activity ID 2.33*: Moisture of cement-treated base (CTB);
- *Activity ID 2.34*: Density of CTB;
- *Activity ID 2.36*: Field density of completed CTB;
- *Activity ID 2.37*: Moisture of completed CTB;
- *Activity ID 2.46*: Field density of completed granular base; and
- *Activity ID 2.47*: Moisture of completed granular base.

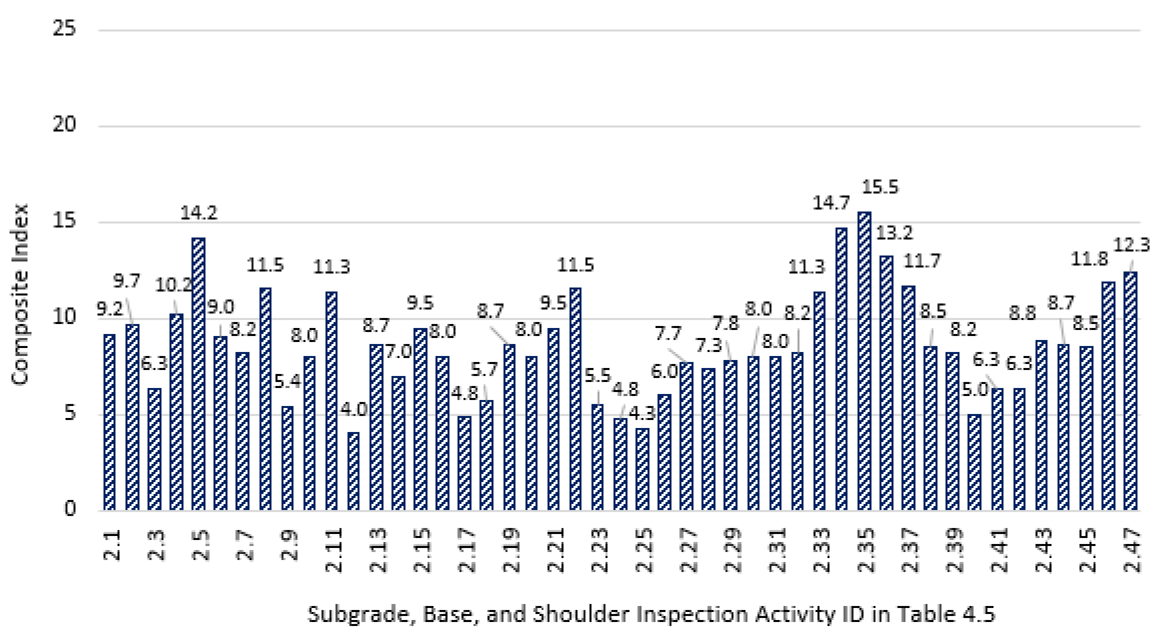

Figure 5.4: Risk Impact of Subgrade, Base, and Shoulders QA Activities (n = 6)

Figure 5.4 also shows that the following eight inspection activities in this division are in the low-risk zone (e.g., CI value less than 6):

- *Activity ID 2.9*: Sample of subgrade hydrated lime and pebble quicklime;
- *Activity ID 2.12*: Sample of stabilization and cold-recycle fly ash;
- *Activity ID 2.17*: Sieve analysis for aggregate of binder material of base course;
- *Activity ID 2.18*: Plasticity for aggregate of binder material of base course;
- *Activity ID 2.23*: Sieve analysis for individual aggregate of shoulders (non-HMA);
- *Activity ID 2.24*: Plasticity of individual aggregate of shoulders (non-HMA);
- *Activity ID 2.25*: Sieve analysis for aggregate of binder material of shoulders (non-HMA); and
- *Activity ID 2.40*: Sieve analysis for aggregate of binder material of granular base.

5.3.3 Risk Assessment Results for Concrete (Bridge Deck) Activities

Figure 5.5 summarizes the risk impact of nine inspection activities in the Concrete (Bridge Deck) Division. There were seven valid responses for this Division. One can observe from Figure 5.5 that only one inspection activity (*Activity ID 3.8*: Permeability of concrete) is in the high-risk inspection zone (i.e., CI value of 15–21). The remaining eight inspection activities are in the moderate-risk zone (i.e., CI value of 6–14):

- *Activity ID 3.1*: Slump of concrete;
- *Activity ID 3.2*: Portland cement approval for concrete;
- *Activity ID 3.3*: Concrete temperature measurement;
- *Activity ID 3.4*: Concrete mass per cubic foot;
- *Activity ID 3.5*: Concrete air content;
- *Activity ID 3.6*: Moisture in aggregate;
- *Activity ID 3.7*: Density of fresh concrete; and
- *Activity ID 3.9*: Concrete strength (cylinders).

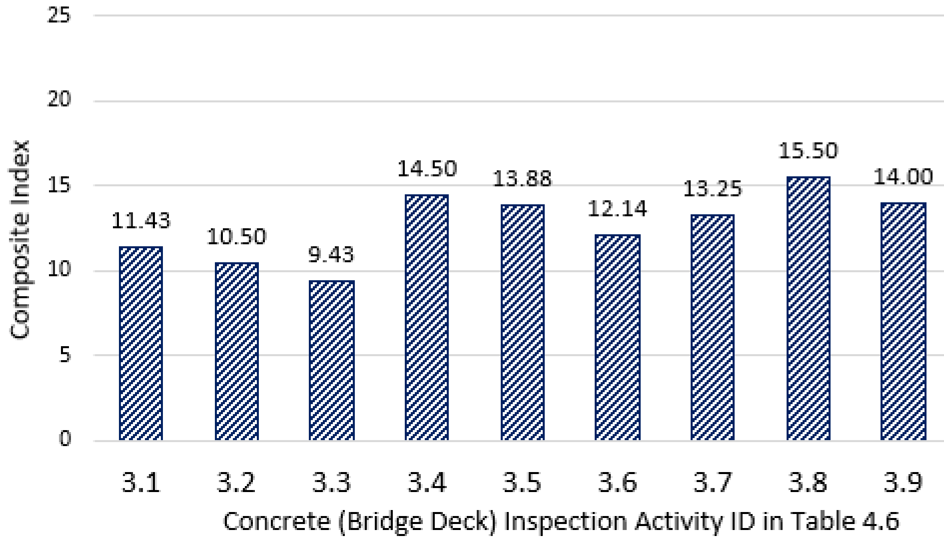

Figure 5.5: Risk Impact of Concrete (Bridge Deck) QA Activities (n = 7)

5.3.4 Risk Assessment Results for Rigid Pavement (PCCP) Activities

Figure 5.6 summarizes the risk impact of 12 inspection activities in the Rigid Pavement (PCCP) Division. There were seven valid responses for this Division. Figure 5.6 indicates that two inspection activities are in the high-risk inspection zone (i.e., CI value of 15–21):

- *Activity ID 4.1*: Concrete mass per cubic foot; and
- *Activity ID 4.6*: PCCP air content.

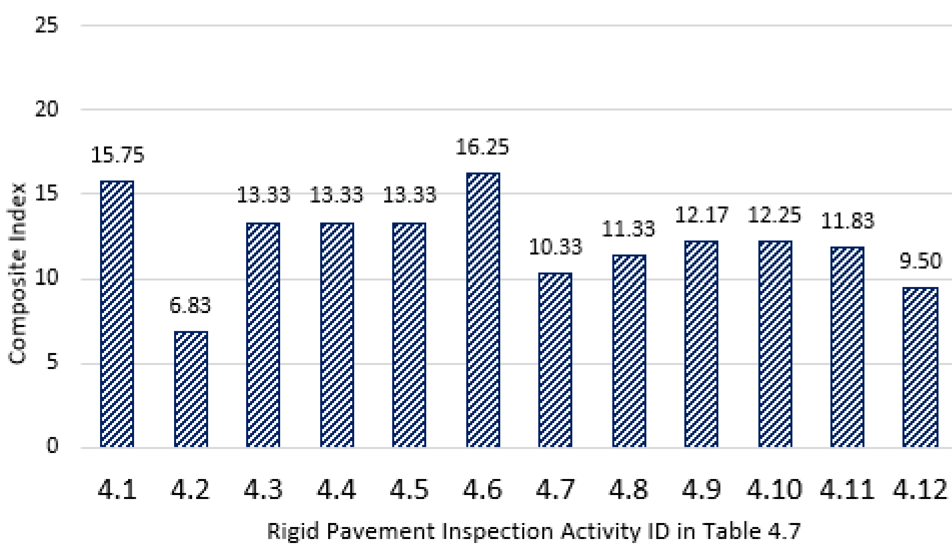

Figure 5.6: Risk Impact of Rigid Pavement (PCCP) QA Activities (n = 7)

Figure 5.6 also shows that the remaining 10 core inspection activities in this division are in the moderate-risk zone (i.e., CI value of 6–14):

- *Activity ID 4.2*: Sieve analysis of individual aggregates;
- *Activity ID 4.3*: Check vibrator frequencies before placing;
- *Activity ID 4.4*: PCCP temperature;
- *Activity ID 4.5*: PCCP slump;
- *Activity ID 4.7*: Moisture in PCCP aggregate;
- *Activity ID 4.8*: Cored PCCP thickness;
- *Activity ID 4.9*: Density of fresh PCCP;
- *Activity ID 4.10*: PCCP permeability;
- *Activity ID 4.11*: PCCP vibrator frequency; and
- *Activity ID 4.12*: Unit weight of PCCP individual aggregate – lightweight aggregates only.

5.3.5 Risk Assessment Results for Flexible Pavement (HMA) Activities

Figure 5.7 summarizes the risk impact of 33 inspection activities in the Flexible Pavement Division. There were eight valid responses for this Division. Figure 5.7 indicates that only one inspection activity (*Activity ID 5.12*: Density of HMA mixtures - field lab) is in the high-risk inspection zone (i.e., CI value of 15–21).

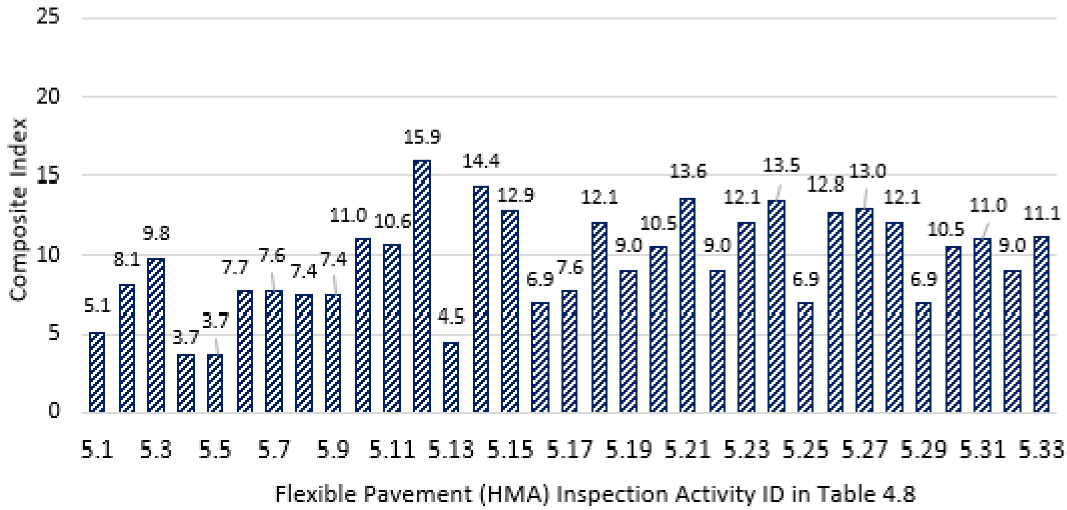

Figure 5.7: Risk Impact of Flexible Pavement (HMA) QA Activities (n=8)

Out of 33 core inspection activities in this Division, 28 activities are in the moderate-risk zone (i.e., CI value of 6–14). The top 10 inspection activities in the moderate-risk zone include:

- *Activity ID 5.14*: Moisture content of HMA mixtures (field lab);
- *Activity ID 5.15*: HMA asphalt binder sampling for testing at plant;
- *Activity ID 5.18*: Asphalt content of HMA mixtures (district lab);
- *Activity ID 5.21*: Air voids of plant mix asphalt (district lab);
- *Activity ID 5.23*: Gradation of plant mix asphalt (district lab);
- *Activity ID 5.24*: Asphalt content of plant mix asphalt (district lab);
- *Activity ID 5.26*: Voids in mineral aggregate (VMA);
- *Activity ID 5.27*: Mix gradation;
- *Activity ID 5.28*: Binder content; and
- *Activity ID 5.33*: HMA construction joints control.

Figure 5.7 also shows that four inspection activities in this division are in the low-risk zone (i.e., CI value less than 6):

- *Activity ID 5.1*: Sieve analysis of HMA individual aggregate;
- *Activity ID 5.4*: Percentage of crushed particles in HMA crushed gravel (coarse aggregate angularity);
- *Activity ID 5.5*: Uncompacted void content of HMA fine aggregate; and
- *Activity ID 5.13*: Voids of HMA mixtures (field lab).

5.4 KDOT Risk-Based Inspection Protocol

Construction inspection plays a pivotal role for KDOT to ensure that a quality product was delivered. Building upon the risk assessment results, a protocol for inspection of KDOT construction activities was created. Specifically, the protocol was developed by connecting the 108 core inspection activities associated with five Divisions: (1) Earthwork; (2) Subgrade, Base, and Shoulders; (3) Concrete (Bridge Deck); (4) Rigid Pavement (PCCP); and (5) Flexible Pavement (HMA) with their risk score (i.e., the CI value), types of inspection, acceptance procedures, and reference documents. Table 5.2 summarizes the KDOT risk-based inspection protocol in detail. As shown in Table 5.2, the protocol could be used to help KDOT project engineers, supervisors, or inspectors prioritize the construction activities and understand when and why an activity should be inspected. Additionally, the inspection protocol can be used as a check list for inspection staff. It is noted that an inspection activity typically has several articles of acceptance criteria based on KDOT Construction Manuals or KDOT Specifications shown in the "References" column. KDOT inspection staff can examine these documents for detailed processes and procedures when inspecting each activity.

Table 5.2: KDOT Risk-Based Inspection Protocol

Element	ID	Activity	CI	Type	Acceptance Procedures	References
Earthwork	1.1	Field density for compacted earth works	15.57	Test	KT-13 or KT-51: Measuring the density of compacted soil	[CM - Part V 5.9.13, 5.9.51 & SPECS 204, 205, 208]
	1.2	Field density of compacted backfilling works	18.00	Test	KT-13 or KT-51: Measuring the density of soil backfilling around a structure	[CM - Part V 5.9.13, 5.9.51 & SPECS 204, 205, 208]
	1.3	Moisture content of earthwork	13.14	Test	Determining the moisture content in accordance with KT-11	[CM - Part V 5.9.51 & SPECS 204, 205, 208]
	1.4	Moisture content for structure backfilling	13.86	Test	Determining the moisture content in accordance with KT-11	[CM - Part V 5.9.51 & SPECS 204, 205, 208]
	1.5	Field density of foundation of MSE walls	13.80	Test	KT-13 or KT-51: Measuring the density of compacted soil (foundation and retained soil)	[SPECS 209]
	1.6	Field density of mechanically stabilized earth fill	15.50	Test	KT-13 or KT-51: Measuring the density of compacted soil	[SPECS 214]
	1.7	Check placement and compaction of granular drainage blanket	9.00	Inspection	Check dimensions and locations according to contract documents	[SPECS 215]
Subgrade, Base, and Shoulders	2.1	Sieve analysis of aggregate for subgrade	9.2	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves.	[SPECS 301, 1110 & 1112]
	2.2	Check the application rate of cement or fly ash (CTB)	9.7	Inspection	The engineer will have the contractor blade a flat area in the path of the cement or fly ash application, place a planar surface with a minimum surface area of 1 square foot (e.g., A straight-sided pan) and of sufficient height to contain the admixture on the prepared area and allow the train to pass over the surface.	[SPECS 303.3]
	2.3	Material passing the no. 200 (75 µm) sieve by the wash method for subgrade aggregate	6.3	Test	KT-03: Determining the quantity of material finer than the no. 200 (75µm) sieve in aggregate by the wash method.	[CM Part V 5.9.03]
	2.4	Plasticity of aggregate of subgrade	10.2	Test	KT-10: Determining the liquid limit, plastic limit and plastic index of soils and the minus no. 40 (425 µm) portions of aggregates.	[CM Part V 5.9.10 - SPECS 301, 1110 & 1112]
	2.5	Moisture content for lime treated subgrade	14.2	Test	KT-11: Determination of the moisture content of soil	[CM Part V 5.9.11 - SPECS 302, 2000 & 2400]
	2.6	Sieve analysis for acceptance of lime treated subgrade	9.0	Test	KT-42: Determining the amount of material retained on the 2, 1 ½ in., and the no. 4 sieves for lime treated soils.	[CM Part V 5.9.42 - SPECS 302, 2000 & 2400]
	2.7	Percent solids of lime slurry in lime treated subgrade	8.2	Test	KT-62: Determining the amount of solids, by percent, contained in lime slurry.	[CM Part V 5.9.62 - SPECS 302, 2000 & 2400]
	2.8	Field density of lime treated subgrade	11.5	Test	KT-13: Measuring the in-place density of soils	[CM Part V 5.9.13 - SPECS 302, 2000 & 2400]

Table 5.2: KDOT Risk-Based Inspection Protocol (Continued)

Element	ID	Activity	CI	Type	Acceptance Procedures	References
Subgrade, Base, and Shoulders	2.9	Sample of subgrade hydrated lime and pebble quicklime	5.4	Test	KT-29: sampling Portland cement, lime, and fly ash in the field	[CM Part V 5.9.29 - SPECS 302, 1103, 2002 & 2003]
	2.10	Sieve analysis for acceptance of fly ash or cement treated subgrade	8.0	Test	KT-42: Determining the amount of material retained on the 1 ½ in. and the ½ in. sieves for cement treated soils	[CM art v 5.9.42 - SPECS 303, 2000, & 2400]
	2.11	Field density of cement or fly ash treated subgrade	11.3	Test	KT-13 or KT-51: Measuring the in-place density of soils and granular base courses	[CM Part V 5.9.13 - SPECS 303, 2000, & 2400]
	2.12	Sample of stabilization and cold recycle fly ash	4.0	Test	KT-29: sampling Portland cement, lime, and fly ash in the field	[CM Part V 5.9.29 - SPECS 303, 604, & 2005]
	2.13	Field density of crushed stone subgrade	8.7	Test	KT-41: Determining density in Portland cement treated bases, aggregate bases, and aggregate shoulders	[CM Part V 5.9.41 - SPECS 304, 1100, & 2400]
	2.14	Relative density of crushed stone subgrade	7.0	Test	KT-69: Determination of the maximum–index dry density/unit weight of soil using a vertically vibrating table	[CM Part V 5.9.69 - SPECS 304, 1100, & 2400]
	2.15	Sieve analysis for aggregate crushed stone of backfill	9.5	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves	[CM Part V 5.9.02 - SPECS 304, 1107, & 1115]
	2.16	Sieve analysis for aggregate of base course	8.0	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves	[CM Part V 5.9.02 - SPECS 305 and 1104]
	2.17	Sieve analysis for aggregate of binder material of base course	4.8	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves	[CM Part V 5.9.02 - SPECS 305 and 1104]
	2.18	Plasticity for aggregate of binder material of base course	5.7	Test	KT-10: Determining the liquid limit, plastic limit, and plastic index of soils and the minus no. 40 (425 μm) portions of aggregates	[CM Part V 5.9.10 - SPECS 305 and 1104]
	2.19	Sieve analysis for combined aggregate of base course	8.7	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves	[CM Part V 5.9.02 - SPECS 305 and 1104]
	2.20	Plasticity of combined aggregate of base course	8.0	Test	KT-10: Determining the liquid limit, plastic limit, and plastic index of the minus no. 40 (425 μm) portions of aggregates	[CM Part V 5.9.10 - SPECS 305 and 1104]
	2.21	Moisture test for combined aggregate of base course	9.5	Test	KT-11: Determination of the moisture content of aggregate	[CM Part V 5.9.11 - SPECS 305 and 1104]
	2.22	Field density of completed aggregate base course	11.5	Test	KT-13: Measuring the in-place density of granular base courses	[CM Part V 5.9.13 - SPECS 305 and 1104]
	2.23	Sieve analysis for individual aggregate of shoulders (non HMA)	5.5	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves	[CM Part V 5.9.02 - SPECS 305 and 1113]

Table 5.2: KDOT Risk-Based Inspection Protocol (Continued)

Element	ID	Activity	CI	Type	Acceptance Procedures	References
Subgrade, Base, and Shoulders	2.24	Plasticity of individual aggregate of shoulders (non HMA)	4.8	Test	KT-10: Determining the liquid limit, plastic limit and plastic index of the minus no. 40 (425 μm) portions of aggregates	[CM Part V 5.9.10 - SPECS 305 and 1113]
	2.25	Sieve analysis for aggregate of binder material of shoulders (non HMA)	4.3	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves	[CM Part V 5.9.02 - SPECS 305 and 1113]
	2.26	Plasticity of binder material of aggregate shoulders (non HMA)	6.0	Test	KT-10: Determining the liquid limit, plastic limit, and plastic index.	[CM Part V 5.9.10 - SPECS 305 and 1113]
	2.27	Sieve analysis for combined aggregate of shoulders (non HMA)	7.7	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves	[CM Part V 5.9.02 - SPECS 305 and 1113]
	2.28	Plasticity of combined aggregate of shoulders (non HMA)	7.3	Test	KT-10: Determining the liquid limit, plastic limit, and plastic index.	[CM Part V 5.9.10 - SPECS 305 and 1113]
	2.29	Moisture of combined aggregate of shoulders (non HMA)	7.8	Test	KT-11: Determination of the moisture content of aggregate.	[CM Part V 5.9.11 - SPECS 305 and 1113]
	2.30	Field density of completed aggregate shoulders (non HMA)	8.0	Test	KT-13: Measuring the in-place density of aggregate shoulders	[CM Part V 5.9.13 - SPECS 305 and 1113]
	2.31	Moisture of completed aggregate shoulders (non HMA)	8.0	Test	KT-11: Determination of the moisture content of completed aggregate shoulders.	[CM Part V 5.9.11 - SPECS 305 and 1113]
	2.32	Sieve analysis for aggregate of cement treated base (CTB)	8.2	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves	[CM Part V 5.9.02 - SPECS 306 and 1105]
	2.33	Moisture of cement treated base (CTB)	11.3	Test	KT-11 or KT-41: Determination of the moisture content of completed aggregate shoulders	[CM Part V 5.9.11 - SPECS 306 and 1105]
	2.34	Density of cement treated base (CTB)	14.7	Test	KT 37 or KT 20: Determining the mass per cubic foot	[CM Part V 5.9.11 - SPECS 306 and 1105]
	2.35	Compressive strength of cement treated base (CTB)	15.5	Test	KT 37 or KT 20: Determining the compressive strength	[SPECS 306 and 1105]
	2.36	Field density of completed cement treated base (CTB)	13.2	Test	KT-13 or KT-41: Measuring the in-place density of completed CTB	[CM Part V 5.9.11 - SPECS 306 and 1105]
	2.37	Moisture of completed cement treated base (CTB)	11.7	Test	KT-11 or KT-41: Determination of the moisture content of completed CTB	[CM Part V 5.9.11 - SPECS 306 and 1105]
	2.38	Sieve analysis for aggregate of granular base	8.5	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves	[CM Part V 5.9.02 - SPECS 307 and 1106]
	2.39	Plasticity of aggregate of granular base	8.2	Test	KT-10: Determining the liquid limit, plastic limit, and plastic index of the minus no. 40 (425 μm) portions of aggregates	[CM Part V 5.9.10 - SPECS 307 and 1106]

Table 5.2: KDOT Risk-Based Inspection Protocol (Continued)

Element	ID	Activity	CI	Type	Acceptance Procedures	References
Subgrade, Base, and Shoulders	2.40	Sieve analysis for aggregate of binder material of granular base	5.0	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves	[CM Part V 5.9.02 - SPECS 307 and 1106]
	2.41	Plasticity of binder material of granular base	6.3	Test	KT-10: Determining the liquid limit, plastic limit, and plastic index	[CM Part V 5.9.10 - SPECS 307 and 1106]
	2.42	Sieve analysis for pulverized aggregate of granular base	6.3	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves	[CM Part V 5.9.02 - SPECS 307 and 1106]
	2.43	Sieve analysis for combined aggregate of granular base	8.8	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves	[CM Part V 5.9.02 - SPECS 307 and 1106]
	2.44	Plasticity of combined aggregate of granular base	8.7	Test	KT-10: Determining the liquid limit, plastic limit, and plastic index	[CM Part V 5.9.10 - SPECS 307 and 1106]
	2.45	Moisture of combined aggregate of granular base	8.5	Test	KT-11: Determination of the moisture content of combined aggregate	[CM Part V 5.9.11 - SPECS 307 and 1106]
	2.46	Field density of completed granular base	11.8	Test	KT-13 or KT-41: Measuring the in-place density of completed granular base	[CM Part V 5.9.13 - SPECS 307 and 1106]
	2.47	Moisture of completed granular base	12.3	Test	KT-11: Determination of the moisture content of granular base	[CM Part V 5.9.13 - SPECS 307 and 1106]
Concrete (Bridge Deck)	3.1	Slump of concrete - bridge deck	11.43	Test	KT-21: Determining the slump of freshly mixed concrete	[CM Part V 5.9.21 - SPECS 401, 402, 703, 710 and 717
	3.2	Portland cement approval for concrete - bridge deck	10.50	Test	KT-29: Sampling Portland cement in the field	[CM Part V 5.9.29 - SPECS 2001, 2004, & 2005]
	3.3	Concrete temperature measurement - bridge deck	9.43	Test	KT-17: obtaining representative samples of freshly mixed concrete as delivered to the project site and determine conformance with quality requirements of the specifications	[CM Part V 5.9.17 - SPECS 401, 402, 703, 710 and 717]
	3.4	Concrete mass per cubic foot - bridge deck	14.50	Test	KT-20: Determining the mass per cubic foot (meter) of freshly mixed concrete	[CM Part V 5.9.20 - SPECS 401, 402, 703, 710 and 717]
	3.5	Concrete air content - bridge deck	13.88	Test	KT-18: Determining the air content of freshly mixed concrete by the pressure method	[CM Part V 5.9.18 - SPECS 401, 402, 703, 710 and 717]
	3.6	Moisture in aggregate - concrete bridge deck	12.14	Test	KT-24: Determining the free moisture or absorption of aggregates for use in concrete	[CM Part V 5.9.24 - SPECS 401, 402, 703, 710 and 717]
	3.7	Density of fresh concrete - bridge deck	13.25	Test	KT-36: Determining the in-place density of freshly mixed concrete in bridge deck overlays using a nuclear density gauge	[CM Part V 5.9.36 - SPECS 401, 402, 703, 710 and 717]
	3.8	Permeability of concrete - bridge deck	15.50	Test	KT-73: Determinations of percent volume of permeable voids in hardened concrete	[CM Part V 5.9.73 - SPECS 401, 402, 703, 710 and 717]
	3.9	Concrete strength (cylinders) - bridge deck	14.00	Test	KT-22 and KT-76: Determining the compressive strength of molded cylindrical concrete specimens	[CM Part V 5.9.73 - SPECS 401, 402, 703, 710 and 717]

Table 5.2: KDOT Risk-Based Inspection Protocol (Continued)

Element	ID	Activity	CI	Type	Acceptance Procedures	References
Rigid Pavement (PCCP)	4.1	Concrete mass per cubic foot - PCCP	15.75	Test	KT-20: Determining the mass per cubic foot (meter) of freshly mixed concrete	[CM Part V 5.9.20 - SPECS 401, 403, 502 and 503]
	4.2	Sieve analysis of individual aggregates - PCCP	6.83	Test	KT-02: Determination of the particle size distribution of aggregates using standard sieves	[SPECS 501 & 503]
	4.3	Check vibrator frequencies before placing PCCP	13.33	Inspection	Inspector Checks the required vibrator frequencies before placing PCCP	[SPECS 501]
	4.4	PCCP temperature	13.33	Test	KT-17: obtaining representative samples of freshly mixed concrete as delivered to the project site and determine conformance with temperature quality requirements of the specifications	[CM Part V 5.9.17 - SPECS 401, 403, 502 and 503]
	4.5	PCCP slump	13.33	Test	KT-21: Determining the slump of freshly mixed concrete	[CM Part V 5.9.21 - SPECS 401, 403, 502 and 503]
	4.6	PCCP air content	16.25	Test	KT-20: Determining the mass per cubic foot (meter) of freshly mixed concrete	[CM Part V 5.9.20 - SPECS 401, 403, 502 and 503]
	4.7	Moisture in PCCP aggregate	10.33	Test	KT-24: Determining the free moisture or absorption of aggregates for use in PCCP	[CM Part V 5.9.24 - SPECS 401, 403, 502 and 503]
	4.8	Cored PCCP thickness	11.33	Test	KT-49: obtaining and testing specimens to determine the compressive strength of in-place concrete in pavement and depth of concrete pavement	[CM Part V 5.9.49 - SPECS 401, 403, 502 and 503]
	4.9	Density of fresh PCCP	12.17	Test	KT-38: Determining the in-place density of freshly mixed concrete in pavements using nuclear density gauge	[CM Part V 5.9.38 - SPECS 401, 403, 502 and 503]
	4.10	PCCP permeability	12.25	Test	KT-73: Determinations of percent volume of permeable voids in hardened concrete	[CM Part V 5.9.73 - SPECS 401, 403, 502 and 503]
	4.11	PCCP vibrator frequency	11.83	Inspection	KDOT standard specification 154.2e requirements for vibrators for rigid pavement	[SPECS 154.2e]
	4.12	Unit weight of PCCP individual aggregate – lightweight aggregates only	9.50	Test	KT-05: Determining the unit weight of fine, coarse, or mixed aggregates. The method is applicable to aggregates not exceeding 1 ½ in. (37.5 mm) in nominal maximum size.	[SPECS 501 & 503]
Flexible Pavement (HMA)	5.1	Sieve analysis of HMA individual aggregate	5.1	Test	KT-05: Determining the unit weight of fine, coarse, or mixed aggregates. The method is applicable to aggregates not exceeding 1 ½ in. (37.5 mm) in nominal maximum size.	[SPECS 501 & 503]
	5.2	Compaction of asphalt pavement layer	8.1	Inspection	Inspector checks compaction of asphalt pavement layer with considering the required tests	[SPECS 600]
	5.3	HMA sampling and storage for testing	9.8	Test	KT-26: Sampling asphalt, cutback, and emulsifier materials, at the point of production and at destination	[CM Part V 5.9.26- SPECS 604]
	5.4	Percentage of crushed particles in HMA crushed gravel (coarse aggregate angularity)	3.7	Test	KT-31: Determining the percent, by mass, of particles, which by visual inspection, exhibit characteristics of crushed aggregate	[CM Part V 5.9.31 - SPECS 603, 611, 1103 & 15-06001]

Table 5.2: KDOT Risk-Based Inspection Protocol (Continued)

Element	ID	Activity	CI	Type	Acceptance Procedures	References
Flexible Pavement (HMA)	5.5	Uncompacted void content of HMA fine aggregate	3.7	Test	KT-50: Determination of the uncompacted void content of a sample of HMA aggregate based on a given gradation. Measure of aggregate angularity, sphericity, and texture.	[CM Part V 5.9.35 - SPECS 603, 611, 1103 & 15-06001]
	5.6	Sieve analysis for HMA aggregate of mineral filler supplement	7.7	Test	KT-02: Determination of the particle size distribution of HMA aggregate of mineral filler supplement using standard sieves	[CM Part V 5.9.02 - SPECS 603, 611, 1103 & 15-06001]
	5.7	Plasticity of HMA mineral filler supplement	7.6	Test	KT-10: Determining the liquid limit, plastic limit, and plastic index of HMA mineral filler supplement	[CM Part V 5.9.10 - SPECS 603, 611, 1103 & 15-06001]
	5.8	Sieve analysis of HMA combined aggregate	7.4	Test	KT-02: Determination of the particle size distribution of HMA combined aggregate	[CM Part V 5.9.02 - SPECS 603, 611, 1103 & 15-06001]
	5.9	Coarse aggregate angularity for combined aggregate - HMA	7.4	Test	KT-31: Determining the percent, by mass, of particles, which by visual inspection, exhibit characteristics of crushed aggregate	[SPECS 602, 603, 611 & 1103]
	5.10	Sand equivalent of HMA combined aggregate	11.0	Test	KT-55: Determining the relative proportions of fine dust or claylike material in minus no. 4 (4.75 mm) HMA combined aggregates.	[CM Part V 5.9.10 - SPECS 603, 611, 1103 & 15-06001]
	5.11	Moisture content of HMA combined aggregate	10.6	Test	KT-11: Determination of the moisture content of HMA combined aggregate	[CM Part V 5.9.11 - SPECS 603, 611, 1103 & 15-06001]
	5.12	Density of HMA mixtures (field lab)	15.9	Test	KT-14: testing bituminous mixes to determine optimum asphalt content, density characteristics, and stability characteristics	[CM Part V 5.9.14 - SPECS 603, 611, 1103 & 15-06001]
	5.13	Voids of HMA mixtures (field lab)	4.5	Test	KT-14: testing bituminous mixes to determine optimum asphalt content, density characteristics, and stability characteristics	[CM Part V 5.9.14 - SPECS 603, 611, 1103 & 15-06001]
	5.14	Moisture content of HMA mixtures (field lab)	14.4	Test	KT-11: Determination of the moisture content of HMA mixtures in field lab	[CM Part V 5.9.11 - SPECS 603, 611, 1103 & 15-06001]
	5.15	HMA asphalt binder sampling for testing at plant	12.9	Test	KT-26: Sampling asphalt, cutback, and emulsifier materials, at the point of production and at destination	[CM Part V 5.9.26 - SPECS 603, 611, 1103 & 15-06001]
	5.16	Density of HMA mixtures (district lab)	6.9	Test	KT-14: testing bituminous mixes to determine optimum asphalt content, density characteristics, and stability characteristics	[CM Part V 5.9.14 - SPECS 603, 611, 1103 & 15-06001]
	5.17	Gradation of HMA mixtures (district lab)	7.6	Test	KT-34: Determination of the particle size distribution of aggregate extracted from asphalt mixtures	[CM Part V 5.9.34 - SPECS 603, 611, 1103 & 15-06001]
	5.18	Asphalt content of HMA mixtures (district lab)	12.1	Test	KT-57: Determination of asphalt content of hot mix paving mixtures by ignition of the asphalt cement at 932°f (500°c) in a furnace	[CM Part V 5.9.57 - SPECS 603, 611, 1103 & 15-06001]
	5.19	Maximum specific gravity of uncompacted plant mix asphalt (field lab)	9.0	Test	KT-39: Determination of the theoretical maximum specific gravity of uncompacted asphalt paving mixtures	[CM Part V 5.9.39 - SPECS 603, 611, 1103 & 15-06001]
	5.20	Moisture content of uncompacted plant mix asphalt (field lab)	10.5	Test	KT-11: Determination of the moisture content of soil and aggregate	[CM Part V 5.9.11 - SPECS 603, 611, 1103 & 15-06001]

Table 5.2: KDOT Risk-Based Inspection Protocol (Continued)

Element	ID	Activity	CI	Type	Acceptance Procedures	References
Flexible Pavement (HMA)	5.21	Air voids of plant mix asphalt (District lab)	13.6	Test	KT-15 and KT-58: the compaction of cylindrical specimens of hot mix asphalt (HMA) using the super pave gyratory compactor	[CM Part V 5.9.15 - SPECS 603, 611, 1103 & 15-06001]
	5.22	Maximum specific gravity of uncompacted plant mix asphalt (District lab)	9.0	Test	KT-39: Determination of the theoretical maximum specific gravity of uncompacted asphalt paving mixtures	[CM Part V 5.9.39 - SPECS 603, 611, 1103 & 15-06001]
	5.23	Gradation of plant mix asphalt (District lab)	12.1	Test	KT-34: Determination of the particle size distribution of aggregate extracted from asphalt mixtures	[CM Part V 5.9.34 - SPECS 603, 611, 1103 & 15-06001]
	5.24	Asphalt content of plant mix asphalt (District lab)	13.5	Test	KT-57: Determination of asphalt content of hot mix paving mixtures by ignition of the asphalt cement at 932°f (500°c) in a furnace	[CM Part V 5.9.57 - SPECS 603, 611, 1103 & 15-06001]
	5.25	Field density (cores or nuclear) of completed HMA road work	6.9	Test	KT-15: Determining the bulk specific gravity of specimens of compacted asphalt mixtures	[CM Part V 5.9.15 - SPECS 603, 611, 1103 & 15-06001]
	5.26	Voids in mineral aggregate (VMA) - HMA	12.8	Test	KT-15 & KT-6: Determining the specific gravity and absorption of aggregates	[SPECS 602]
	5.27	Mix gradation - HMA	13.0	Test	Testing mix gradation at field lab	[SPECS 602]
	5.28	Binder content- HMA	12.1	Test	KT-57: conduct the tests for binder content on representative portions of the HMA, quartered from the larger sample of HMA	[SPECS 602]
	5.29	Theoretical maximum specific gravity of asphalt paving mixtures-HMA (field lab)	6.9	Test	KT-39: Determination of the theoretical maximum specific gravity of uncompacted asphalt paving mixtures	[CM Part V 5.9.39 - SPECS 602]
	5.30	Voids filled with asphalt (VFA)-HMA	10.5	Test	KT-15, KT-39, and KT-58	[SPECS 602]
	5.31	Voids in mineral aggregate (VMA) - HMA	11.0	Test	KT-15 & KT-6: Determining the specific gravity and absorption of aggregates	[SPECS 602]
	5.32	Dust to effective binder content (d/b) ratio - HMA	9.0	Test	Examining dust to effective binder content (D/B) ratio in HMA	[SPECS 602]
	5.33	HMA construction joints control	11.1	Inspection	Inspector review making and checking transverse and longitudinal joints, an acceptable surface texture and meet density requirements, apply a light coat of asphalt emulsion or asphalt binder if needed. Before placing the fresh HMA against a cut joint, spray or paint the contact surface with a coat or asphalt binder	[SPECS 602]

5.5 Summary

This chapter presented the risk assessment results of 108 core activities associated with five divisions: Earthworks; Subgrade, Base, and Shoulders; Concrete (Bridge Deck); Rigid Pavement (PCCP); and Flexible Pavement (HMA). The results were based on input from 16 KDOT and FHWA experts. However, the experts only rated the risk of inspection activities based on their personal expertise. The risk impact of each activity was then evaluated based on the CI value. Specifically, the risk impacts of 108 activities were categorized into four main risk zones: (1) the critical risk zone with the CI value ranging from "22" to "25"; (2) the high-risk zone with the CI value ranging from "15" to "21"; (3) the moderate-risk zone with the CI value ranging from "6" to "14"; and (4) the low-risk zone with the CI value ranging from "1" to "5." Finally, the chapter presents a KDOT risk-based inspection protocol.

Chapter 6: Conclusions and Recommendations

6.1 Summary

Material QA for highway construction is essential to meet the objectives of state DOTs and the FHWA. Traditionally, DOTs have based quality standards of materials on detailed descriptions of required materials and construction methods. Acceptance has been determined based on pass/fail standards or engineering experience and judgment. However, DOTs are facing an increasing gap between the demand for inspection and available resources. Many state DOTs, including KDOT, have lost experienced construction inspection staff while the numbers of projects and required levels of inspection have increased. To address these challenges, DOTs often rely on contractors' QC and outsource to a third party for testing and inspection. This strategy, however, is not always a cost-effective approach.

This study proposed a risk-based protocol for KDOT to optimize resource allocation for the inspection of transportation construction projects. To develop the risk-based protocol, a comprehensive list of 302 testing and inspection activities were retrieved from KDOT's *Construction Manual*, construction checklists, *Standard Specifications*, QA guides, and *Bridge Construction Manual*. Four levels of hierarchical structure (Divisions, Sections, QA Activities, and Acceptance Methods) were used to connect each inspection activity with relevant KDOT documents. Appendix B describes all 302 inspection activities. Based on survey responses and interviews with KDOT and FWHA experts, the comprehensive list was reduced to a core list of 108 activities. These core inspection activities were classified based on five divisions: Earthwork; Subgrade, Base, and Shoulders; Concrete (Bridge Deck); Rigid Pavement (PCCP); and Flexible Pavement (HMA).

Risk assessment and analysis was conducted to identify the risk impacts of inspection not meeting the requirements (e.g., missed/reduced inspection). The risk of each core inspection activity was assessed and evaluated using two factors: (1) the probability of an inspection not meeting requirements, and (2) the consequence of an inspection not meeting requirements. The consequence of an inspection not meeting requirements was evaluated according to cost, safety, and service interruption. Probability and consequences of each core inspection activity were rated based on the five-point scale: (1) Very Low; (2) Low; (3) Moderate; (4) High; and (5) Very High.

A composite risk index was developed to assess the overall risk impact and prioritization of the 108 core inspection activities. There are four risk zones (critical, high, moderate, and low) depending on the CI values ranging from "1" to "25." The critical risk zone has the CI value from "22" to "25." The high-risk zone has the CI value from "15" to "21." The moderate-risk zone has the CI value from "6" to "14." Finally, the low-risk zone has the CI value from "1" to "5."

Based on the composite risk index, a KDOT risk-based inspection protocol was proposed. Results showed that the greater the risk impacts due to missed/reduced inspection, the higher its priority for inspection. Consequently, with budget constraints and increased public scrutiny, a risk-based prioritization approach may help KDOT efficiently allocate limited inspection resources, such as distributing available resources to the most critical inspection items/construction activities. Furthermore, because all inspection items are categorized after the construction process is complete, field engineers know what and when to inspect. The proposed risk-based inspection protocol is timely for KDOT due to the need to resolve inspection workforce reductions, limited inspection resources, and QC/QA risk optimization and materials costs for highway construction projects throughout the United States.

6.2 Findings and Recommendations

State DOTs have begun to consider risks and their impacts on QA practices. Many current risk-based inspection approaches (Appendix A) aim to evaluate material testing and workmanship inspection based on criticality, the results of which can beneficially increase construction quality and lead to lower life cycle costs. The findings of this study are intended to enhance the inspection of construction projects by utilizing reduced inspection resources within KDOT. The key findings are summarized as follows:

- The proposed risk-based inspection protocol includes 108 core activities (Table 5.2). Specifically, there are seven activities in the Earthwork Division; 47 activities in the Subgrade, Base, and Shoulders Division; nine activities in the Concrete (Bridge Deck); 12 activities in the Rigid Pavement (PCCP); and 33 activities in the Flexible Pavement (HMA). Each activity is aligned with the risk score (i.e., the CI value), types of inspection, acceptance procedures, and reference documents (i.e., KDOT *Construction Manual* or *Standard Specifications*).

- KDOT's *Construction Manual* specifies the sample size, sampling process, testing methods, and acceptance criteria for construction materials, while KDOT's *Standard Specifications* includes requirements for materials and construction operations. However, both documents do not provide explicit information on the frequency, methods of construction inspections, or inspection priorities.
- KDOT's *Standard Specifications* and *Construction Manual* can be used to connect risk-prioritized inspection activities to create a dynamic inspection form that can be standardized within KDOT's project management system.
- Examination of the practices of seven state DOTs revealed two categories of construction inspection and various acceptance methods (Appendix A). Material inspection often includes project-produced materials, fabricated materials, and standard manufactured materials. Acceptance methods of material inspection typically include sampling and testing (e.g., field statistical tests and central lab verification), material certification (e.g., manufactured products from certified suppliers and certified sources of supply), and visual inspection (e.g., shop inspection and visual field inspection). Construction-process inspections typically include visual field examination and compliance with project specifications and plans (e.g., check dimensions and levels).
- The 108 core activities in the risk-based inspection protocol are heavily focused on material inspection. The suggestion is to include more inspection activities related to construction operation and processes.
- The proposed risk-based inspection protocol was developed based on a programmatic or top-down approach that helps KDOT prioritize various construction inspection activities based on the composite risk index value. However, the proposed protocol did not consider the effects of specific

project characteristics and work attributes. Therefore, a bottom-up approach should be developed to allow the project-level team or project manager to apply the risk ratings and prioritization to a project-specific items list (i.e., project type and size or complexity, experience of available DOT inspection staff, project delivery method, and third-party coordination issues) that could reduce the level of inspection resources needed to ensure project success.

- Knowledge loss is primarily attributed to the transfer from seasoned inspectors to new inspectors, especially when experienced QA staff members retire. Therefore, utilization of e-construction technologies could improve construction inspection processes and reduce inspection resources and effort. These technologies help fill the gap between the increased numbers of highway construction projects and decreasing inspection resources.

Based on the findings, the recommendations are as follows:

- Use the risk-based inspection protocol to guide allocation of inspection staff.
- Employ the proposed risk assessment approach to evaluate the risks of other construction inspection activities beyond the scope of this project.
- Develop inspection forms and checklists to assist KDOT inspection staff when using risk-based approaches.
- Develop a digital risk-based inspection system by considering potential efficiencies using evolving technologies and e-inspection practices.

References

23 CFR 637 (2011). *Construction inspection and approval*.

American Petroleum Institute (API). (2016). *API Recommended Practice 580, Risk-Based Inspection*. Washington, DC: Author.

Andersen, G. R., Chouinard, L. E., Hover, W. H., & Cox, C. W. (2001). Risk indexing tool to assist in prioritizing improvements to embankment dam inventories. *Journal of Geotechnical and Geoenvironmental Engineering*, *127*(4), 325–334.

Ashley, D. B., Diekmann, J. E., & Molenaar, K. R. (2006). Guide to risk assessment and allocation for highway construction management (Report No. FHWA-PL-06-032). Washington, DC: Federal Highway Administration.

Bai, Y., & Bai, Q. (2014). *Subsea pipeline integrity and risk management* (1st ed.). Houston, TX: Gulf Professional Publishing.

Baker, T. E., Molohon, R. J., & McIntyre, R. W. (2010). *Materials risk analysis* (Report No. WA-RD 745.1). Olympia, WA: Washington State Department of Transportation.

California Department of Transportation (Caltrans). (2015). *Construction quality assurance program manual*. Sacramento, CA: Author.

Federal Highway Administration (FHWA). (2009). *Quality assurance stewardship review summary report for fiscal years 2003 through 2008*. Washington, DC: Author.

Federal Highway Administration (FHWA). (2012). *Construction quality assurance for design-build highway projects* (Report No. FHWA-HRT-12-039). Washington, DC: Author.

Federal Highway Administration (FHWA). (2017). Engineering inspection of highway and street construction on federal-aid projects (Technical Advisory T 5080.1). Retrieved from https://www.fhwa.dot.gov/construction/t508001.cfm

Kamsu-Foguem, B. (2016). Information structuring and risk-based inspection for the marine oil pipelines. *Applied Ocean Research*, *56*, 132–142.

Kansas Department of Transportation (KDOT). (n.d.). *Bridge construction manual*. Retrieved from https://www.ksdot.org/bureaus/burStructGeotech/constructionmanual/bcm.asp

Kansas Department of Transportation (KDOT). (2014). *Construction manual, Parts I–IV*. Retrieved from https://www.ksdot.org/burconsmain/Connections/ConstManual/index.asp

Kansas Department of Transportation (KDOT). (2015). *Standard specifications for state road and bridge construction*. Retrieved from https://www.ksdot.org/burconsmain/specprov/specifications.asp

Kansas Department of Transportation (KDOT). (2018). *Construction manual, Part V*. Retrieved from https://www.ksdot.org/burconsmain/Connections/ConstManual/index.asp

Montgomery, D. C., & Runger, G. C. (2010). *Applied statistics and probability for engineers* (5th ed.). Hoboken, NJ: John Wiley & Sons.

Mostafavi, A., & Abraham, D. M. (2012). *INDOT construction inspection priorities* (Report No. FHWA/IN/JTRP-2012/09). https://doi.org/10.5703/1288284314669

National Cooperative Highway Research Program (NCHRP). (2010). *Guidebook on risk analysis tools and management practices to control transportation project costs* (NCHRP Report 658). Washington, DC: Transportation Research Board.

National Cooperative Highway Research Program (NCHRP). (2014). *Proposed guideline for reliability-based bridge inspection practices* (NCHRP Report 782). https://doi.org/10.17226/22277

National Cooperative Highway Research Program (NCHRP). (2017). *Guidelines for optimizing the risk and cost of materials QA programs* (NCHRP Report 838). https://doi.org/10.17226/23691

Patel, R. J. (2005, November). *Risk based inspection*. Paper presented at the 3rd Middle East Nondestructive Testing Conference & Exhibition, Manama, Bahrain.

Ross, S. M. (2014). *Introduction to probability and statistics for engineers and scientists* (5th ed.). San Diego, CA: Academic Press.

Soares, W. A., de Vasconcelos, V., & Rabello, E. G. (2015). *Risk-based inspection in the context of nuclear power plants*. Paper presented at the 2015 International Nuclear Atlantic Conference, São Paulo, Brazil.

South Dakota Department of Transportation (SDDOT). (2013). *Required samples, tests, and certificates*.

Texas Department of Transportation (TxDOT). (2011). *Design-build quality assurance program implementation guide*. Retrieved from https://www.txdot.gov/business/resources/materials.html

Texas Department of Transportation (TxDOT). (2017). *Material inspection guide*. Retrieved from https://www.txdot.gov/business/resources/materials.html

United States Department of Energy (U.S. DOE). (2011). *Risk management guidance*. Washington, DC: U.S. DOE Office of Management.

Virginia Department of Transportation (VDOT). (2012). *Minimum requirements for quality assurance and quality control on design build and public-private transportation act projects*. Retrieved from https://www.virginiadot.org/business/design-build.asp

Wight, R., Alvarado, A., Chaput, M., Clayton, D., Garcia, R. R., Hoyne, D., Lewis, J., Lutz, R. A., & Smith, R. (2017). *Developing and maintaining construction inspection competence* (NCHRP Project 20 68A). Washington, DC: Transportation Research Board.

Appendix A: Key State-of-Practice of Risk-Based Inspection

A.1 California DOT

Various divisions within the California DOT (Caltrans) are attempting to incorporate risk-based decision-making into their business processes. For example, the Caltrans Division of Construction has developed a risk-based approach that assigns four tiers to construction materials based on their criticality (Caltrans, 2015). Table A.1 summarizes these tiers and their consequences of failure. Tier 1 items have the greatest consequence of failure (catastrophic), Tier 2 includes safety-related failure for employees or the public, Tier 3 items cause an interruption in service or environmental impact, and Tier 4 items have the least consequence (e.g., minimal impact).

Table A.1: Tier Levels Based on Consequence of Failure

Tier	Failure Category	Consequence of Failure	Example Items
1	Catastrophic	Greatest consequence of failure. Failure is likely to cause loss of life or serious injury.	Structural steel, precast girders, and prestressing
2	Safety	Failure creates a safety hazard for employees or the public.	Delineation, safety barriers, lighting, signal controllers
3	Interrupt Service	Failure or repair may cause an interruption in service, or environmental impact.	Pavements, bases, embankment, storm water pollution prevention plan-best management practice devices
4	Monetary	Monetary loss only – consequence of failure is considered minimal in terms of project performance.	Grass seed, drainage and irrigation products, fencing

Source: Caltrans (2015)

The appropriate level of inspection, sampling, and testing resources are assigned to each contract item based on the item's consequence of failure. Caltrans uses the four tier levels to determine the type and level of QA requirements for each item. Table A.2 shows Caltrans' standard specification sections with tier levels.

Table A.2: Specification Sections with Associated Tier Levels

Specification Section	Specification 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	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	X	X	
53	Shotcrete			X	X
53-2	Structural Shotcrete	X			
54	Waterproofing				X
55	Steel Structures	X	X		X
56	Signs		X		
56	Overhead Sign Structures	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	

Source: Caltrans (2015)

Table A.2: Specification Sections with Associated Tier Levels (Continued)

Specification Section	Specification Section Description	Tier 1	Tier 2	Tier 3	Tier 4
67	Structural Plate Culverts		X	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

Source: Caltrans (2015)

Caltrans uses a qualitative risk-based decision framework to accept fabricated materials (NCHRP, 2017). The main benefit of risk-based acceptance is the minimization of errors due to the reduction of material variances or of testing and sampling (Caltrans, 2015). The approach also deploys inspectors through a risk-based decision process to ensure that the QA effort is scaled correctly. If the acceptance plan risks are acceptable and the specifications adequately produce the desired performance, sampling frequencies should be reduced. If the risks are unacceptable, however, the quality verification plan should be re-assessed, and increased sampling frequencies should be considered to reduce the risk (Caltrans, 2015).

Figure A1.1 illustrates a qualitative risk-based assessment matrix of material and workmanship associated with consequences of material failures and project types (NCHRP, 2017). The risk score determines the level of QA efforts ranging from low (programmatic) to high (continuous inspection). The low level may not include a shop inspection, while the high level includes shop inspection or a full-time plant inspector (NCHRP, 2017).

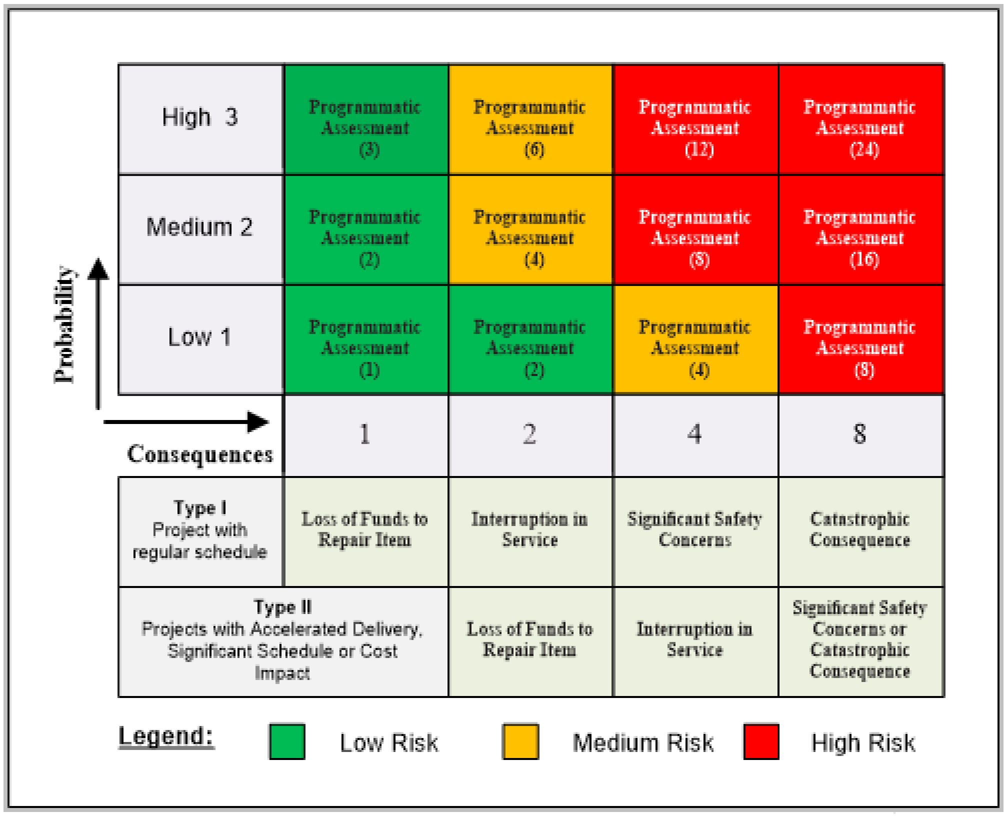

Figure A.1: Risk-Based Inspection Matrix
Source: NCHRP (2017)

A.2 Florida DOT

The Florida DOT (FDOT) utilizes a decentralized structure of eight districts. The FDOT headquarters (central office) is responsible for general policy and QA procedures, while the districts are responsible for materials QA on projects. For materials that are under control from the production facility, FDOT may reduce the sampling and testing frequency (NCHRP, 2017). For example, the frequency of inspections of structural concrete, excavation, and embankment materials decreases by 50% when 12 or more QC tests are within tolerance because the perceived risk is low due to reliable contractor QC performance. However, inspection criticality is much higher for pre-stressed beams, piles, steel beams, or similar safety-critical structural elements. In general, FDOT uses safety-related criteria to differentiate between more- and less-critical materials. Sampling and testing frequencies also increase or decrease based on materials criticality. Table A.3 shows examples of reduced QA testing in FDOT.

Table A.3: Reduced QA Strategies

Material	Possible Optimization Strategies
Section 346, Concrete	50% reduction in sampling frequencies (i.e., doubled lot size) when produced for the same mix design and production facility and where average strength results for 10 consecutive tests meet the strength criteria
Section 347, Non-structural concrete (i.e., sidewalk, curb, gutters)	Acceptance by certification on the delivery ticket, with discretionary sampling and testing to verify quality
Section 120, Excavation and embankment density Section 125, Excavation for structures and pipe density Section 200, Rock base density Sections 327/330, Pavement cross slope measurements Section 410, Precast box culvert absorption tests Section 462, Tendon post-tensioning Section 560, Structural steel soluble salt/conductivity tests	50% reduction in the required sampling and testing frequency when materials are shown to be under control
Section 334, Hot mix asphalt (Type FC and SP mixtures) that are less than 2,000 tons for an entire project	FDOT Engineer can accept the asphalt mix on the basis of visual inspection, and may require the Contractor to run QC tests and run independent verification tests at its discretion

Source: NCHRP (2017)

FDOT also uses alternative contracting methods to adopt other QA strategies for projects. For design-build (DB) contracts, the contractor is responsible for QC and FDOT inspectors are responsible for QA. For public-private partnership (P3) projects, the developer is responsible for verification, and FDOT conducts the risk-based auditing. In general, FDOT implements various inspection strategies to reduce inspection frequency and determine material criticality and element structural safety. However, FDOT does not use explicit risk-based QA inspection for its projects.

A.3 Indiana DOT

In 2011, Purdue University conducted a study to evaluate the current inspection practices of the Indiana DOT (INDOT). The Purdue research team surveyed 101 experts from INDOT, other state DOTs, and consultants. Results showed that inspection practices vary. Table A.4 shows the inspection practices of state DOTs and consultants associated with construction activities. In the table, the denotation “I” represents INDOT inspection practices, “D” represents inspection practices from other state DOTs, and “C” represents inspection practices from consultants.

Table A.4: Inspection Practices by INDOT

Construction Activity	Activity	Activity	Activity	Activity	Activity
Traffic control-set up	IC	ICD			C
Clearing site		C	ICD	ID	D
Stripping	C	I	ICD	ID	D
Clearing site-bridge	C	IC	ICD	ID	I
Installing soil erosion/sediment control items	C	ICD	I		
Excavation		IC	ICD	D	
Blasting	ICD	ICD	C		
Handling /removal of regulated waste	IC	ICD			
Aggregate base courses	IC	ICD			
Embankment	IC	ICD	D		
Milling		ICD	ICD	CD	D
Asphalt paving	ICD	ID			
Concrete paving	ICD	ID			
Concrete forms (structures)		IC	ID	D	D
Reinforcement steel in structures	C	ICD		D	
Placement of concrete in structures	ICD	D			
Structure rehabilitation (repairs to concrete deck)	ICD	ICD			
Drilled shafts	C	ID			
Driven piles	ICD	ID			
Sheet piles	IC	ICD	D		
Cofferdams	C	ICD	I		
Beam erection	IC	ID			
Bolting structural connections	IC	ICD			
Post-tensioning (pre-stressed structures)	IC	ID			
Painting steel		ICD	ICD	D	
Guardrail/cable rail		ICD	ICD	D	
Barrier curb	I	ICD	ICD		
Sidewalk		IC	ICD	D	
Drainage	C	ICD	ID		

Table A.4: Inspection Practices by INDOT (Continued)

Construction Activity	Activity	Activity	Activity	Activity	Activity
Traffic stripes/traffic markings	IC	ICD	IC		D
Fence			ICD	ICD	D
Electrical conduit and wiring		ICD	ICD	D	
ITS—fiber optic conduit and cable		ICD	ICD	D	
Highway lighting (foundations and poles)		ICD	ID		
Traffic signals (foundations and poles)		ICD	ID		
Overhead sign structures	I	ICD	ID		
Landscape plantings			ICD	ID	ID
Pipe placement	IC	ICD			
Seal coating	I	ICD	ICD		
Sound wall post placement	C	ICD	ICD		
Sound wall panel placement		ICD	ICD		
Placement of lighting features		IC	ICD	D	
Sub-grade treatment	IC	ICD	D		
Retaining walls	IC	ICD			

The study also prioritized construction activities as high, medium-high, medium, medium-low, and low levels. The higher the priority of an activity for inspection, the greater the risk impacts due to reduced inspection (Mostafavi & Abraham, 2012). Table A.5 summarizes the list of prioritized construction activities for inspection.

Mostafavi and Abraham (2012) found that the following inspection activities are critical:

- Activities related to buried work, such as rebar installation and pipe placement;
- Activities requiring testing, such as aggregate base course and asphalt paving;
- Activities involving safety provisions, such as structure rehabilitation; and
- Activities with high-cost items, such as pile driving.

Table A.6 shows a portion of INDOT's protocol for the inspection of construction activities. For example, site clearing, which is a low-priority activity, requires only random inspection, while concrete forms, which is a medium-priority activity, requires frequent inspection. High-priority activities such as aggregate base course require constant inspection based on the specification (e.g., number of compactor passes, depth of each lift, or documentation processes).

Table A.5: INDOT Inspection Priority Level

High Priority	Medium-High Priority	Medium Priority	Medium-Low Priority	Low Priority
• Aggregate base courses • Asphalt paving • Bolting structural connections • Concrete paving • Driven piles • Embankment • Placement of concrete in structures • Post-tensioning (pre-stressed structures) • Reinforcement steel in structures • Retaining walls • Structure rehabilitation (repair concrete deck)	• Beam erection • Pipe placement • Sub-grade treatment • Drilled shafts • Guardrail • Overhead sign structure • Painting steel • Traffic marking	• Barrier curb • Blasting • Concrete forms (structures) • Drainage • Excavation • Handling/removal of regulated waste • Highway Lighting • Installing soil erosion/sediment control items • Sound wall panel placement • Sound wall post placement • Traffic control—set up • Traffic signals	• Cofferdam • Electrical conduit and wiring • Fence • ITS—fiber optic conduit and cable • Landscape plantings • Milling • Placement of lighting features • Seal coating • Sheet piles • Sidewalk	• Clearing site • Clearing site—bridge • Stripping

Source: Mostafavi and Abraham (2012)

Table A.6: INDOT's Protocol for Inspection of Construction Activities

Construction Activity	Priority	Macro-Consequences Due to Missed/Reduced Inspection	Critical Items to be Watched	Frequency of Inspection
Traffic control—setup	Medium	Decreased safety	Type of signs Location of signs Correct placement and installation	Frequently Frequently Frequently
Clearing site	Low	—	Areas to and not be cleared Clearing obstructions Removal to adequate depth Identify wet spots	Randomly Randomly Randomly Randomly
Stripping	Low	—	Removal of topsoil Stay within removal depth limits Correct removal area	Randomly Randomly Randomly
Clearing site—bridge	Low	—	Stay within removal depth limits Correct removal area Keep sufficient topsoil for finishing slopes	Randomly Randomly Randomly
Installing soil erosion/ sediment control items	Medium	Functional failure	Correct item Correct location Proper installation	Randomly Frequently Frequently
Excavation	Medium	Decreased safety, functional failures	Log and calculate areas excavated Depth of excavation Safety of operation Elevation Proper undercut Test material for placement in other locations Verifying hauling of waste to proper sites	Frequently Frequently Frequently Randomly Frequently Frequently Frequently
Blasting	Medium	Decreased safety, functional failures	Safety of operation Lay out and spacing of holes Measure and documentation	Frequently Randomly Frequently
Handling/removal of regulated waste	Medium	Decreased safety, increased user costs	Proper handling according to regulations Complete removal Safety	Frequently Frequently Frequently
Aggregate base courses	High	Functional failures, increased maintenance costs, decreased design life	Moisture and density control Compactor passes Depth of each lift Documentation Obtain tickets for materials (depending on payment method)	Frequently Constantly Constantly Constantly Frequently

Source: Mostafavi and Abraham (2012)

A.4 South Dakota DOT

The South Dakota DOT (SDDOT) requires acceptance sampling and testing at a construction site to be performed by qualified technicians from the Area Engineer, who will direct the activities of the assigned personnel (SDDOT, 2013). In addition, SDDOT notes that sampling and testing should be supplemented by visual inspection and observation of construction operations and processes to ascertain the appropriate sample size for testing and producing consistent, satisfactory results.

According to SDDOT, a failed acceptance sample or test produces results outside of the specification (SDDOT, 2013). Because certain materials used in highway construction present higher risks if failure occurs, SDDOT uses certification processes, specifically an Approved Products List, to determine the risk levels of materials. Certification is the process by which a contractor, manufacturer, or supplier certifies or guarantees that certain products, materials, or items conform to specifications. The Central Testing Laboratory prepares, revises, maintains, and distributes the Approved Products List; items or brand-name products on this list must maintain a history of satisfactory results from acceptance tests and plant inspections and tests, specification compliance, and field performance. SDDOT uses three tiers to rank materials based on criticality:

- **Tier 1** – Critical Materials: Tier 1 materials are crucial to safety or costly to replace. SDDOT allows contractors to install a Tier 1 material only if they furnish certification documents from the materials manual and the citification engineer verifies that the certified material conforms to specifications.
- **Tier 2** – Normal Materials: SDDOT allows contractors to install Tier 2 materials only if contractors furnish certification documents from the materials manual or the contractors use a material listed on the Approved Products List by a certified supplier.
- **Tier 3** – Noncritical Materials: Tier 3 materials require no certification documents from the materials manual. A contractor may install Tier 3 materials on a project at any time.

A.5 Texas DOT

The Texas DOT (TxDOT) has implemented two types of acceptance procedures for its QA program. The first type, a traditional approach, uses acceptance testing and inspection, performed by TxDOT, in which the acceptance decision is only based on TxDOT testing and inspection results. The second type utilizes contractor-performed acceptance in which QC testing and inspection activities are used for acceptance (TxDOT, 2011). This type of acceptance adopts explicit use of risk management principles.

Figure A1.2 illustrates the TxDOT QA program, which requires contractors to submit a Construction Quality Management Plan (CQMP). The acceptance program involves QA from a construction QA firm and owner verification (e.g., TxDOT districts). For materials accepted on the basis of sampling and testing, the analysis of material properties determines how much owner verification testing should be performed to validate contractor test results.

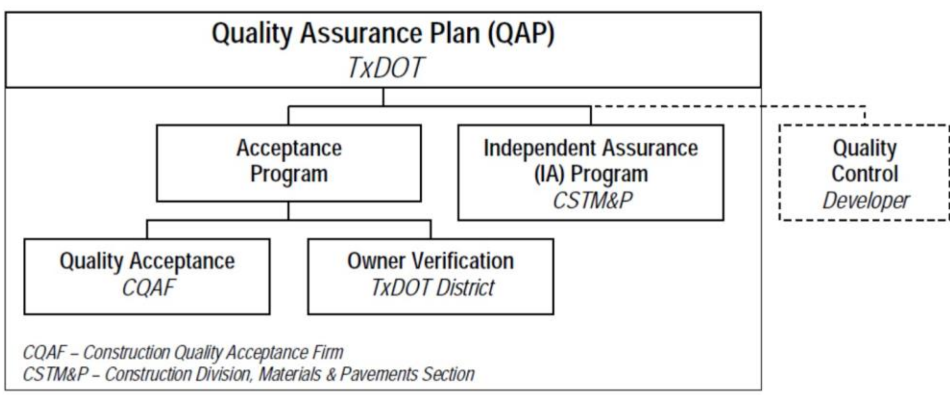

Figure A.2: Components of the TxDOT QA Program
Source: TxDOT (2011)

TxDOT applies three tiers of owner-verification testing for specific materials and properties based on perceived residual risk after construction is complete.

- **Level 1** testing analyzes parameters that are strong indicators of performance (e.g., compressive strength for structural concrete and percent soil compaction).
- **Level 2** testing analyzes parameters that are secondary measures of performance (e.g., concrete slump test).

- **Level 3** includes observation verification for materials whose risk of failure does not affect long-term performance of the facility or materials that require minimum QA tests for compliance.

Table A.7 shows TxDOT analysis categories for owner verification in three levels. The TxDOT Material Inspection Guide also provides detailed procedures for sampling, testing, and inspecting procedures and instructions for specific roadway materials (TxDOT, 2017).

As part of TxDOT's commitment to FHWA, the project team conducts a materials-specific risk workshop to discuss quality risks of identified materials and identify other potential material quality risks. The project team evaluates the appropriate information in preparation for the materials quality risk workshop, and this information is distributed to workshop participants with an agenda prior to the workshop so that participants can discuss the impacts and risks associated with usage of each material (TxDOT, 2011).

Table A.7: Example of TxDOT Analysis Categories for Owner Verification

MATERIAL/PRODUCT	TEST FOR	TEST NO.	TxDOT Acceptance
EMBANKMENT (CUTS & FILLS)	Liquid Limit	Tex-104-E	2
	Plasticity Index	Tex-106-E	1
	Linear Shrinkage	Tex-107-E	2
	Gradation	Tex-110-E	2
	Moisture/Density	Tex-114-E	3
	In-Place Density	Tex-115-E	1
RETAINING WALL (NON-SELECT BACKFILL)	Liquid Limit	Tex-104-E	2
	Plasticity Index	Tex-106-E	1
	Linear Shrinkage	Tex-107-E	2
	Gradation	Tex-110-E	2
	Moisture/Density	Tex-114-E	3
	In-Place Density	Tex-115-E	1
RETAINING WALL (SELECT BACK FILL)	Gradation	Tex-110-E	2
	Resistivity	Tex-129-E	2
	pH	Tex-128-E	2
	Soundness	Tex-411-A	3
	In-Place Density	Tex-115-E	1

Source: TxDOT (2011)

A.6 Virginia DOT (VDOT)

QA procedures and required testing procedures for various materials are described in a notebook for the Virginia DOT (VDOT). Although VDOT provides for certified products, or materials accepted by a manufacturer's certification, the QA procedures vary by project. VDOT also requires projects to be delivered via alternative project delivery methods. For example, the VDOT manual *Minimum Requirements for Quality Assurance and Quality Control on Design Build and Public-Private Transportation Act Projects* (VDOT, 2012) requires the construction QA team to be distinct and separate from the construction production forces staff.

To optimize the required number of inspection resources, VDOT typically reduces the frequency of testing for small quantities and large volumes of project-produced materials and identifies producer or supplier qualifications. As shown in Table A.8, VDOT implements three phases of inspection: (1) preparatory inspections and testing; (2) intermediate inspection and testing; and (3) completion inspection and testing.

Table A.8: Example of VDOT Phases of Inspection

No.	Item of Work	Preparatory Inspection	Intermediate Inspections	Completion Inspection
1.	Clearing and Grubbing (C&G) VDOT Section 301	Design-Builder's QA Manager to schedule and conduct preparatory inspection meeting (hold point) to review work prior to beginning construction activity on feature of Work.	Monitor that the QAM is confining effort to C&G activities and to areas so designated for C&G within the plans and scheduled within the next 30 days. Areas not worked within 30-day period should be temporarily seeded.	Physical field inspection performed with final payment
		Verify approval of design documents for locations of work to be performed.	For testing and inspection of clearing and grubbing refer to frequencies specified in Table 105.4, Part 2 and/or VDOT Construction and/or Materials Manual of Inspection.	OVST Final document review.
		The Quality Assurance (QAM IA & VST) and Quality Control (QC) requirements as specified in the Design-Builder's QA/QC Plan		
		Identify items of work and the frequency of OIA and OVST		
2.	Excavation and Backfill of Structures VDOT Contract Special Provisions & Section 303/304/401	Design-Builder's QA Manager to schedule and conduct preparatory inspection meeting (hold point) to review work prior to beginning construction activity on feature of Work.	Verify by observation or review of the QAM's records, that each foundation has been probed or tested and has been accepted by the QAM. Frequency - On key structures identified by the VDOT Project Manager	Review TL-124(s), to verify that the appropriate frequency of testing was performed during the operation.
		QAM to verify work related design documents have been approved.	Verify that proper lift depths and density tests are being performed as required. Review the completed TL-124(s) to verify that the appropriate frequency of testing was performed.	Physical field inspection performed with final payment.
		Verify the Quality Assurance (QAM IA & VST) and Quality Control (QC) requirements as specified in the Design-Builder's QA/QC Plan	QC one per 100 lf or 150 cy, QAM IA one per 1,500 cy, QAM VST one per 1,500 cy	

Source: VDOT (2012)

Based on interviews with VDOT representatives, researchers found that VDOT has established a tiered, or risk-based, approach to QA oversight for locally let, federally funded projects (NCHRP, 2017). Although primary QA responsibility has been delegated to local staff, VDOT must still perform some oversight to satisfy its stewardship role. Table A.9 shows three levels of oversight (high, moderate, and low) based on the criticalities of project elements. VDOT typically conducts random site visits or QA audits for less-critical projects and frequent site inspections and/or verification testing for more-critical projects.

Table A.9: VDOT Non-compliance Risk Oversight Levels

Oversight Level	Probability	Impact/Probability
High (H)	High probability of non-compliance	Significant impact on infrastructure due to non-compliance Significant effects to quality of construction, cost, and schedule
Moderate (M)	Moderate probability of non-compliance	Moderate impact on infrastructure due to non-compliance Moderate effects to quality of construction, cost, and schedule
Low (L)	Low probability of non-compliance	Low impact on infrastructure due to non-compliance Low effects to quality of construction, cost, and schedule

Source: NCHRP (2017)

A.7 Washington State DOT

In the Material Risk Analysis report published in 2010, the Washington State DOT (WSDOT) examines two main components of risk when accepting construction materials: (1) the likelihood of a material failing to meet specifications, and (2) the consequences of that material failing to meet specifications (Baker, Molohon, & McIntyre, 2010). Every common construction material is rated based on those two components, and the combined ratings are used to preliminarily determine where the material should fall on the materials assurance continuum. The highest level of materials assurance involves (Baker et al., 2010). Ideally, these two main components of materials risks can be evaluated based on tracking performances and life cycle costs from management systems. However, such data is lacking. WSDOT stated that "management systems with sufficient data collection and analysis to determine life cycle performance are expensive to create and even more expensive to operate and populate" (Baker et al., 2010). In fact, tracking life cycle costs and utilizing intensive database management systems for materials of lesser value (e.g., curbs and sidewalks) are not practical (Baker et al., 2010).

To formally evaluate the risk of materials (failure to meet specifications and the consequences of those failures), WSDOT employed a two-step approach. In the first step, WSDOT established a conceptual ranking of QA acceptance based on the following four levels of materials examination:

- **Level 1** includes WSDOT acceptance testing or a combination of fabrication inspection and a requirement for a manufacturer's quality system plan (e.g., structural steel).
- **Level 2** requires a manufacturer's certification of compliance with a quality system plan (e.g., soil nails, structural earth walls, ground anchors, and guardrail).
- **Level 3** requires either a manufacturer's certification of compliance or a catalog cut stating the qualities of the material used (e.g., fencing, compost, soil amendments, and other non-structural items that do not require testing or certification).
- **Level 4** requires visual inspection in the field to verify the correct product is used.

These four material levels are used to determine the quality of any material by combining QA acceptance levels and material risk assessment (likelihood and consequence of failure). Figure A1.3 shows the rankings of these acceptance methods from most intense with the highest level of assurance to the lowest level.

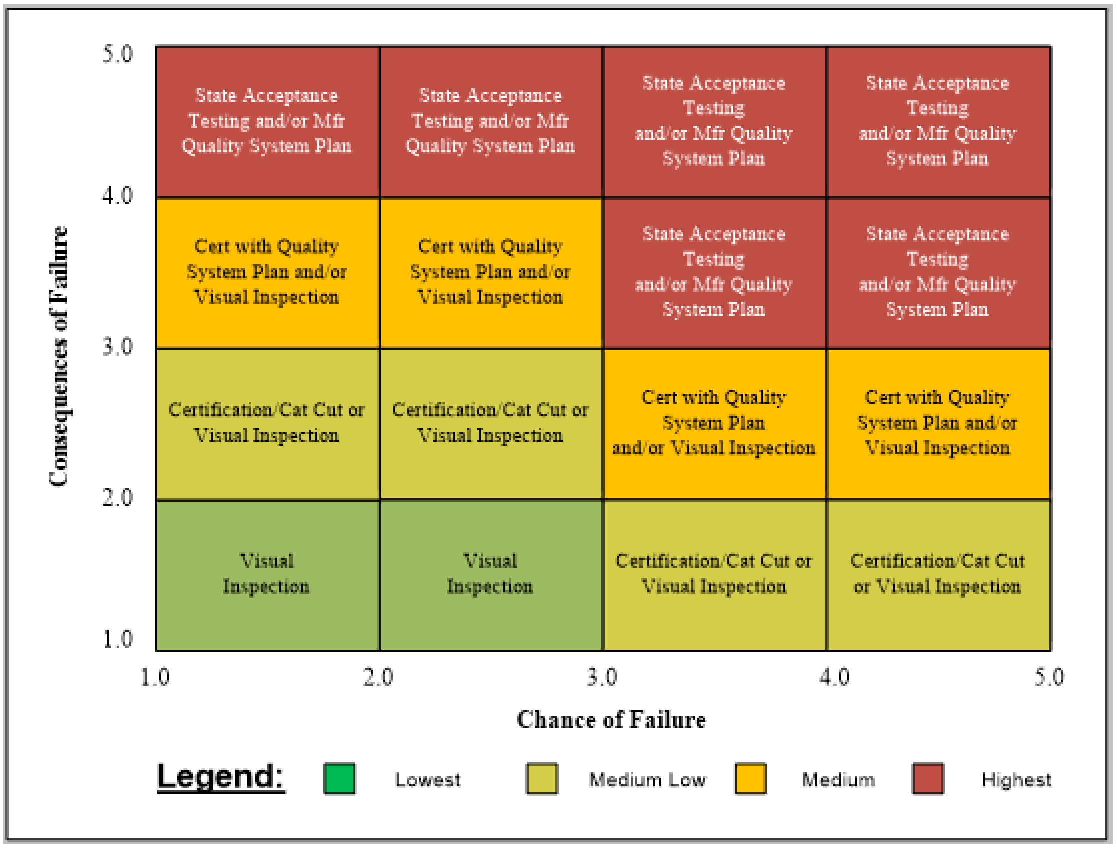

Figure A.3: WSDOT Materials Acceptance Rating Matrix by WSDOT
Source: NCHRP (2017)

The second step in the risk evaluation of materials assigns risk ratings for all materials in the WSDOT program. Due to a lack of data on the actual performance and life cycle costs of materials, WSDOT uses the Delphi technique to evaluate material risk. Baker et al. (2010) performed two rounds of surveys with a variety of experts to evaluate risks associated with construction materials. Figure A1.4 summarizes the results of the materials risk assessment by presenting numbers of materials by acceptance category before and after the risk assessment. The numbers of materials in the two highest acceptance levels (Level 1 and Level 2) decreased, while low-risk materials with low-acceptance methods (Level 3 and Level 4) increased.

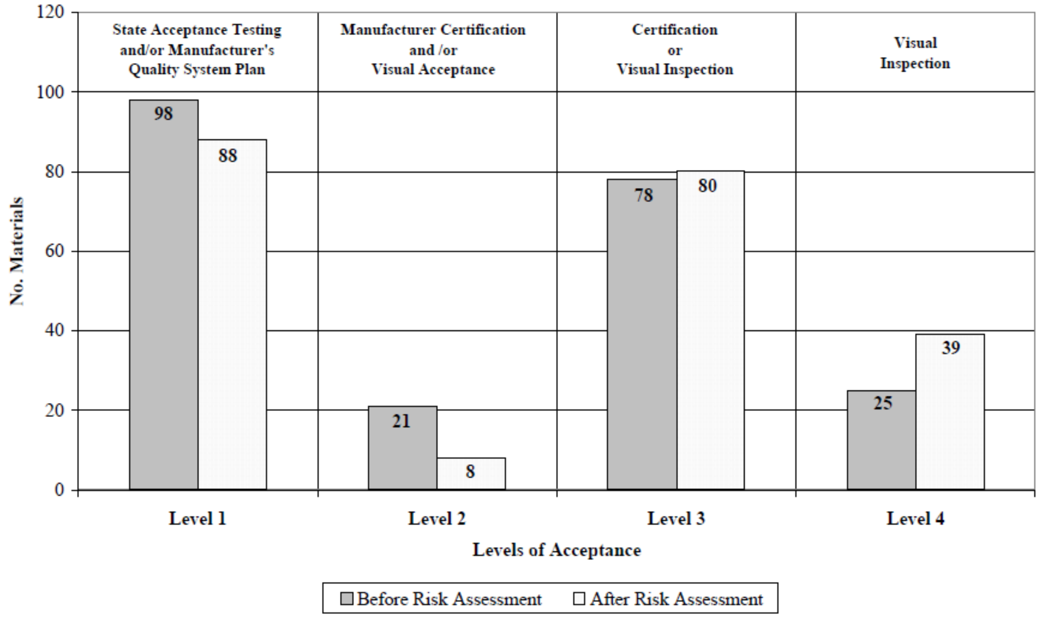

Figure A.4: WSDOT Material Risk Assessment
Source: Baker et al. (2010)

In summary, WSDOT rates common construction materials for risk in two categories (chance of failure and consequence of failure), and the acceptance criteria for each material is matched to the level of risk. Based on the materials risk analysis, WSDOT implemented a rational system for testing some materials, inspecting the fabrication of some materials, accepting manufacturers' certification of compliance on others, or visually inspecting other materials (Baker et al., 2010). WSDOT typically spends 40%–50% of the department's QA costs for pavements and/or structures (NCHRP, 2017).

Appendix B: Comprehensive List of Inspection Items

Construction Division	Section*	CN*	Activity	Acceptance	
				Method*	Procedures
Division 100 - General Clauses and Covenants	SPECS 106.4, 602.2	1	Approval for personnel who should meet part v QC testing procedures	C, O	Documents review and approval
	SPECS 106.4, 602.2	2	Approval of testing facilities	C	Engineer approves testing facilities and laboratories
	SPECS 802.3	3	Land surveyor approval	O	Contractor provides a land surveyor, trained, experienced, and licensed by the Kansas state board of technical professions
	SPECS 106.1	4	Concrete source(s) approval	O	Contractor provides concrete source for approval
	CM- part III 3.25.01 & 4.01	5	As built (record) plans review	O	Review as built plans and compare with related activities onsite
	CM- part IV 3.25.01 & 4.01 SPECS 105.10	6	Working drawing plans approval	O	Review working drawing plans and compare with design drawings and specifications
	CM- part IV 3.25.01 & 4.01 SPECS 105.10	7	Design plans review	O	Review design and check any conflict between drawings and the other contract documents
	CM- part IV 4.01	8	Examine the standard specifications and special provisions prior to construction	O	Review the standard specifications, special provisions, any project special provisions, exploratory work documents, addenda, etc.
	CM - part IV- 4.01.11 - SPECS 805	9	Verify that adequate traffic control devices are used	I	Verify these devices on site and at their proposed locations, are used in conformance with the traffic control plan and the contract documents
	CM - part IV- 4.01.03	10	Check construction limits	I	Check the project location before any work is done; make sure the construction limits are properly defined. With attendance of the contractor’s superintendent
	CM - part IV- 4.01.05	11	Check the status of utilities relocation - preconstruction	I	Check the status of utilities to make sure all utilities have been properly relocated.
	SPECS 105.9	12	Subcontractors approval	O	Based on the contract requirements, general contractor submits to the engineer subcontractor approval forms to obtain approval for subletting part of the contract including lower-tier subletting
	SPECS 106.2	13	Obtain engineer's approval to use the project right-of-way	O	Contractor should obtain the engineer’s approval to use the project right-of-way, other KDOT right-of-way, or other KDOT property (mixing strips) for plant sites, stockpiles, and haul roads.
	SPECS 802.3	14	Written report of all right-of-way survey monuments set	O	Before the completion of project construction, the contractor provides the engineer with a written report of all right-of-way survey monuments set
	SPECS 803.3 & 803.4	15	Field offices and laboratory approval	O	Approval of field offices and laboratory location by engineer
	SPECS 828	16	Fence and gates installation	I	Check construction of the designated type of fence and gates as shown in the contract documents, length, height, and materials preapproval

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Division 100 - General Clauses and Covenants	SPECS 901	17	SWPPP joint inspections (storm water pollution prevention plan)	I	The inspector and the contractor's environmental inspector perform a joint inspection of the temporary erosion and pollution control devices every 14 days during normal work hours and within 24 hours of a rainfall event of ½ inch or more. Continue inspections at this frequency until all physical work is complete and the engineer issues the notice of acceptance or a partial notice of acceptance
	CM part IV - 4.01.11 SPECS 104.16	18	Approval for traffic control devices	C, O	Verify that the submitted traffic control devices in conformance with the traffic control plan and the contract documents
	SPECS 106.4	19	Obtain engineer's approval for testing facility location on site	O	Before beginning mixture production, contractor should obtain the engineer's approval of the testing facility, including the facility's location and the testing equipment
	SPECS 107.2	20	Obtain KDHE 401 certification for working in waterway	C	If the contractor's method of operation requires placing material in a waterway, obtain both a corps' section 404 permit and a KDHE 401 certification (applicable when water flow exceeds 5 cubic feet/second).
	CM part IV - 4.01.06	21	Check if the project includes an environmental packet -preconstruction	O	Check to see if the project includes an environmental packet. There may be unusual wildlife habitats, restrictions on timing of construction activities and water pollution controls.
	CM part III - 3.05.01	22	Check all benchmark elevations before level works	I	Check all benchmark elevations before any other level work is started, compare adjacent benchmarks, and document the level prior to running benchmarks.
	SPECS 905	23	Placing of mulching materials	I	Engineer approves mulching material, check placing and punching mulching materials as shown in drawings
Division 150 - Equipment	SPECS 152.2	24	Weighing equipment testing and certifying	C	Use and maintain weighing devices (mechanical or electronic) at locations approved by the engineer. Have the weighing devices tested and certified by a licensed service company
	SPECS 152.1b	25	Coating the bed of HMA hauling equipment	I	The engineer must approve the coating material before it is used
	SPECS 151	26	Compaction equipment approval	O	Verify rollers requirements in SPECS 151
	SPECS 152.1c	27	Calibrate water tank hauling and distribution equipment	O	Use pneumatic-tired water equipment. Calibrated tanks of 1000 gallon capacity or larger. Equipped with spray bars and pressure pumps. Equip water tanks with control valves that are operated from the driver's seat. Provide the engineer with the means to verify the calibration of the water tanks.
	SPECS 154.1	28	Concrete mixtures approval	O	Verify the requirements in SPECS 154.1 items B, C, D, or E
	SPECS 155.2	29	Calibration and check of asphalt distributer	I	Verify the requirements in SPECS 155.2 items B and A
	SPECS 155.6	30	HMA plant approval	O	Verify the requirements in SPECS 155.5 items A, B, or C
	SPECS 153.1	31	Verify calibration of central mixing plant for stabilized base and shoulders	C	Contractor provides the engineer with the means to verify the calibration of the plant

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Division 150 - Equipment	SPECS 153.2	32	Verify calibration of traveling mixing plant for stabilized base and shoulders	C	Contractor provides the engineer with the means to verify the calibration of the plant
	SPECS 153	33	Calibrate stationary mixing plant for stabilized base and shoulders	C	Provide the engineer with the means to verify the calibration of the plant
		34	Testing equipment calibration	C	Calibrating shakers and sieves, nuclear gages, profilegraph, thermometers
	SPECS 151.3	35	Check the tire pressure of compaction pneumatic-tired rollers	I	The contractor provides the engineer with a suitable gauge to check the tire pressure of pneumatic-tired rollers
	SPECS 152.1c	36	Calibration of the tanks of water hauling and distributing equipment	C	Contractor provides the engineer with the means to verify the calibration of the water tanks
	SPECS 154.9	37	Approval of concrete sawing equipment	I	Check the use of standard manufacture concrete sawing equipment. Other sawing devices are based on acceptable performance, and with the approval of the Engineer
	SPECS 155	38	Certificate of approval to the asphalt distributor operator	C	Keep this certificate in the distributor at all times and make it available to the engineer in charge on each project on which the distributor is used indicating the record of the calibration and check.
	SPECS 156.3	39	Check roadside improvement equipment	I	The engineer will check the machine on a slab or hard ground with the power take-off running to determine if enough roots are being fed through the machine.
Division 200 - Earthwork Compaction	SPECS 201 & CM part IV 4.02.01	40	Clearing site and grubbing	I	Random verification of clearing and grubbing of vegetation and debris, backfilling stump holes, and stripping, stockpile the existing topsoil, clearing obstructions, and identify wet spots. Verify adherence to work limits, and compliance with planned/required protection/restoration.
	CM part IV 3.04.03	41	Check alignment	I	Check the angles and the distances as shown on the plans, orientate the project to the correct land ties
	CM part III 3.04.01	42	Check grade elevations - preconstruction	I	Check all grade elevations on the plan-profile sheets before any grade stakes or slope stakes are set and make grade computations with considering percentage of shrinkage. The inspector responsible for inspecting the grading operations should become familiar with the staking procedures that will be used on the project, observing the drainage of the adjacent lands.
	CM part IV 4.02.13	43	Check finish grading	I	Before finish grading begins, point out any corrections and/or clean-up work that needs to be done, confirm that slope stakes are in place and legible so that slopes and grades can be checked. Confirm that the subgrade is being trimmed to the elevation of the stakes and make random checks on the bluetop stakes themselves to verify that they were placed accurately and have not been disturbed. Record all grading works.
	CM part III 3.06.02	44	Check the plans and record cross-section stations	O	Before going into the field to take original cross-sections, the construction engineer/manager and construction staff shall check over the plans thoroughly and record all the plus stations at which it will be necessary to take original cross-sections due to the design of the improvement. A study of the plans will reveal a number of points at which it will be necessary to take final cross-sections.

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Division 200 - Earthwork Compaction	CM part IV 4.02.02 & SPECS 202	45	Check removal of existing structures	I	Check removal of structures identified and non-identified on plans that are in conflict with the new construction. Excluded are utilities and structures for which other provisions are made for removal
	SPECS 202.2	46	Check backfill material after removal of existing structure	I	The engineer will accept the backfill material based on visual inspection
	SPECS 203	47	Check resetting of existing culverts	I	Examine the removed structures without damaging, and then check their resetting at the locations shown in the contract plans.
	SPECS 205 & CM part IV 4.02.10	48	Excavation works dimensions and grades	I	Confirm obtaining permits if required before beginning. Check the ditch sections and roadway slopes as they are being excavated to the required grade, width and slope, the drainage outlets before constructing the ditches to confirm the direction of flow, rock in the roadbed is properly subgraded, and disposal of any unsuitable material.
	SPECS 804.3	49	Haul roads approval	O	The contractor provides the engineer with a written description of the designated haul roads. The description shall include, materials being delivered, materials hauled to the project site and return routes from the project site. The engineer will notify the owners of the roads (city and county) of the contractor’s designations.
	SPECS 205.4	50	Check materials and equipment storages locations	I	Where such storage is necessary, contractor obtains the engineer’s written approval and include in the project SWPPP appropriate best management practices for the storage area.
	SPECS 205.4	51	Approval before wasting surplus excavation material	I	Contractor obtains the engineer’s approval before wasting surplus excavation material
	SPECS 205 & CM part IV 4.02.11	52	Blasting during rock excavation	I	Check safety of operation frequently, lay out and spacing of holes randomly, and measure and documentation process
	SPECS 205 & CM part IV 4.02.04	53	embankment layers approval	I, O	In addition to required tests, check roller and compaction equipment approval, verify appropriate temporary erosion and pollution control devices are installed, confirm approval of proceeding layer before placing the succeeding layer, measure embankment area constantly, and lifts height and width
	SPECS 206	54	Placement of select soil on the finished slopes	I	Confirm use the topsoil designated in the contract documents, non-usage of topsoil containing toxic matter, soil is on the finished slopes at the locations shown in the contract documents
	SPECS 211	55	Installation of geofoam lightweight embankment fill	I	In addition to material approval, examine construction of the geofoam-fill in successive layers of blocks with the block’s long axis alternating by 90° and offsetting blocks by half their widths to prevent the continuation of joints within the polystyrene mass, connecting the polystyrene blocks with gripper plates, placing gripper plates between horizontal layers of geofoam, placement in the locations designated in the contract documents

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Division 200 - Earthwork Compaction	SPECS 213	56	Placement of prefabricated vertical drain	I	Verify approval of prefabricated vertical drain contractor, approval of 3 test prefabricated vertical drains before drains installation. Confirm drains installation from the working surface to the depth and location shown in the contract documents
	CM- part V 5.2.1 & SPECS 1107	57	Sampling aggregates of backfill for MSE wall	T	KT-1: Sampling of course and fine aggregates for quality tests and for inspection and testing of aggregates being produced for construction
	SPECS 214	58	Installation of mechanically stabilized earth fill (MSE)	I	In addition to system and materials approval, check removal of any existed material before construction, foundation and each layer compaction, check the plumpness and tolerances of each facing row prior to erection of the next facing row, the overall vertical and horizontal alignment, and connectors placement
	CM - part V 5.9.13, 5.9.51 & SPECS 204, 205, 208	59	Field density for compacted earth works	T	KT-13 or KT-51: Measuring the density of compacted soil
	CM - part V 5.9.13, 5.9.51 & SPECS 204, 205, 208	60	Field density of compacted backfilling works	T	KT-13 or KT-51: Measuring the density of soil backfilling around a structure
	CM - part V 5.9.51 & SPECS 204, 205 & 208	61	Moisture content of earthwork	T	Determining the moisture content in accordance with KT-11
	CM - Part V 5.9.51 & SPECS 204, 205, 208	62	Moisture content for structure backfilling	T	Determining the moisture content in accordance with KT-11
	SPECS 209	63	Field density of foundation of MSE walls	T	KT-13 or KT-51: Measuring the density of compacted soil (foundation and retained soil)
	SPECS 214	64	Field density of mechanically stabilized earth fill	T	KT-13 or KT-51: Measuring the density of compacted soil
	SPECS 215	65	Check placement and compaction of granular drainage blanket	I	Check dimensions and locations according to contract documents
	CM part IV 4.01.18	66	Compaction of earthwork pre-work checklist review	I	Throughout the project, the compaction of earthwork checklist should be utilized as a guideline before earthwork compaction operations.
Division 300 - Subgrade Modification, Base and Shoulders	CM- Part V 5.2.7.8 & SPECS 106.4, 602.2	67	Cement treated base (CTB) quality control plan approval	O	Documents review and approval for cement treated base (CTB) quality control plan
	SPECS 301, 1110 & 1112	68	Sieve analysis of aggregate for subgrade	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves.
	SPECS 303.3	69	Check the application rate of cement or fly ash (CTB)	I	The engineer will check the application rate of cement or fly ash by having the contractor blade a flat area in the path of the cement or fly ash application, place a planar surface with a minimum surface area of 1 square foot (e.g., A straight-sided pan) and of sufficient height to contain the admixture on the prepared area and allow the train to pass over the surface. Weigh the test surface before and after the cement or fly ash application and calculate the application rate. Other methods to check the application rate may be used

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Division 300 - Subgrade Modification, Base and Shoulders	SPECS 301& CM part IV 4.04.03 & 4.06.06	70	Check subgrade preparation for the base or sub-base	I	Checklist: check subgrade for crown grade, alignment and surface (lime treated, cement or fly ash, or crushed stone) for the different type bases or sub-bases.
	CM- part IV 4.04.03	71	Check subgrade for crown grade and alignment	I	Regardless of the procedure used in preparing the subgrade, the inspector should carefully check the subgrade at frequent intervals for crown grade and alignment.
	CM part IV 4.06.06	72	Subgrade final check for conformance before sub-base	I	Checklist: check for grade, cross-section and drainage before sub-base placement
	CM Part V 5.9.03	73	Material passing the no. 200 (75 µm) sieve by the wash method for subgrade aggregate	T	KT-03: Determining the quantity of material finer than the no. 200 (75µm) sieve in aggregate by the wash method.
	SPECS 305 & CM part IV 4.04.09	74	Verify preparation of sub-base before PCCP	I	Checklist: visually verify compaction of the aggregate base, trimming the surface to the specified lines and grades.
	SPECS 305 & CM part IV 4.04.09	75	Verify the final preparation of base course before HMA	I	Checklist: visually verify compaction and trimming the surface to the specified lines and grades.
	SPECS 305 & CM part IV 4.04.11	76	Check aggregate shoulders construction	I	Checklist: shaping the shoulders to provide a uniform shoulder line, completing entrances and side roads with the same surface as the adjoining roadway. And according to contract plans
	CM Part V 5.9.07	77	Percentage of clay lumps and friable particles in the aggregates of subgrade	T	KT-07: Determining the percentage of clay lumps and friable particles in aggregate.
	CM Part V 5.9.08	78	Percentage of shale or shale-like materials in aggregate of subgrade	T	KT-08: determine the percentage of shale, mudstone, clay stone or other materials which would exhibit the properties of shale upon weathering
	CM Part V 5.9.10 - SPECS 301, 1110 & 1112	79	Plasticity of aggregate of subgrade	T	KT-10: Determining the liquid limit, plastic limit and plastic index of soils and the minus no. 40 (425 µm) portions of aggregates.
	CM Part V 5.9.35 - SPECS 301, 1110 & 1112	80	Sticks in aggregate of subgrade	T	KT-35: Determining the percentage of sticks and similar material (leaves, bark, etc.) In aggregate.
	SPECS 301, 305 & 1702	81	Sample of calcium chloride for subgrade modification or aggregate base	C, T	Receipt and approval of a type D certification as SPECS 2600
	CM Part V 5.9.11 - SPECS 302, 2000 & 2400	82	Moisture content for lime treated subgrade	T	KT-11: Determination of the moisture content of soil
	CM Part V 5.9.42 - SPECS 302, 2000 & 2400	83	Sieve analysis for acceptance of lime treated subgrade	T	KT-42: Determining the amount of material retained on the 2, 1 ½ in. and the no. 4 sieves for lime treated soils

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Division 300 - Subgrade Modification, Base and Shoulders	CM Part V 5.9.62 - SPECS 302, 2000 & 2400	84	Percent solids of lime slurry in lime treated subgrade	T	KT-62: Determining the amount of solids, by percent, contained in lime slurry.
	CM Part V 5.9.13 - SPECS 302, 2000 & 2400	85	Field density of lime treated subgrade	T	KT-13: Measuring the in-place density of soils
	CM Part V 5.9.29 - SPECS 302, 1103, 2002 & 2003	86	Sample of subgrade hydrated lime and pebble quicklime	T	KT-29: Sampling Portland cement, lime and fly ash in the field
	CM Part V 5.9.42 - SPECS 303, 2000, & 2400	87	Sieve analysis for acceptance of fly ash or cement treated subgrade	T	KT-42: Determining the amount of material retained on the 1 ½ in. and the ½ in. sieves for cement treated soils
	CM Part V 5.9.13 - SPECS 303, 2000, & 2400	88	Field density of cement or fly ash treated subgrade	T	KT-13 or KT-51: Measuring the in-place density of soils and granular base courses
	Cm Part V 5.9.29 - SPECS 303, 604, & 2005	89	sample of stabilization and cold recycle fly ash	T	KT-29: Sampling Portland cement, lime and fly ash in the field
	CM Part V 5.9.41 - SPECS 304, 1100, & 2400	90	Field density of crushed stone subgrade	T	KT-41: Determining density in Portland cement treated bases, aggregate bases and aggregate shoulders
	CM Part V 5.9.69 - SPECS 304, 1100, & 2400	91	Relative density of crushed stone subgrade	T	KT-69: Determination of the maximum–index dry density/unit weight of soil using a vertically vibrating table
	CM Part V 5.9.02 - SPECS 304, 1107, & 1115	92	Sieve analysis for aggregate crushed stone of backfill	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves
	CM Part V 4.04.05	93	Check base courses and sub-bases materials dumping	I	The inspector should make sure that each load is dumped in the distance allotted, and that no overlapping of the distance allotted to each load is permitted. Tables showing the length of spread for each weight or volume of load shall be calculated ahead of time for use during hauling operations.
	CM Part V 5.9.02 - SPECS 305 & 1104	94	Sieve analysis for aggregate of base course	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves
	CM Part V 5.9.02 - SPECS 305 & 1104	95	Sieve analysis for aggregate of binder material of base course	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves
	CM Part V 5.9.10 - SPECS 305 & 1104	96	Plasticity for aggregate of binder material of base course	T	KT-10: Determining the liquid limit, plastic limit and plastic index of soils and the minus no. 40 (425 μm) portions of aggregates.
	CM Part V 5.9.02 - SPECS 305 & 1104	97	Sieve analysis for combined aggregate of base course	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves

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Division 300 - Subgrade Modification, Base and Shoulders	CM Part V 5.9.10 - SPECS 305 and 1104	98	Plasticity of combined aggregate of base course	T	KT-10: Determining the liquid limit, plastic limit and plastic index of the minus no. 40 (425 μm) portions of aggregates.
	CM Part V 5.9.11 - SPECS 305 & 1104	99	Moisture test for combined aggregate of base course	T	KT-11: Determination of the moisture content of aggregate.
	CM Part V 5.9.13 - SPECS 305 & 1104	100	Field density of completed aggregate base course	T	KT-13: Measuring the in-place density of granular base courses
	CM Part V 5.9.02 - SPECS 305 & 1113	101	Sieve analysis for individual aggregate of shoulders (non HMA)	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves
	CM Part V 5.9.10 - SPECS 305 & 1113	102	Plasticity of individual aggregate of shoulders (non HMA)	T	KT-10: Determining the liquid limit, plastic limit and plastic index of the minus no. 40 (425 μm) portions of aggregates.
	CM Part V 5.9.02 - SPECS 305 & 1113	103	Sieve analysis for aggregate of binder material of shoulders (non HMA)	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves
	Cm Part V 5.9.10 - SPECS 305 & 1113	104	plasticity of binder material of aggregate shoulders (non HMA)	T	KT-10: Determining the liquid limit, plastic limit and plastic index.
	CM Part V 5.9.02 - SPECS 305 & 1113	105	sieve analysis for combined aggregate of shoulders (non HMA)	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves
	CM Part V 5.9.10 - SPECS 305 & 1113	106	Plasticity of combined aggregate of shoulders (non HMA)	T	KT-10: Determining the liquid limit, plastic limit and plastic index.
	CM Part V 5.9.11 - SPECS 305 & 1113	107	Moisture of combined aggregate of shoulders (non HMA)	T	KT-11: Determination of the moisture content of aggregate.
	CM Part V 5.9.13 - SPECS 305 & 1113	108	Field density of completed aggregate shoulders (non HMA)	T	KT-13: Measuring the in-place density of aggregate shoulders
	CM Part V 5.9.11 - SPECS 305 & 1113	109	Moisture of completed aggregate shoulders (non HMA)	T	KT-11: Determination of the moisture content of completed aggregate shoulders.
	-	110	Approval for surface drainage materials	C	Submitting of drainage system elements for approval
	-	111	Surface drainage system installation	I	Check installation of longitudinal underdrain pipes, transverse pipes, outlet protectors, and other end sections according to the plans
	CM Part V 5.9.02 - SPECS 306 & 1105	112	Sieve analysis for aggregate of cement treated base (CTB)	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves
	CM Part V 5.9.11 - SPECS 306 & 1105	113	Moisture of cement treated base (CTB)	T	KT-11 or KT-41: Determination of the moisture content of completed aggregate shoulders.
	CM Part V 5.9.11 - SPECS 306 & 1105	114	Density of cement treated base (CTB)	T	KT 37 or KT 20: Determining the mass per cubic foot.
	SPECS 306 & 1105	115	Compressive strength of cement treated base (CTB)	T	KT 37 or KT 20: Determining the compressive strength.
	CM Part V 5.9.11 - SPECS 306 & 1105	116	Field density of completed cement treated base (CTB)	T	KT-13 or KT-41: Measuring the in-place density of completed CTB

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Division 300 - Subgrade Modification, Base and Shoulders	CM Part V 5.9.11 - SPECS 306 & 1105	117	Moisture of completed cement treated base (CTB)	T	KT-11 or KT-41: Determination of the moisture content of completed CTB
	CM Part V 5.9.02 - SPECS 307 & 1106	118	Sieve analysis for aggregate of granular base	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves
	CM Part V 5.9.10 - SPECS 307 & 1106	119	Plasticity of aggregate of granular base	T	KT-10: Determining the liquid limit, plastic limit and plastic index of the minus no. 40 (425 μm) portions of aggregates.
	CM Part V 5.9.02 - SPECS 307 & 1106	120	Sieve analysis for aggregate of binder material of granular base	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves
	CM Part V 5.9.10 - SPECS 307 & 1106	121	Plasticity of binder material of granular base	T	KT-10: Determining the liquid limit, plastic limit and plastic index.
	CM Part V 5.9.02 - SPECS 307 & 1106	122	Sieve analysis for pulverized aggregate of granular base	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves
	CM Part V 5.9.02 - SPECS 307 & 1106	123	Sieve analysis for combined aggregate of granular base	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves
	CM Part V 5.9.10 - SPECS 307 & 1106	124	Plasticity of combined aggregate of granular base	T	KT-10: Determining the liquid limit, plastic limit and plastic index.
	CM Part V 5.9.11 - SPECS 307 & 1106	125	Moisture of combined aggregate of granular base	T	KT-11: Determination of the moisture content of combined aggregate.
	CM Part V 5.9.13 - SPECS 307 & 1106	126	Field density of completed granular base	T	KT-13 or KT-41: Measuring the in-place density of completed granular base
	CM Part V 5.9.13 - SPECS 307 & 1106	127	Moisture of completed granular base	T	KT-11: Determination of the moisture content of granular base.
	CM part IV 4.04	128	Aggregate base course dimensions and compactor passes	I	Check the depth of each lift and compactor passes
	SPECS 830.3	129	Approval of slope protection and underlying geotextile	C	Check construction of the slope protection with materials and to the lines and grades shown in the contract documents. Contractor provides the engineer with a copy of the manufacturer's recommendation installs and secures the geotextile fabric as recommended by the manufacturer.
Division 400 - Concrete (Bridge Deck)	CM- Part V 5.2.7.4 & v 5.2.7.6 - SPECS 106.4	130	Concrete (bridge deck) quality control plan approval	O	Documents review and approval for concrete (bridge deck) quality control plan, include detailing the procedures and monitoring of bridge deck construction within the specifications
	SPECS 402.2 & 717.2 & 729.2 & 739.2	131	Bridge deck concrete materials approval	C, O	Contractor provides materials that comply with the applicable requirements. Including aggregate, admixtures, and plasticizers, cement, fly ash, silica fume, slag cement and blended supplemental, cementitious, and water. For overlays use supplemental cementitious materials at allowable substitution rates as listed in table 401-2. For polymer concrete or slurry polymer concrete, contractor submits polymer, epoxy, polyester, methyl methacrylate materials for approval.

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Division 400 - Concrete (Bridge Deck)	SPECS 717 & 729 & 739	132	Overlay concrete placing and anchoring the rails - bridge deck	I	Contractor provides method of anchoring and supporting the rails and the concrete placing procedure for approval by the engineer. For polymer concrete or slurry polymer concrete overlay placing, see SPECS 729 d and 739 d.
	SPECS 717 & 729 & 739	133	Preparation of surface for concrete overlay - bridge deck	I	Prior to placement of concrete, engineer check sand or shot blasting of the surface followed by an air blast to the bottom 3 inches, and edges against which concrete is to be placed to remove all dirt, oil, pavement marking and other foreign material, as well as any unsound concrete, laitance and curing material from the surface. Wet sand blasting may be used only with approval of the engineer.
	BCM 8.5.3	134	Bridge deck concrete placement and consolidation	I	Consolidation of the concrete by uniformly vibrating the concrete
	BCM 8.5.7 SPECS 710 & 717	135	Bridge deck surface finish	I	Check finishing all top surfaces, striking off bridge decks with a self-propelled finishing machine. Correction of surface variations exceeding ⅛ inch in 10 feet by use of an approved profiling device, or other method approved by the engineer.
	SPECS 729.3 b & 739.3 b	136	Polymer concrete overlay equipment check - bridge deck	I, C, O	Equipment is subject to approval of the engineer and must comply with these requirements in SPECS 729.3 b & 739.3 b
	BCM 8.6.2	137	Application of loads - bridge deck	I	Check the maximum bridge deck loading limits during curing process and according to table 710-2 of BCM.
	BCM 8.4.4	138	Waterproofing works for bridge deck	I	Check acceptance of waterproofing materials, check location, length, overlap of waterproofing layers
	BCM 8.4.6 - SPECS 710	139	Bridge deck curing and protection	I	Engineer checks: covering concrete surfaces according to spec - Table 710-1. checking wet burlap, liquid membrane-forming compound, white polyethylene sheeting, or other impermeable materials are placed on concrete surfaces shortly after initial set.
	BCM 8.5.8 - SPECS 710 & 717 h	140	Construction joints installation	I	Check installation of construction joints based on plans, and specifications.
	BCM 8.5.8 - SPECS 719	141	Expansion joints installation	I	Check installation of expansion joints based on locations in plans, and specifications.
	-	142	Concrete sampling and storage for testing- bridge deck	O	Taking the required number of samples and keeping these samples at the designated storage area based on contract requirements and the standards
	CM Part V 5.9.21 - SPECS 401, 402, 703, 710 & 717	143	Slump of concrete - bridge deck	T	KT-21: Determining the slump of freshly mixed concrete.
	CM Part V 5.9.21 - SPECS 401.3	144	Concrete mix design(s) approval- bridge deck	O	Design the concrete mixes specified in the contract documents
	CM Part V 5.9.29 - SPECS 2001, 2004, & 2005	145	Portland cement approval for concrete - bridge deck	O	KT-29: Sampling Portland cement in the field

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Division 400 - Concrete (Bridge Deck)	CM Part V 5.7.13	146	Water source approval for use with Portland cement- bridge deck	T, O	Water from domestic or city supplies and from other sources approved by health authorities for domestic use may be accepted without testing for all concrete except that to be used in the production of prestressed concrete units. All water must be tested before it is used in concrete for the production of prestressed units.
	CM part IV 4.05.03 & SPECS 6.0 & 8.5.1	147	Deck form installation - bridge deck	I	Check the forms for line, elevation, plumpness, spacing, quality of lumber, bracing, strength, etc. Before concrete placing for bridge deck.
	SPECS 710	148	Removal of forms and false work - bridge deck	I	Under normal conditions, the engineer will allow removal of forms and false work according to spec - table 710-3. The Determination of the time requirement for the removal of forms commences after all the concrete for the placement is in place and finished.
	SPECS 711, 1601 & 1602	149	Steel bars source approval for concrete reinforcement - bridge deck	T	Material specifications and prequalifying testing should follow AASHTO m 31 or AASHTO m 322
	SPECS 1603 & 106.1	150	Steel wire fabric source approval for concrete reinforcement of bridge deck	T	Conduct all prequalifying tests as specified in subsection1603.2b.
	SPECS 712	151	Shear connector installation	I	Check placement of shear connectors base on plans
	CM part IV 4.05.03	152	Placement of reinforcing steel for bridge deck	I	Check placement of reinforcing steel as shown on plans, comply type of steel with the approved source, support all horizontal reinforcement with wire bar supports, plastic bar supports or supplementary bars, clearness, splices
	-	153	Bridge deck miscellaneous items installation (drains, conduits, etc.)	I	Miscellaneous items.
	BCM sec 2.2	154	Check staking the critical elements of bridge	I	Check both vertically and horizontally and compare with the plans when staking work is completed by contractor
	CM Part V 5.9.17 - SPECS 401, 402, 703, 710 & 717	155	Concrete temperature measurement - bridge deck	T	KT-17: obtaining representative samples of freshly mixed concrete as delivered to the project site and determine conformance with quality requirements of the specifications
	CM Part V 5.9.20 - SPECS 401, 402, 703, 710 & 717	156	concrete mass per cubic foot - bridge deck	T	KT-20: Determining the mass per cubic foot (meter) of freshly mixed concrete
	CM Part V 5.9.18 - SPECS 401, 402, 703, 710 & 717	157	Concrete air content - bridge deck	T	KT-18: Determining the air content of freshly mixed concrete by the pressure method
	CM Part V 5.9.24 - SPECS 401, 402, 703, 710 & 717	158	moisture in aggregate - concrete bridge deck	T	KT-24: Determining the free moisture or absorption of aggregates for use in concrete
	CM Part V 5.9.36 - SPECS 401, 402, 703, 710 & 717	159	Density of fresh concrete - bridge deck	T	KT-36: Determining the in-place density of freshly mixed concrete in bridge deck overlays using a nuclear density gauge

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Division 400 - Concrete (Bridge Deck)	CM Part V 5.9.73 - SPECS 401, 402, 703, 710 & 717	160	Permeability of concrete - bridge deck	T	KT-73: Determinations of percent volume of permeable voids in hardened concrete
	CM Part V 5.9.73 - SPECS 401, 402, 703, 710 & 717	161	Concrete strength (cylinders) – bridge deck	T	KT-22 and KT-76: Determining the compressive strength of molded cylindrical concrete specimens
	SPECS 1404	162	Verification sample of concrete curing compounds (infrared spectroscopy)	T	Liquid membrane forming compounds (curing compounds) for spraying on horizontal and vertical concrete surfaces to retard the loss of water during the early hardening period and subsequent curing period. Complies with ASTM C 309, verification samples by infrared spectroscopy is done according to ASTM E 1252
	CM Part V 5.9.02	163	Sieve analysis of sand for bridge joint gap	T	KT-02: Determination of the particle size distribution of sand aggregates using standard sieves
	-	164	Fixing electrical conduit and other wiring- bridge deck	I	Inspect the installation of the conduit and that it has been placed in the proper location, inspect the installation of handholds and their location, inspect the pulling of wiring to ensure that it is not damaged during the pulling process
	-	165	Concrete surface smoothness	I	-
	SPECS 710	166	Grinding and grooving for bridge deck	I	Engineer's approval for correcting surface variations exceeding ⅛ inch in 10 feet by use of an approved profiling device
	SPECS 851.1	167	Waterproofing membrane for bridge deck	I	Check installation of the waterproofing membrane at the locations designated in the contract documents before an overlay. Contractor provides pavement-waterproofing membrane that meets Division 1700 and provides the project engineer with a copy of the fabric manufacturer’s recommendations for installation.
	SPECS 729 h	168	Polymer concrete overlay bond evaluation - bridge deck	T	KT-70: measure the tensile rupture strength between hydraulic cement concrete and polymer concrete overlays.
Division 500 - Rigid Pavement	CM- Part V 5.2.7.4 & SPECS 106.4	169	PCCP quality control plan approval	O	Documents review and approval for concrete quality control plan
	CM Part V 5.9.20 - SPECS 401, 403, 502 & 503	170	Concrete mass per cubic foot - PCCP	T	KT-20: Determining the mass per cubic foot (meter) of freshly mixed concrete
	CM Part V 5.3.1	171	Concrete mix design(s) approval- PCCP	T	Follow KDOT form no. 694 requirements, and concrete paving checklist revision 3-6-2018
	SPECS 501 & 503	172	Sieve analysis of individual aggregates - PCCP	T	KT-02: Determination of the particle size distribution of aggregates using standard sieves.

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				Method*	Procedures
Division 500 - Rigid Pavement	CM Part V 5.7.13	173	Water source approval for use with Portland cement- PCCP	T, O	Water from domestic or city supplies and from other sources approved by health authorities for domestic use may be accepted without testing for all concrete except that to be used in the production of prestressed concrete units. All water must be tested before it is used in concrete for the production of prestressed units.
	CM part IV 4.06.04	174	Check batching plant and equipment before batching operations - PCCP	I	Prior to the start of batching operations, the inspector must thoroughly check, verify calibrations, and verify that all equipment is of an approved design, and complies with the standard specifications. Hoppers or bins should be set level and loaded for at least 24 hours prior to calibration.
	-	175	Check vibrator frequencies before placing PCCP	I	Inspector Checks the required vibrator frequencies before placing PCCP
	-	176	PCCP sampling and storage for testing	O	Taking a sample from fresh PCCP for storage and testing
	-	177	Check paving equipment for leaks	I	Check paving equipment for any leaks
	CM part IV 4.06 - SPECS 501	178	Observing PCCP paving process	I	Inspect the material behind the paver for defects, inspect the concrete to ensure that concrete is uniform, measure and document
	CM part IV 4.06.05	179	Observing contractor’s daily moisture tests of concrete mix - PCCP	I	The inspector will observe the testing procedures. These tests are required so that batch weights may be adjusted, and to verify that the maximum water cement and/or fly ash ratio is not being exceeded
	CM Part V 5.9.17 - SPECS 401, 403, 502 & 503	180	PCCP temperature	T	KT-17: obtaining representative samples of freshly mixed concrete as delivered to the project site and determine conformance with temperature quality requirements of the specifications
	CM Part V 5.9.21 - SPECS 401, 403, 502 & 503	181	PCCP slump	Test	KT-21: Determining the slump of freshly mixed concrete.
	-	182	PCCP water cement ratio	Test	Water cement ratio testing
	SPECS 839.3	183	Rubblizing Portland cement concrete pavement- PCCP	I, T	The engineer will determine the location of the test section to demonstrate compliance with the rubblizing specification, designate areas that require leveling after rublizing completion. Contractor provides equipment to verify compliance with the sizing requirements. Vary the energy and striking patterns of the pavement breaker, and, when necessary, make repeated passes with the equipment until the specified rubblization is achieved.
	CM part IV 4.06.06	184	Checking PCCP forms for alignment and grade	I	They must be plumb and to line and grade on both sides of the lane. The distance between opposite forms must be measured with a steel tape. The elevation of the top of the forms should be checked to make sure that it is the same as the grade staked. The forms should also be checked with a straight edge across joints

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Division 500 - Rigid Pavement	CM part IV 4.06.05	185	Inspection of PCCP delivery trucks	I	Agitating and non-agitating units shall have interior surfaces that are smooth and watertight, having gates or other means to control the concrete discharge. The interiors should be free from excessive accumulations of hardened concrete and from other obstructions or deterioration sufficient to interfere with the proper discharge of concrete. The interiors should be free of any foreign materials which may contaminate fresh concrete
	CM part IV 4.06.06	186	Check PCCP concrete placement to the line and grade shown on plans	I	The inspector verifies that the contractor places concrete in a satisfactory manner to the line and grade shown on the plans.
	CM part IV 4.06.04	187	Checking placement of PCCP longitudinal joints before placing concrete	I	Check locations of joints, dimensions, with plans and slandered specifications. Tie bars should either be placed mechanically or supported securely with bar chairs driven into the subgrade. When bar chairs are used it may be necessary to use 3 chairs for each bar instead of two. When the bars are placed mechanically, they should be placed at the proper spacing and to the proper depth, after the first pass of the concrete spreader and before the mesh reinforcement is placed. Care should be taken to see that the tie bars remain in their proper position during subsequent placing of the mesh and the remaining course of concrete before placing concrete
	CM part IV 4.06.04	188	Check PCCP transverse expansion joints	I	Before placing of the concrete, check locations of different types of joints, dimensions with plans
	CM part IV 4.06.04	189	Check PCCP transverse contraction joints	I	Joints spacing are to be as shown on the plans, one end of each dowel must be greased. Nose caps are not required but there must not be any burrs on the coated end of the dowel.
	CM part IV 4.06.06	190	Check placing wire mesh and dowel bars for PCCP	I	The reinforcement must be fully supported over its entire area. Check that the mesh is placed, lapped and tied as noted in the contract documents
	CM part IV 4.06.06	191	PCCP consolidation and machine finishing	I	The inspector sees that the equipment is adequate and in condition to produce satisfactory work, verifies that it is in a condition to perform satisfactorily and to produce the quality of work required by the standard specifications
	CM part IV 4.06.06	192	Check joint sawing - PCCP	I	All joints should be wet sawed and constructed as shown in the contract documents
	CM part IV 4.06.06	193	Sealing of PCCP joints	I	Sealing of joints with approved material and based on contract documents and specifications
	CM Part V 5.9.20 - SPECS 401, 403, 502 & 503	194	PCCP air content	T	KT-20: Determining the mass per cubic foot (meter) of freshly mixed concrete
	CM Part V 5.9.22 - SPECS 401, 403, 502 & 503	195	PCCP beam mold for flexural strength	T	KT-22: making and curing test specimens in the field, using freshly mixed concrete
	Cm Part V 5.9.46 - SPECS 401, 403, 502 & 503	196	Review PCCP profilograph test results - PCCP	O	KT-46: testing by contractor. Results reviewed by KDOT for determining the smoothness, i.e., Profile index, of both concrete and asphalt pavement using the California type 25-foot (7.6 mm), profilograph or equivalent

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Division 500 - Rigid Pavement	SPECS 501 & 503	197	Percentage of clay lumps and friable particles in individual aggregate - PCCP	T	KT-07: Determining the percentage of clay lumps and friable particles in aggregate.
	SPECS 501 & 504	198	Coal in PCCP individual aggregate	T	AASHTO 113
	CM Part V 5.9.24 - SPECS 401, 403, 502 & 503	199	Moisture in PCCP aggregate	T	KT-24: Determining the free moisture or absorption of aggregates for use in PCCP
	CM Part V 5.9.49 - SPECS 401, 403, 502 & 503	200	Cored PCCP thickness	T	KT-49: obtaining and testing specimens to determine the compressive strength of in-place concrete in pavement and depth of concrete pavement
	CM Part V 5.9.38 - SPECS 401, 403, 502 & 503	201	Density of fresh PCCP	T	KT-38: Determining the in-place density of freshly mixed concrete in pavements using nuclear density gauge
	CM Part V 5.9.71 - SPECS 401, 403, 502 & 503	202	PCCP air void analyzer	T	KT-71: Determining the characteristics of the air-void system of freshly mixed concrete using a sample of mortar. Spacing factor, specific surface and entrained air content are determined by capturing air bubbles released from a mortar sample
	CM Part V 5.9.73 - SPECS 401, 403, 502 & 503	203	PCCP permeability	T	KT-73: Determinations of percent volume of permeable voids in hardened concrete
	SPECS 154.2e	204	PCCP vibrator frequency	T	KDOT standard specification 154.2e requirements for vibrators for rigid pavement.
	CM part IV 4.06.06	205	Weather conditions for PCCP placement	O	Check the weather conditions before PCCP placement
	CM part IV 4.06.04	206	PCCP surface texturing	I	The inspector checks textured areas of the surface
	CM part IV 4.06.06	207	Placing concrete protection and curing for PCCP	I	Check PCCP curing by either the damp burlap cure or the membrane cure and check concrete protection from cold weather
	SPECS 2207, 2208, 2209,2210, 2211,2212, 2213, 2216	208	Approval for rigid pavement marking material (cold plastic, high durability, thermoplastic)	C	Provide cold plastic pavement marking material that complies with ASTM d 4505 reflectivity level ii.
	SPECS 2214	209	Approval for epoxy rigid pavement marking material	C, T	Manufacturers must provide a 1-quart sample of each color plus 1 quart of hardener to the engineer of tests. Also include a copy of the quality control test report for each lot of material, an infrared spectroscopy analysis for each component, material safety data sheets and a complete set of installation recommendations and instructions
	CM part IV 4.06.06 - SPECS 503	210	PCCP surface trueness and smoothness	I	The smoothness of the pavement is determined by using a 10-foot straightedge or by the profilograph test. Requirements for pavement trueness are described in division 500 of the standard specifications.

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Division 500 - Rigid Pavement	CM part IV 4.06.06	211	PCCP form removal	I	The side forms remain in place at least 12 hours after the concrete has been placed, the forms must be pulled away from the edge of the slab without prying against the concrete
	CM part IV 4.06	212	Pavement defects inspection - PCCP	I	-
	-	213	PCCP random crack remediation	I	-
	-	214	Review the PCCP checklist	O	Review concrete paving checklist revision 3-6-2018 for confirmation
	806.3	215	Applying durable pavement marking - PCCP	I, C	Check materials and equipment preapproval and using equipment designed for the preparation and application of the appropriate type of pavement marking material, personnel with certificate, marking contractor approval, test strep approval after 24 hours of its placement. After applying, check alignment, width, and removing unsatisfactory marking
	SPECS 812	216	Check installation of highway permanent signs and object markers - PCCP	I, C	Check materials preapproval and locations, number as shown in the contract documents
	SPECS 814	217	Check installation of electric lighting systems and traffic signals - PCCP	I, C	The inspector checks materials preapproval, examine locations, number as shown in the contract documents
	SPECS 815	218	Installation of catch basins, inlet, outlets, manholes and junction boxes - PCCP	I	Check locations, dimensions, levels, and materials of catch basins, inlet, outlets, manholes and junction boxes as shown in the contract documents.
	SPECS 827	219	Guardrail and guideposts installation - PCCP	I	The inspector checks construction of the designated type of guardrail and guidepost as shown in the contract documents, location, holes excavation, length, height, and verifies material approval
	SPECS 501 & 503	220	Unit weight of PCCP individual aggregate – lightweight aggregates only	T	KT-05: Determining the unit weight of fine, coarse, or mixed aggregates. The method is applicable to aggregates not exceeding 1 ½ in. (37.5 mm) in nominal maximum size.
	SPECS 824.3	221	Sidewalk construction approval - PCCP	I	Check the excavation to the required depth and to a width that will permit the installation and bracing of the forms, shaping the foundation and compaction to a firm even surface conforming to the section shown in the contract documents. And check removal of all soft and yielding material and replace with acceptable material.
	SPECS 855	222	Solid interlocking paving units (paving bricks) installation-PCCP	I	Check installing solid interlocking paving units (paving bricks) at the locations designated in the contract documents, bedding, levels, dimensions, and vibration.
	SPECS 501, 503	223	Percentage of shale or shale-like materials in PCCP individual aggregate	T	KT-08: determine the percentage of shale, mudstone, clay stone or other materials which would exhibit the properties of shale upon weathering
	SPECS 503& 501	224	Sticks in PCCP individual aggregate	T	KT-35: Determining the percentage of sticks and similar material (leaves, bark, etc.) In PCCP aggregate.

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Division 500 - Rigid Pavement	CM part IV 4.06.01	225	Concrete pavement construction checklist review	I	Throughout the project, the concrete pavement construction checklist should be utilized as a guideline for the construction and inspection of Portland cement concrete pavement operations.
	CM part IV 4.06.06	226	Inspecting subgrade for conformance before PCCP placement	I	Before any subbase material is placed, the subgrade must be checked for grade, cross-section and drainage
Division 600 - Flexible Pavement (HMA)	CM- part 5.2.7.1 & SPECS 106.4	227	HMA quality control plan approval	O	Documents review and approval for contractor's HMA quality control plan
	SPECS 602.2b	228	Submitting quality control organization for the certified inspection and testing (CIT) training program	O	Contractor provides a quality control organization or private testing firm having personnel certified according to the policy and procedures manual for the certified inspection and testing (CIT) training program
	CM Part V 5.9.02 - SPECS 603, 611, 1103 & 15-06001	229	Sieve analysis of HMA individual aggregate	T	KT-02: Determination of the particle size distribution of HMA aggregates using standard sieves
	CM part IV 4.07.01 - SPECS 602	230	HMA job mix formulas (JMF) approval	O	Review the proposed JMF for each combination of HMA aggregates
	CM part IV 4.07.01	231	Weather conditions for HMA placement	O	Check the conditions of the weather before placing HMA
	-	232	Spreading and finishing mixture- HMA	I	-
	-	233	Compaction of asphalt pavement layer- HMA	I	Inspector checks compaction of asphalt pavement layer with considering the required tests
	CM part IV 4.07.01	234	Mix design (DMF) approval for HMA	O	The contractor submits a mix design to the District lab at least 10 working days prior to production
	-	235	HMA sampling and storage for testing	I, O	KT 26: Sampling asphalt, cutback, and emulsifier materials, at the point of production and at destination.
	CM part IV 4.07.01	236	Fiber additive in HMA	I	-
	CM Part V 5.2.7 SPECS 602.2	237	HMA quality control plan (QCP) approval	O	At the pre-construction conference, contractor submits to the engineer for approval, see section 5.2.7-contractor’s quality control plan, CM Part V.
	CM Part V 5.9.07 - SPECS 603, 611, 1103 & 15-06001	238	Percentage of clay lumps and friable particles in HMA aggregate	T	KT-07: Determining the percentage of clay lumps and friable particles in HMA aggregate.
	CM part IV 4.07.01	239	Check the underlying surface cleanliness and preparation to receive HMA	I	Make sure the contractor cleans the roadway, usually by brooming. HMA will not bond to the underlying pavement if the surface is not cleaned.
	CM part IV 4.07.01	240	Verifying the elevation of milled surface to receive HMA	I	Verifying the elevation of milled surface to receive HMA
	CM part IV 4.07.01	241	Check tack coat (emulsified asphalt) applying to the roadway before HMA	I	Verify the rate at which the tack is placed and do not permit paving on the roadway until the tack has broken (turned black)

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Division 600 - Flexible Pavement (HMA)	CM Part V 5.9.08 - SPECS 603, 611, 1103 & 15-06001	242	Percentage of shale or shale-like materials in HMA aggregate	T	KT-08: determine the percentage of HMA shale, mudstone, clay stone or other materials which would exhibit the properties of shale upon weathering
	CM Part V 5.9.31 - SPECS 603, 611, 1103 & 15-06001	243	Percentage of crushed particles in HMA crushed gravel (coarse aggregate angularity)	T	KT-31: Determining the percent, by mass, of particles, which by visual inspection, exhibit characteristics of crushed aggregate
	CM Part V 5.9.35 - SPECS 603, 611, 1103 & 15-06001	244	Sticks and leaves in HMA aggregate	T	KT-35: Determining the percentage of sticks and similar material (leaves, bark, etc.) in HMA aggregate.
	CM Part V 5.9.35 - SPECS 603, 611, 1103 & 15-06001	245	Uncompacted void content of HMA fine aggregate	T	KT-50: Determination of the uncompacted void content of a sample of HMA aggregate based on a given gradation. Measure of aggregate angularity, sphericity, and texture
	CM Part V 5.9.02 - SPECS 603, 611, 1103 & 15-06001	246	Sieve analysis for HMA aggregate of mineral filler supplement	T	KT-02: Determination of the particle size distribution of HMA aggregate of mineral filler supplement using standard sieves
	CM Part V 5.9.10 - SPECS 603, 611, 1103 & 15-06001	247	Plasticity of HMA mineral filler supplement	T	KT-10: Determining the liquid limit, plastic limit and plastic index of HMA mineral filler supplement
	CM part IV 4.07.01	248	Check roadway cleaning before HMA placement	I	Make sure the contractor cleans the roadway, usually by brooming. HMA will not bond to the underlying pavement if the surface is not cleaned
	CM Part V 5.9.02 - SPECS 603, 611, 1103 & 15-06001	249	Sieve analysis of HMA combined aggregate	T	KT-02: Determination of the particle size distribution of HMA combined aggregate
	SPECS 602, 603, 611 & 1103	250	Coarse aggregate angularity for combined aggregate - HMA	T	KT-31: Determining the percent, by mass, of particles, which by visual inspection, exhibit characteristics of crushed aggregate
	CM Part V 5.9.10 - SPECS 603, 611, 1103 & 15-06001	251	Sand equivalent of HMA combined aggregate	T	KT-55: Determining the relative proportions of fine dust or claylike material in minus no. 4 (4.75 mm) HMA combined aggregates.
	CM Part V 5.9.11 - SPECS 603, 611, 1103 & 15-06001	252	Moisture content of HMA combined aggregate	T	KT-11: Determination of the moisture content of HMA combined aggregate
	CM Part V 5.9.14 - SPECS 603, 611, 1103 & 15-06001	253	Density of HMA mixtures (field lab)	T	KT-14: Testing bituminous mixes to determine optimum asphalt content, density characteristics, and stability characteristics
	CM Part V 5.9.14 - SPECS 603, 611, 1103 & 15-06001	254	Voids of HMA mixtures (field lab)	T	KT-14: testing bituminous mixes to determine optimum asphalt content, density characteristics, and stability characteristics
	CM part IV 4.07.01 - SPECS 602	255	observing HMA paving process	I	Check for daily QC/QA sampling locations, obtain tickets as they are placed to ensure that delivery was made, check that material is being rolled properly, and observe the material behind the paver is being rolled properly

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Division 600 - Flexible Pavement (HMA)	CM Part V 5.9.11 - SPECS 603, 611, 1103 & 15-06001	256	Moisture content of HMA mixtures (field lab)	T	KT-11: Determination of the moisture content of HMA mixtures in field lab
	CM Part V 5.9.26 - SPECS 603, 611, 1103 & 15-06001	257	HMA asphalt binder sampling for testing at plant	T	KT-26: Sampling asphalt, cutback, and emulsifier materials, at the point of production and at destination
	CM Part V 5.9.14 - SPECS 603, 611, 1103 & 15-06001	258	Density of HMA mixtures (District lab)	T	KT-14: testing bituminous mixes to determine optimum asphalt content, density characteristics, and stability characteristics
	CM Part V 5.9.14 - SPECS 603, 611, 1103 & 15-06001	259	Voids of HMA mixtures (District lab)	T	KT-14: testing bituminous mixes to determine optimum asphalt content, density characteristics, and stability characteristics
	CM Part V 5.9.14 - SPECS 603, 611, 1103 & 15-06001	260	Stability of HMA mixtures (District lab)	T	KT-14: testing bituminous mixes to determine optimum asphalt content, density characteristics, and stability characteristics
	CM Part V 5.9.14 - SPECS 603, 611, 1103 & 15-06001	261	Flow of HMA mixtures (District lab)	T	KT-14: testing bituminous mixes to determine optimum asphalt content, density characteristics, and stability characteristics
	CM Part V 5.9.34 - SPECS 603, 611, 1103 & 15-06001	262	Gradation of HMA mixtures (District lab)	T	KT-34: Determination of the particle size distribution of aggregate extracted from asphalt mixtures
	Cm Part V 5.9.57 - SPECS 603, 611, 1103 & 15-06001	263	Asphalt content of HMA mixtures (District lab)	T	KT-57: Determination of asphalt content of hot mix paving mixtures by ignition of the asphalt cement at 932°f (500°c) in a furnace
	CM Part V 5.9.39 - SPECS 603, 611, 1103 & 15-06001	264	Maximum specific gravity of uncompacted plant mix asphalt (field lab)	T	KT-39: Determination of the theoretical maximum specific gravity of uncompacted asphalt paving mixtures.
	CM Part V 5.9.11 - SPECS 603, 611, 1103 & 15-06001	265	Moisture content of uncompacted plant mix asphalt (field lab)	T	KT-11: Determination of the moisture content of soil and aggregate
	CM Part V 5.9.15 - SPECS 603, 611, 1103 & 15-06001	266	Air voids of plant mix asphalt (District lab)	T	KT-15 and KT-58: the compaction of cylindrical specimens of hot mix asphalt (HMA) using the super pave gyratory compactor
	CM Part V 5.9.39 - SPECS 603, 611, 1103 & 15-06001	267	Maximum specific gravity of uncompacted plant mix asphalt (District lab)	T	KT-39: Determination of the theoretical maximum specific gravity of uncompacted asphalt paving mixtures
	CM Part V 5.9.34 - SPECS 603, 611, 1103 & 15-06001	268	Gradation of plant mix asphalt (District lab)	T	KT-34: Determination of the particle size distribution of aggregate extracted from asphalt mixtures

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Division 600 - Flexible Pavement (HMA)	CM Part V 5.9.57 - SPECS 603, 611, 1103 & 15-06001	269	Asphalt content of plant mix asphalt (District lab)	T	KT-57: Determination of asphalt content of hot mix paving mixtures by ignition of the asphalt cement at 932°f (500°c) in a furnace
	CM Part V 5.9.15 - SPECS 603, 611, 1103 & 15-06001	270	Field density (cores or nuclear) of completed HMA road work	T	KT-15: Determining the bulk specific gravity of specimens of compacted asphalt mixtures. The specimens may have been molded in the laboratory or cut or cored form compacted pavement. None required if specified [plan] lift thickness is less than 1.5”
	CM Part V 5.9.46 - SPECS 603, 611, 1103 & 15-06001	271	Profilograph for completed HMA works	T	KT-46: testing by contractor. Results reviewed by KDOT for determining the smoothness, i.e., Profile index, of asphalt pavement using the California type 25-foot (7.6 mm), profilograph or equivalent.
	SPECS 2207, 2208, 2209,2210, 2211,2212, 2213, 2216	272	Approval for HMA pavement marking material	C	Provide cold plastic pavement marking material that complies with ASTM d 4505 reflectivity level II.
	SPECS 2214	273	Approval for epoxy HMA pavement marking material	C, T	Manufacturers must provide a 1-quart sample of each color plus 1 quart of hardener to the engineer of tests. Also include a copy of the quality control test report for each lot of material, an infrared spectroscopy analysis for each component, material safety data sheets and a complete set of installation recommendations and instructions.
	SPECS 600	274	Asphalt mixture temperature-HMA	T	KT-11: Determination of the moisture content of HMA mixtures
	SPECS 600	275	Asphalt mixture sampling in plant-HMA	T	Asphalt mixture sampling in plant-HMA and storage
	SPECS 602	276	Voids in mineral aggregate (VMA) - HMA	T	Calculate the percent voids in the mineral aggregate in the compacted paving mixture.
	SPECS 602	277	Mix gradation - HMA (field lab)	T	Testing mix gradation at field lab
	CM part IV 4.07.01	278	Verify the percentage of components going into the plant mix correlate with JMF	I	The plant inspector should verify that the percentage of components going into the mix correlate with the current job mix formula (JMF). The contractor may make adjustments to the JMF during production in order to meet the volumetric properties. The contractor must inform the inspector of changes to the JMF prior to making the change.
	SPECS 602	279	Binder content- HMA	T	KT-57: conduct the tests for binder content on representative portions of the HMA, quartered from the larger sample of HMA. Take a random sample weighing a minimum of 55 pounds from behind the paver and transport it to the test facility, using a method to retain heat to facilitate sample-quartering procedures, record and document all test results and calculations on data sheets provided by KDOT.
	CM Part V 5.9.39 - SPECS 602	280	Theoretical maximum specific gravity of asphalt paving mixtures- HMA (field lab)	T	KT-39: Determination of the theoretical maximum specific gravity of uncompacted asphalt paving mixtures
	SPECS 602	281	Voids filled with asphalt (VFA)- HMA	T	KT-15, KT-39, and KT-58
	SPECS 602	282	Voids in mineral aggregate (VMA) - HMA	T	KT-15 & KT-6: Determining the specific gravity and absorption of aggregates

Construction Division	Section*	CN*	Activity	Acceptance	
				Method*	Procedures
Division 600 - Flexible Pavement (HMA)	SPECS 602	283	Dust to effective binder content (D/B) ratio - HMA	T	Examining dust to effective binder content (D/B) ratio in HMA
	SPECS 602	284	HMA construction joints control	I	Inspector review making and checking transverse and longitudinal joints, an acceptable surface texture and meet density requirements, apply a light coat of asphalt emulsion or asphalt binder if needed. Before placing the fresh HMA against a cut joint, spray or paint the contact surface with a coat or asphalt binder
	SPECS 615	285	Sealing of HMA cracks and joints	I	Seal joints in the HMA overlay at the locations shown in the contract documents or as designated by the engineer, using hot type joint sealing compound complying with spec 1500, begin 48 hours after placing the surface course to mallow the mat to cool, clean the entire depth of the cracks before beginning, contractor provides 2 copies of the manufacturer’s recommendations for preparation and application of the sealant
	SPECS 603	286	HMA pavement corrugations	I	Check surface grinding so corrugations are parallel to the pavement edge with ridges 1/16 inch, ±1/32 inch higher than the valleys of the corrugations
	SPECS 603	287	Profilographs after HMA pavement sections are corrected	I	Contractor re-profile the pavement surface to verify compliance with the specified pavement smoothness, provide the engineer with the profilographs and their evaluation within 2 working days after correcting the pavement surface
	SPECS 602.4	288	Check the pavement for longitudinal streaks	I	The engineer will check the pavement for longitudinal streaks and other irregularities. Make every effort to prevent or correct any irregularities in the pavement, such as changing pavers or using different and additional equipment
	SPECS 604.3	289	Check the temperature of asphalt emulsion- HMA	I	The engineer does not accept asphalt emulsion with a temperature greater than 120ºf
	SPECS 608.3	290	Check HMA seal after 30 days	I	The engineer, along with the contractor, will inspect the seal, 30 days after work is completed on the seal
	SPECS 614.4	291	End of day quantities signed by Engineer	I	At the end of each day of production, the contractor provides the engineer with a document signed by the plant foreman or the project manager listing the dry weight of each aggregate, mineral filler and the tons of asphalt binder. The dry weight is the tons of the material less the water content
	SPECS 604.3f	292	A light application of asphalt material (smoke coat) on the recycled surface	I	For surface treatment or overlay, when required by the engineer, the contractor applies a light application of asphalt material (smoke coat) on the recycled surface, and blot with fine sand, as necessary
	SPECS 806.3	293	Applying durable pavement marking - HMA	I, C	Check materials and equipment preapproval and using equipment designed for the preparation and application of the appropriate type of pavement marking material, personnel with certificate, marking contractor approval, test strep approval after 24 hours of its placement. After applying, check alignment, width, and removing unsatisfactory marking

Construction Division	Section*	CN*	Activity	Acceptance	
				Method*	Procedures
Division 600 - Flexible Pavement (HMA)	SPECS 812	294	Check installation of highway permanent signs and object markers - HMA	I, C	Check materials preapproval and locations, number as shown in the contract documents
	SPECS 814	295	Check installation of electric lighting systems and traffic signals - HMA	I, C	The inspector checks materials preapproval, examine locations, number as shown in the contract documents
	SPECS 815	296	Installation of catch basins, inlet, outlets, manholes and junction boxes - HMA	I	Check locations, dimensions, levels, and materials of catch basins, inlet, outlets, manholes and junction boxes as shown in the contract documents
	SPECS 824.3	297	Sidewalk construction approval - HMA	I	Check the excavation to the required depth and to a width that will permit the installation and bracing of the forms, shaping the foundation and compaction to a firm even surface conforming to the section shown in the contract documents. And check removal of all soft and yielding material and replace with acceptable material
	SPECS 827	298	Guardrail and guideposts installation - HMA	I	The inspector checks construction of the designated type of guardrail and guidepost as shown in the contract documents, location, holes excavation, length, height, and verifies material approval
	SPECS 852	299	Check paving fabric installation	I	Check installing the paving fabric at the locations designated in the contract documents and according to the manufacturer’s instructions. Contractor provides a paving fabric that complies with section 1710 and provides the engineer with a copy of the paving fabric manufacturer’s installation instructions.
	SPECS 855	300	Solid interlocking paving units (paving bricks) installation-HMA	I	Check installing solid interlocking paving units (paving bricks) at the locations designated in the contract documents, bedding, levels, dimensions, and vibration
	Cm part IV 4.01.187	301	Review pre-work asphalt sealing checklist	I	Checklist should be utilized as a guideline for asphalt sealing operations.
	Cm part IV 4.01.18	302	HMA pavement construction checklist review	I	Throughout the project, the HMA pavement construction checklist should be utilized as a guideline for the construction and inspection of HMA pavement operations.

CN- Comprehensive number, CM- Construction manual, BCM- Bridge construction manual, SPECS- Specifications, I- Inspection, T-test, C- certification, O-other.

Appendix C: Risk Assessment Results

ID		Activity	CN*	CI for Cost	CI for Safety	CI for Service Interruption	Average	Highest CI	Risk Impact %
Earthwork	1.1	Field density for compacted earth works	59	15.57	11.00	13.86	13.48	15.57	62.29%
	1.2	Field density of compacted backfilling works	60	18.00	14.00	16.29	16.10	18.00	72.00%
	1.3	Moisture content of earthwork	61	13.14	9.50	10.71	11.12	13.14	52.57%
	1.4	Moisture content for structure backfilling	62	13.86	12.67	12.86	13.13	13.86	55.43%
	1.5	Field density of foundation of MSE walls	63	12.29	13.80	13.67	13.25	13.80	55.20%
	1.6	Field density of mechanically stabilized earth fill	64	13.33	13.80	15.50	14.21	15.50	62.00%
	1.7	Check placement and compaction of granular drainage blanket	65	9.00	8.20	9.00	8.73	9.00	36.00%
Subgrade, base and shoulders	2.1	Sieve analysis of aggregate for subgrade	68	8.83	6.75	9.17	8.25	9.17	36.67%
	2.2	Check the application rate of cement or fly ash (CTB)	69	8.00	7.50	9.67	8.39	9.67	38.67%
	2.3	Material passing the no. 200 (75 µm) sieve by the wash method for subgrade aggregate	73	6.17	4.25	6.33	5.58	6.33	25.33%
	2.4	Plasticity of aggregate of subgrade	79	9.17	7.00	10.17	8.78	10.17	40.67%
	2.5	Moisture content for lime treated subgrade	82	14.17	12.75	13.83	13.58	14.17	56.67%
	2.6	Sieve analysis for acceptance of lime treated subgrade	83	9.00	6.00	8.33	7.78	9.00	36.00%
	2.7	Percent solids of lime slurry in lime treated subgrade	84	8.00	6.25	8.17	7.47	8.17	32.67%
	2.8	Field density of lime treated subgrade	85	11.50	7.25	10.00	9.58	11.50	46.00%

ID		Activity	CN*	CI for Cost	CI for Safety	CI for Service Interruption	Average	Highest CI	Risk Impact %
	2.9	Sample of subgrade hydrated lime and pebble quicklime	86	5.40	2.33	4.80	4.18	5.40	21.60%
	2.10	Sieve analysis for acceptance of fly ash or cement treated subgrade	87	7.50	6.00	8.00	7.17	8.00	32.00%
	2.11	Field density of cement or fly ash treated subgrade	88	11.33	9.50	11.17	10.67	11.33	45.33%
	2.12	Sample of stabilization and cold recycle fly ash	89	4.00	3.33	4.00	3.78	4.00	16.00%
	2.13	Field density of crushed stone subgrade	90	8.67	5.75	7.83	7.42	8.67	34.67%
	2.14	Relative density of crushed stone subgrade	91	7.00	3.00	6.50	5.50	7.00	28.00%
	2.15	Sieve analysis for aggregate crushed stone of backfill	92	9.50	6.50	9.50	8.50	9.50	38.00%
	2.16	Sieve analysis for aggregate of base course	94	8.00	5.50	8.00	7.17	8.00	32.00%
	2.17	Sieve analysis for aggregate of binder material of base course	95	4.83	3.50	4.83	4.39	4.83	19.33%
	2.18	Plasticity for aggregate of binder material of base course	96	5.67	3.25	5.67	4.86	5.67	22.67%
	2.19	Sieve analysis for combined aggregate of base course	97	8.67	5.75	7.50	7.31	8.67	34.67%
	2.20	Plasticity of combined aggregate of base course	98	8.00	4.25	6.83	6.36	8.00	32.00%
	2.21	Moisture test for combined aggregate of base course	99	9.50	4.75	8.33	7.53	9.50	38.00%
	2.22	Field density of completed aggregate base course	100	11.50	6.75	10.50	9.58	11.50	46.00%
	2.23	Sieve analysis for individual aggregate of shoulders (non HMA)	101	5.50	4.50	4.33	4.78	5.50	22.00%
	2.24	Plasticity of individual aggregate of shoulders (non HMA)	102	3.67	4.75	3.50	3.97	4.75	19.00%

ID		Activity	CN*	CI for Cost	CI for Safety	CI for Service Interruption	Average	Highest CI	Risk Impact %
	2.25	Sieve analysis for aggregate of binder material of shoulders (non HMA)	103	4.17	4.25	3.67	4.03	4.25	17.00%
	2.26	Plasticity of binder material of aggregate shoulders (non HMA)	104	6.00	5.75	4.67	5.47	6.00	24.00%
	2.27	Sieve analysis for combined aggregate of shoulders (non HMA)	105	7.67	4.50	4.50	5.56	7.67	30.67%
	2.28	Plasticity of combined aggregate of shoulders (non HMA)	106	7.33	4.50	4.33	5.39	7.33	29.33%
	2.29	Moisture of combined aggregate of shoulders (non HMA)	107	7.83	7.00	5.00	6.61	7.83	31.33%
	2.30	Field density of completed aggregate shoulders (non HMA)	108	8.00	4.75	6.17	6.31	8.00	32.00%
	2.31	Moisture of completed aggregate shoulders (non HMA)	109	8.00	5.75	5.67	6.47	8.00	32.00%
	2.32	Sieve analysis for aggregate of cement treated base (CTB)	112	8.17	5.00	7.00	6.72	8.17	32.67%
	2.33	Moisture of cement treated base (CTB)	113	11.33	6.75	10.17	9.42	11.33	45.33%
	2.34	Density of cement treated base (CTB)	114	14.67	9.50	13.17	12.45	14.67	58.67%
	2.35	Compressive strength of cement treated base (CTB)	115	15.50	9.50	13.17	12.72	15.50	62.00%
	2.36	Field density of completed cement treated base (CTB)	116	13.17	9.50	12.33	11.67	13.17	52.67%
	2.37	Moisture of completed cement treated base (CTB)	117	11.67	10.00	11.67	11.11	11.67	46.67%
	2.38	Sieve analysis for aggregate of granular base	118	7.67	5.75	8.50	7.31	8.50	34.00%
	2.39	Plasticity of aggregate of granular base	119	8.17	5.75	7.33	7.08	8.17	32.67%

ID		Activity	CN*	CI for Cost	CI for Safety	CI for Service Interruption	Average	Highest CI	Risk Impact %
	2.40	Sieve analysis for aggregate of binder material of granular base	120	5.00	3.50	5.00	4.50	5.00	20.00%
	2.41	Plasticity of binder material of granular base	121	6.33	3.25	6.33	5.30	6.33	25.33%
	2.42	Sieve analysis for pulverized aggregate of granular base	122	6.33	3.75	5.67	5.25	6.33	25.33%
	2.43	Sieve analysis for combined aggregate of granular base	123	8.83	4.25	7.33	6.80	8.83	35.33%
	2.44	Plasticity of combined aggregate of granular base	124	8.67	4.00	8.00	6.89	8.67	34.67%
	2.45	Moisture of combined aggregate of granular base	125	8.50	5.25	7.80	7.18	8.50	34.00%
	2.46	Field density of completed granular base	126	11.83	8.00	10.00	9.94	11.83	47.33%
	2.47	Moisture of completed granular base	127	12.33	8.00	10.00	10.11	12.33	49.33%
Concrete (bridge deck)	3.1	Slump of concrete - bridge deck	143	11.29	9.80	11.43	10.84	11.43	45.71%
	3.2	Portland cement approval for concrete - bridge deck	145	10.50	10.25	10.50	10.42	10.50	42.00%
	3.3	Concrete temperature measurement - bridge deck	155	8.86	7.60	9.43	8.63	9.43	37.71%
	3.4	Concrete mass per cubic foot - bridge deck	156	14.50	10.67	13.29	12.82	14.50	58.00%
	3.5	Concrete air content - bridge deck	157	13.88	8.83	10.43	11.05	13.88	55.50%
	3.6	Moisture in aggregate - concrete bridge deck	158	12.14	8.20	7.14	9.16	12.14	48.57%
	3.7	Density of fresh concrete - bridge deck	159	13.25	9.33	12.25	11.61	13.25	53.00%
	3.8	Permeability of concrete - bridge deck	160	15.50	11.20	12.13	12.94	15.50	62.00%
	3.9	Concrete strength (cylinders) – bridge deck	161	14.00	8.71	13.75	12.15	14.00	56.00%

ID		Activity	CN*	CI for Cost	CI for Safety	CI for Service Interruption	Average	Highest CI	Risk Impact %
Rigid Pavement (PCCP)	4.1	Concrete mass per cubic foot - PCCP	170	15.75	13.00	15.33	14.69	15.75	63.00%
	4.2	Sieve analysis of individual aggregates - PCCP	172	5.75	6.33	6.83	6.30	6.83	27.33%
	4.3	Check vibrator frequencies before placing PCCP	175	10.88	10.00	13.33	11.40	13.33	53.33%
	4.4	PCCP temperature	180	9.00	13.33	9.00	10.44	13.33	53.33%
	4.5	PCCP slump	181	11.14	13.33	11.60	12.02	13.33	53.33%
	4.6	PCCP air content	194	16.25	15.25	15.17	15.56	16.25	65.00%
	4.7	Moisture in PCCP aggregate	199	8.71	10.33	9.00	9.35	10.33	41.33%
	4.8	Cored PCCP thickness	200	10.50	10.67	11.33	10.83	11.33	45.33%
	4.9	Density of fresh PCCP	201	11.25	10.75	12.17	11.39	12.17	48.67%
	4.10	PCCP permeability	203	12.25	12.25	11.67	12.06	12.25	49.00%
	4.11	PCCP vibrator frequency	204	10.38	9.25	11.83	10.49	11.83	47.33%
	4.12	Unit weight of PCCP individual aggregate – lightweight aggregates only	220	9.50	6.50	7.83	7.94	9.50	38.00%
Flexible Pavement (HMA)	5.1	Sieve analysis of HMA individual aggregate	220	5.14	4.00	4.83	4.66	5.14	20.57%
	5.2	Compaction of asphalt pavement layer- HMA	233	15.88	13.50	12.86	14.08	15.88	63.50%
	5.3	HMA sampling and storage for testing	235	4.50	2.60	3.00	3.37	4.50	18.00%
	5.4	Percentage of crushed particles in HMA crushed gravel (coarse aggregate angularity)	243	8.13	6.40	7.00	7.18	8.13	32.50%
	5.5	Uncompacted void content of HMA fine aggregate	245	9.25	9.75	9.80	9.60	9.80	39.20%
	5.6	Sieve analysis for HMA aggregate of mineral filler supplement	246	2.71	3.67	3.40	3.26	3.67	14.67%

ID		Activity	CN*	CI for Cost	CI for Safety	CI for Service Interruption	Average	Highest CI	Risk Impact %
	5.7	Plasticity of HMA mineral filler supplement	247	2.71	3.67	3.40	3.26	3.67	14.67%
	5.8	Sieve analysis of HMA combined aggregate	249	6.63	5.67	7.67	6.66	7.67	30.67%
	5.9	Coarse aggregate angularity for combined aggregate - HMA	250	7.63	6.60	6.67	6.97	7.63	30.50%
	5.10	Sand equivalent of HMA combined aggregate	251	5.88	6.00	7.40	6.43	7.40	29.60%
	5.11	Moisture content of HMA combined aggregate	252	7.43	5.00	6.80	6.41	7.43	29.71%
	5.12	Density of HMA mixtures (field lab)	253	14.38	11.50	10.57	12.15	14.38	57.50%
	5.13	Voids of HMA mixtures (field lab)	254	12.86	10.00	10.00	10.95	12.86	51.43%
	5.14	Moisture content of HMA mixtures (field lab)	256	6.86	6.33	5.20	6.13	6.86	27.43%
	5.15	HMA asphalt binder sampling for testing at plant	257	7.63	4.40	6.00	6.01	7.63	30.50%
	5.16	Density of HMA mixtures (District lab)	258	12.13	8.20	9.14	9.82	12.13	48.50%
	5.17	Gradation of HMA mixtures (District lab)	262	9.00	6.20	6.83	7.34	9.00	36.00%
	5.18	Asphalt content of HMA mixtures (District lab)	263	10.50	5.40	7.71	7.87	10.50	42.00%
	5.19	Maximum specific gravity of uncompacted plant mix asphalt (field lab)	264	12.13	7.40	7.86	9.13	12.13	48.50%
	5.20	Moisture content of uncompacted plant mix asphalt (field lab)	265	6.86	5.00	5.00	5.62	6.86	27.43%
	5.21	Air voids of plant mix asphalt (District lab)	266	10.50	8.20	7.71	8.80	10.50	42.00%
	5.22	Maximum specific gravity of uncompacted plant mix asphalt (District lab)	267	11.00	6.40	7.71	8.37	11.00	44.00%

ID		Activity	CN*	CI for Cost	CI for Safety	CI for Service Interruption	Average	Highest CI	Risk Impact %
	5.23	Gradation of plant mix asphalt (District lab)	268	9.00	6.20	6.83	7.34	9.00	36.00%
	5.24	Asphalt content of plant mix asphalt (District lab)	269	11.13	6.20	7.71	8.35	11.13	44.50%
	5.25	Field density (cores or nuclear) of completed HMA road work	270	13.63	10.60	10.71	11.65	13.63	54.50%
	5.26	Voids in mineral aggregate (VMA) - HMA	282	11.00	7.80	8.29	9.03	11.00	44.00%
	5.27	Mix gradation - HMA	277	9.00	6.40	8.80	8.07	9.00	36.00%
	5.28	Binder content- HMA	279	12.13	6.50	8.71	9.11	12.13	48.50%
	5.29	Theoretical maximum specific gravity of asphalt paving mixtures- HMA (field lab)	280	13.50	7.00	9.29	9.93	13.50	54.00%
	5.30	Voids filled with asphalt (VFA)- HMA	281	6.88	4.67	6.57	6.04	6.88	27.50%
	5.31	Voids in mineral aggregate (VMA) - HMA	282	10.63	7.50	8.29	8.81	10.63	42.50%
	5.32	Dust to effective binder content (d/b) ratio - HMA	283	12.75	7.80	9.86	10.14	12.75	51.00%
	5.33	HMA construction joints control	284	13.00	11.14	11.57	11.90	13.00	52.00%

* Comprehensive number

Appendix D: Key Terminology

Source: KDOT (2018)

Agency: The State Highway or Transportation Department, Commission, or other organization, constituted under State or Commonwealth laws, that administers highway or transportation work. The term Agency was chosen for the purpose of consistency, as this document is intended for use by any governing organization attempting to prepare specifications for the purpose of highway or transportation work.

Acceptable Quality Level (**AQL**): The level of established actual quality for a quality characteristic that is fully acceptable.

Acceptance Program: All factors that comprise the State's determination of the degree of compliance with contract requirements and value of a product. These factors include the State's sampling, testing and inspection, and validated results of contractor sampling and testing.

Assurance Sampling and Testing: Split or replicate samples used as an independent check of the sampling and testing procedures and equipment. These samples are to assure testing is being performed properly by both the contractor's and the State's personnel. The results of assurance tests are not to be used as a basis of material acceptance.

Buyer's Risk: Also called *agency's risk*, or *risk of a Type II* or *beta (ß) error*. It is the risk to the agency of accepting rejectable quality level (*RQL*) material or workmanship.

Certified Technician: A technician certified by some agency as proficient in performing certain duties.

Disincentive: A pre-established decrease in payment to the contractor applied to a contract bid item for which the level of materials quality and workmanship, determined by statistical means, does not meet the specified acceptable quality level *(AQL)*. The disincentive is usually expressed as a percentage of the original Contract bid-price.

Dispute Resolution: The procedure used to resolve conflicts resulting from discrepancies between the State's verification results and the Contractor's quality control results of sufficient magnitude to impact payment. Any laboratory used for dispute resolution must be accredited by the AASHTO Accreditation program for the tests to be performed.

Incentive/disincentive provision (for quality): A pay adjustment schedule which functions to motivate the contractor to provide a high level of quality.

Independent Assurance (IA): IA is an unbiased and independent verification of the Quality Assurance system used and of the reliability of the test results obtained in the regular sampling and testing activities. KDOT's IA will consist of observations by independent personnel to assure that specified procedures are followed (witnessing), and split or replicate sampling and testing.

Lower Specification Limit (**LSL)**: The lower statistically based limiting value associated with a quality characteristic and used to evaluate the acceptability of a lot.

Percent within Limits (PWL): The percentage of the lot falling above a lower specification limit, beneath an upper specification limit, or between upper and lower specification limits.

Quality Assurance (QA): All those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality. QA activities include acceptance, independent assurance, verification, and prequalification sampling and testing; inspection; reporting of results; and any follow up that may be necessary due to test failure. Without these actions, it would be impossible for the Engineer to accurately verify compliance or in many cases the level of compliance with the requirements of the contract documents.

Quality Control (QC): The sum total of operational techniques and activities performed or conducted by the contractor and/or producer to make sure that a product meets contract specification requirements. QC activities generally are outlined in a contractor's process control plan which lists such items as types of tests to be performed, sampling locations, sampling frequencies, equipment calibration procedures and frequencies, and documentation procedures.

Quality Control Plan: A project-specific document prepared by the contractor that identifies all QC personnel and procedures that will be used to maintain all production and placement processes "in control" and meet the agency specification requirements. The document also addresses actions to be taken in the event that a process goes "out of control."

Qualified Laboratories: Laboratories used for sampling and testing of materials are those approved through appropriate programs as determined by KDOT.

Quality Level Analysis: A statistical procedure that provides an estimate of the percentage of a given lot that is within specification limits (*PWL*) or outside specifications limits (*PD*).

Qualified Technician: Personnel who are certified through appropriate programs as determined by KDOT.

Rejectable Quality Level (RQL): The level of established actual quality for a quality characteristic that is rejectable when using a particular quality measure.

Replicate Tests: Tests performed by independent assurance personnel using equipment other than that used by project personnel but performed on a portion of the sample used by project personnel.

Seller's Risk (α): Also called *contractor's risk,* or *risk of a type 1* or *alpha (α) error.* The risk to the contractor of having acceptable quality level *(AQL)* material or workmanship rejected.

Split Samples: Sampling and splitting of the material conducted under the observation of independent assurance personnel. Tests on separate portions are performed by KDOT designated independent assurance personnel using equipment other than that used by project personnel.

Target Value: The value that is placed on a quality characteristic that represents the mean of the expected distribution of the specified population.

Upper Specification Limit (USL): The upper statistically based limiting value associated with a quality characteristic and used with a quality measure to evaluate the quality of a lot.

Verification Sampling and Testing: Sampling and testing performed to validate the quality of the product or to check the adequacy of mix designs. If quality control sampling and testing is used in the acceptance program, verification sampling and testing will also be used to validate the quality control sampling and testing. Verification samples are independent samples obtained by KDOT.

K-TRAN

KANSAS TRANSPORTATION RESEARCH AND NEW-DEVELOPMENT PROGRAM

Kansas
Department of Transportation