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Efficient Construction Material Testing and Inspection Based on Risk Levels

Revised Final Report

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16. Abstract The South Dakota Department of Transportation (SDDOT) uses a traditional approach to construction inspection and material testing. Research in the early 1990s, Project SD91-05: Essential Testing and Inspection Levels help set the current inspection and testing program. Due to this report being more than 30 years old, SDDOT has taken steps to review the feasibility of implementing risk-based approaches to construction inspection and material testing. Risk-based approaches focus on the value of each material test and inspection type, helping agencies direct resources to where they provide the most value and reduce the risk to end quality and performance. This, in turn, reduces impacts on cost, schedule, and safety. Therefore, due to limited resources, this research project investigates the current construction material testing and inspection program to determine frequencies and, if appropriate, modify it using risk-based approaches. To accomplish this, the research team conducted an intensive literature review, focus group interviews with SDDOT personnel and third-party contractors and consultants, and case studies with five state DOTs. A risk assessment was conducted using a list of material testing and construction inspection activities. Each activity was rated by 19 SDDOT field personnel, and an average expected value was calculated to identify the top-risky material testing and construction inspection activities. The risk assessment condensed down the list of material testing activities to 72 and construction inspection activities to 35. Then, a quantitative analysis of material testing and construction inspection data for 189 projects from the material sampling and testing (MS&T) was conducted. This analysis confirmed the risk assessment and yielded failure rates for material testing activities. Furthermore, the rankings were validated using construction inspection diaries (287 field events across 51 projects, 2020-2026), with nearly 90% of the top-ranked inspection		

activities confirmed by field evidence. A staffing analysis of 83 projects found that inspection effort tracks project size rather than activity risk and is concentrated among a few lead inspectors, which reinforces the case for a risk-based program that directs limited resources to where they add the most value. The results of the data collection, review, and subsequent analyses result in a series of recommendations and priorities to adjust material testing and construction inspection frequencies at SDDOT using risk-based approaches.

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TABLE OF CONTENTS

DISCLAIMER	2
ACKNOWLEDGEMENTS	2
TECHNICAL REPORT STANDARD TITLE PAGE	3
TABLE OF CONTENTS	5
LIST OF TABLES	9
LIST OF FIGURES	12
TABLE OF ACRONYMS	13
EXECUTIVE SUMMARY	17
BACKGROUND AND PROBLEM DESCRIPTION	17
RESEARCH OBJECTIVES	17
RESEARCH APPROACH	17
REQUIREMENTS, PRACTICES, AND TECHNOLOGIES	18
RISK ASSESSMENT AND STAKEHOLDER INPUT	18
MATERIAL TESTING PRIORITIES	18
CONSTRUCTION INSPECTION PRIORITIES	19
FIELD STAFFING AND WORKFORCE	19
RECOMMENDATIONS	19
1. <i>Implement Risk-Based Material Testing Priorities</i>	19
2. <i>Prioritize Construction Inspection by Impact and Frequency</i>	20
3. <i>Plan Field Staffing Around Risk and Seasonal Demand</i>	20
4. <i>Modernize Data Systems and Adopt Field Technologies</i>	20
1.0 PROBLEM DESCRIPTION	21
2.0 RESEARCH OBJECTIVES	22
2.1 REVIEW REQUIREMENTS AND PRACTICES COMMONLY USED FOR CONSTRUCTION MATERIAL TESTING AND INSPECTION BY THE FEDERAL HIGHWAY ADMINISTRATION (FHWA), AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO), AND STATE TRANSPORTATION AGENCIES	22
2.2 REVIEW SDDOT'S MATERIAL TESTING AND INSPECTION FOR ALL CONSTRUCTION ACTIVITIES AND EVALUATE THE LEVEL OF RISK ASSOCIATED WITH EACH ACTIVITY	22
2.3 PRIORITIZE AND RECOMMEND POTENTIAL MODIFICATIONS TO THE SDDOT CONSTRUCTION MATERIAL TESTING AND INSPECTION FREQUENCIES BASED ON RISK-BASED ANALYSIS	22

2.4	RECOMMEND WAYS TO IMPROVE THE EFFICIENCY OF CONSTRUCTION MATERIAL TESTING AND INSPECTION WHILE CONSIDERING CURRENT AND EMERGING TECHNOLOGIES.	22
3.0	TASK DESCRIPTIONS	24
3.1	MEET WITH THE PROJECT TECHNICAL PANEL TO REVIEW THE PROJECT SCOPE AND WORK PLAN.	24
3.2	PERFORM A LITERATURE REVIEW OF RELEVANT INFORMATION FROM THE FHWA, AASHTO, AND SURROUNDING STATE TRANSPORTATION AGENCIES.	24
3.3	REVIEW SDDOT’S CONSTRUCTION MATERIAL TESTING AND INSPECTION PROGRAM.	24
3.4	CONDUCT CASE STUDIES WITH STATE TRANSPORTATION AGENCIES.	25
3.5	SUBMIT TECHNICAL MEMORANDUM #1.	25
3.6	IDENTIFY AND EVALUATE THE LEVEL OF RISK WITH THE CURRENT SDDOT CONSTRUCTION MATERIAL TESTING AND INSPECTION PROGRAM.	25
3.7	DEVELOP RECOMMENDATIONS, PRIORITIZATION, AND IMPLEMENTATION STRATEGIES FOR THE FREQUENCIES OF SDDOT CONSTRUCTION MATERIALS TESTS AND INSPECTIONS.	28
3.8	SUBMIT TECHNICAL MEMORANDUM #2.	28
3.9	PREPARE FINAL REPORT AND ASSOCIATED DELIVERABLES.	28
3.10	MAKE AN EXECUTIVE PRESENTATION TO THE SDDOT RESEARCH REVIEW BOARD.	28
4.0	FINDINGS AND CONCLUSIONS	29
4.1	RESEARCH OBJECTIVE #1: REVIEW REQUIREMENTS AND PRACTICES COMMONLY USED FOR MATERIAL TESTING AND CONSTRUCTION INSPECTION	29
4.1.1	<i>Federal Regulations</i>	30
4.1.2	<i>Risk-Based Inspection Methods</i>	32
4.1.3	<i>Current Construction Material Testing and Inspection Practices at State DOTs</i>	39
4.1.4	<i>Existing and Emerging Inspection Technologies</i>	57
4.2	RESEARCH OBJECTIVE #2: REVIEW SDDOT’S CONSTRUCTION MATERIAL TESTING AND INSPECTION PROGRAM	60
4.2.1	<i>SDDOT Reports and Manuals Used for Construction Material Testing and Inspection</i>	61
4.2.2	<i>Risk Assessment of Construction Material Testing and Inspection Activities</i>	62
4.2.3	<i>Interviews with SDDOT Personnel, Contractors, and Material Suppliers</i>	65
4.2.4	<i>Interviews with Contractors, Consultants, and Material Suppliers</i>	76
4.2.5	<i>Case Studies with State DOTs</i>	81
4.3	RESEARCH OBJECTIVE #3: PRIORITIZE AND RECOMMEND POTENTIAL MODIFICATIONS TO SDDOT CONSTRUCTION MATERIAL TESTING AND INSPECTION	123
4.3.1	<i>Material Testing Activities</i>	123

4.3.2	<i>Material Testing Priorities</i>	138
4.3.3	<i>Construction Inspection Activities</i>	142
4.3.4	<i>Construction Inspection Priorities</i>	152
4.4	RESEARCH OBJECTIVE #4: RECOMMEND WAYS TO IMPROVE THE EFFICIENCY OF CONSTRUCTION MATERIAL TESTING AND INSPECTION	159
4.4.1	<i>Decision Support for Material Testing and Construction Inspection</i>	159
4.4.2	<i>Field Staffing for Material Testing and Construction Inspection</i>	172
5.0	RECOMMENDATIONS.....	181
5.1	ADOPT A RISK-BASED FRAMEWORK FOR MATERIAL TESTING AND CONSTRUCTION INSPECTION.....	181
5.2	MAINTAIN FULL TESTING FREQUENCY FOR HIGH-PRIORITY MATERIAL TESTS	181
5.3	REDUCE TESTING FREQUENCY FOR LOW-PRIORITY MATERIAL TESTS	182
5.4	CONTINUE ROUTINE TESTING FOR LOW-RISK ACTIVITIES WITH HIGH FAILURE RATES	182
5.5	TIE TESTING-FREQUENCY DECISIONS TO PROJECT SCOPE AND CHARACTERISTICS	182
5.6	REDUCE DUPLICATIVE TESTING ACROSS SDDOT, CONTRACTORS, AND SUPPLIERS	183
5.7	PRIORITIZE CONSTRUCTION INSPECTION ACTIVITIES USING COMBINED IMPACT AND FREQUENCY	183
5.8	PROVIDE CONTINUOUS INSPECTION FOR HIGH-IMPACT, HIGH-FREQUENCY ACTIVITIES.....	183
5.9	MANAGE HIGH-FREQUENCY, LOWER-SEVERITY ACTIVITIES THROUGH ACCEPTANCE TESTING AND PROCESS CONTROL	184
5.10	USE HOLD-POINT INSPECTIONS FOR HIGH-IMPACT, LOW-FREQUENCY ACTIVITIES	184
5.11	APPLY STANDARDIZED CHECKLISTS FOR ROUTINE, LOW-RISK INSPECTION ACTIVITIES	184
5.12	MAINTAIN AN IMPACT MINIMUM SO THAT RARE BUT HIGH-IMPACT INSPECTION ACTIVITIES STAY UNDER CLOSE OBSERVATION	185
5.13	USE STAFFING BENCHMARKS AND SEASONAL DEMAND TO PLAN INSPECTOR ASSIGNMENTS	185
5.14	PROTECT THE EXPERIENCED INSPECTION CORE THROUGH CROSS-TRAINING AND SUCCESSION PLANNING	185
5.15	MODERNIZE THE DATA SYSTEM AND ADOPT FIELD TECHNOLOGIES TO SUPPORT RISK-BASED MANAGEMENT	186
6.0	RESEARCH BENEFITS	187
7.0	REFERENCES.....	189
8.0	APPENDIX A: ANNOTATED BIBLIOGRAPHY	199
	APPENDIX B: INTERVIEW QUESTIONS FOR SDDOT PERSONNEL	210
	APPENDIX C: INTERVIEW QUESTIONS FOR CONTRACTORS AND CONSULTANTS	213
	APPENDIX D: INTERVIEW QUESTIONS FOR MATERIAL SUPPLIERS.....	215
	APPENDIX E: CASE STUDY QUESTIONNAIRE.....	217

APPENDIX F: MATERIAL TESTING ACTIVITIES COMPILED FROM SDDOT MATERIALS MANUAL – MSTR INFORMATION.....	220
APPENDIX G: CONSTRUCTION INSPECTION ACTIVITIES COMPILED FROM SDDOT MANUALS.....	234
APPENDIX H: SUMMARY OF MATERIAL TESTING AND CONSTRUCTION INSPECTION TECHNOLOGIES	237
APPENDIX I: MATERIAL TESTING ACTIVITIES AVERAGE EXPECTED VALUES AND RANKING	247
APPENDIX J: CONSTRUCTION INSPECTION ACTIVITIES AVERAGE EXPECTED VALUES AND RANKING	251
APPENDIX K: 189 SDDOT PROJECTS REVIEWED FOR MATERIAL TESTING FROM THE MS&T	253
APPENDIX L: 51 SDDOT PROJECTS REVIEWED FOR CONSTRUCTION INSPECTION DAILY DIARY EVENTS.....	263
APPENDIX M: 83 SDDOT PROJECTS REVIEWED FOR FIELD PERSONNEL STAFFING	266

LIST OF TABLES

TABLE 1: CORE ELEMENTS OF A CONSTRUCTION QA PROGRAM	30
TABLE 2: RATING SCALE FOR OCCURRENCE FACTOR (NASEM, 2014)	38
TABLE 3: RATING SCALE FOR IMPACT FACTORS (NASEM, 2014)	39
TABLE 4: RISK ASSESSMENT FACTORS (TRAN AND MOHAMED, 2021)	45
TABLE 5: INSPECTION PRESENCE FOR RISK-BASED INSPECTION OF MAJOR WORK TYPES (TAYLOR ET AL., 2021).....	47
TABLE 6: PROJECT COMPONENTS AND RISK LEVELS CATEGORIZED BY MDOT (MISSISSIPPI DOT, 2021)	48
TABLE 7: PAY ITEMS IN SPECIFIC PROJECT PHASE WITH RISK LEVEL (MISSISSIPPI DOT, 2021).....	49
TABLE 8: NYSDOT ANALYSIS CATEGORIES FOR VERIFICATION TESTING (NASEM, 2017).....	51
TABLE 9: TXDOT'S THREE TIERS OF VERIFICATION TESTS (TEXAS DOT, 2017)	53
TABLE 10: EXAMPLE OF TXDOT ANALYSIS CATEGORIES FOR OWNER VERIFICATION FOR EMBANKMENTS (CUTS AND FILLS)	53
TABLE 11: EXAMPLE OF WISDOT CONSTRUCTION INSPECTION OPERATIONS (WISCONSIN DOT, 2018)	55
TABLE 12: SAMPLE OF RISK-BASED MATERIAL TESTING AND CONSTRUCTION INSPECTION IN USE BY DOTs (NASEM, 2023)	57
TABLE 13: STATE DOT INSPECTION PROGRAMS.....	57
TABLE 14: EMERGING MATERIAL TESTING AND CONSTRUCTION INSPECTION TECHNOLOGIES	58
TABLE 15: RISK MATRIX USED FOR THE TASK 3 ROUND TWO RISK ASSESSMENT	63
TABLE 16: TOP 10 HIGHEST EXPECTED VALUES FOR MATERIAL TESTING ACTIVITIES.....	64
TABLE 17: TOP 10 HIGHEST EXPECTED VALUES FOR CONSTRUCTION INSPECTION ACTIVITIES	64
TABLE 18: RISK ASSESSMENT RESULTS FOR MATERIAL TESTING CATEGORIES	65
TABLE 19: RISK ASSESSMENT RESULTS FOR CONSTRUCTION INSPECTION CATEGORIES	65
TABLE 20: NUMBER OF INTERVIEWEES FROM EACH SDDOT REGION.....	66
TABLE 21: ROLE DESCRIPTIONS FOR SDDOT TECHNICIANS AND PROJECT ENGINEERS	66
TABLE 22: TECHNOLOGIES USED TO SUPPORT MATERIAL TESTING AND CONSTRUCTION INSPECTION	70
TABLE 23: FEEDBACK ON THE INITIAL RISK ASSESSMENT FOR MATERIAL TESTING.....	70
TABLE 24: FEEDBACK ON CONSTRUCTION INSPECTION RISK ASSESSMENT	72
TABLE 25: CHALLENGES IN TESTING AND INSPECTION OF KEY CONSTRUCTION ELEMENTS	80
TABLE 26: TIER LEVELS BASED ON IMPACT OF FAILURE (CALTRANS, 2023)	84
TABLE 27: CALTRANS PROGRAMMATIC APPROACHES TO MATERIAL TESTING	85
TABLE 28: LIST OF DOCUMENTS REVIEWED FOR SDDOT PROJECTS IN THE MS&T SYSTEM	123
TABLE 29: UNCLASSIFIED EXCAVATION TESTING ANALYSIS RESULTS	124

TABLE 30: SUBBASE, BASE COURSE, CUSHION MATERIAL TESTING ANALYSIS RESULTS	125
TABLE 31: FDR TESTING ANALYSIS RESULTS	126
TABLE 32: ASPHALT CONCRETE TESTING ANALYSIS RESULTS	126
TABLE 33: ASPHALT LIQUID TESTING ANALYSIS RESULTS	127
TABLE 34: ASPHALT SURFACE TREATMENT TESTING ANALYSIS RESULTS	128
TABLE 35: PCC PAVEMENT TESTING ANALYSIS RESULTS	129
TABLE 36: PIPE AND BOX CULVERT UNDERCUT BACKFILL TESTING ANALYSIS RESULTS	130
TABLE 37: GRANULAR BRIDGE END BACKFILL & BRIDGE END EMBANKMENT TESTING ANALYSIS RESULTS	130
TABLE 38: PCC STRUCTURES TESTING ANALYSIS RESULTS	131
TABLE 39: PRE-CAST AND PRE-STRESSED CONCRETE TESTING ANALYSIS RESULTS	132
TABLE 40: FAILURE AND CORRECTION RATES FOR THE TOP 30 CONSTRUCTION MATERIAL TESTING ACTIVITIES	133
TABLE 41: SUMMARY OF TESTING ACTIVITIES WITH HIGH FAILURE RATES AND ASSOCIATED RISK ASSESSMENT RANK	136
TABLE 42: SUMMARY OF TESTING ACTIVITIES WITH MODERATE FAILURE RATES AND ASSOCIATED RISK ASSESSMENT RANK	136
TABLE 43: SUMMARY OF TESTING ACTIVITIES WITH LOW FAILURE RATES AND ASSOCIATED RISK ASSESSMENT RANK	137
TABLE 44: SUMMARY OF HIGH-PRIORITY MATERIAL TESTING ACTIVITIES	139
TABLE 45: SUMMARY OF MEDIUM-PRIORITY MATERIAL TESTING ACTIVITIES	140
TABLE 46: SUMMARY OF LOW PRIORITY MATERIAL TESTING ACTIVITIES	141
TABLE 47: DOCUMENTED EVENTS FOR ROADWAY AND DRAINAGE EXCAVATION AND EMBANKMENT CONSTRUCTION INSPECTIONS	143
TABLE 48: DOCUMENTED EVENTS FOR ASPHALT CONCRETE INSPECTIONS	144
TABLE 49: DOCUMENTED EVENTS FOR PCC PAVEMENT INSPECTIONS	145
TABLE 50: DOCUMENTED EVENTS FOR STRUCTURAL CONCRETE	146
TABLE 51: DOCUMENTED EVENTS FOR DRILLED SHAFT CONSTRUCTION INSPECTIONS	146
TABLE 52: DOCUMENTED EVENTS FOR PIPE CULVERT INSPECTIONS	147
TABLE 53: DOCUMENTED EVENTS FOR BRIDGE DECK PREPARATION AND RESURFACING INSPECTIONS	147
TABLE 54: DOCUMENTED EVENTS FOR REINFORCING STEEL INSPECTIONS	148
TABLE 55: BOX, PIPE, AND PLATE PIPE CULVERT UNDERCUTTING	148
TABLE 56: DOCUMENTED EVENTS FOR BRIDGE END BACKFILL INSPECTIONS	149
TABLE 57: DOCUMENTED EVENTS FOR TEMPORARY TRAFFIC CONTROL INSPECTIONS	149
TABLE 58: DOCUMENTED EVENTS FOR TRAFFIC SIGNALS AND ROADWAY LIGHTING INSPECTIONS	150
TABLE 59: DOCUMENTED EVENTS FOR STEEL BEAM GUARDRAIL INSPECTIONS	150

TABLE 60: CONFIRMATION CATEGORIES FOR THE TOP 20 TASK 3 CONSTRUCTION INSPECTION ACTIVITIES	151
TABLE 61: CATEGORIES FOR THE TOP 20 CONSTRUCTION INSPECTION ACTIVITIES	151
TABLE 62: STRONGLY CONFIRMED CONSTRUCTION INSPECTION ACTIVITIES	153
TABLE 63: RELATIVE SCORE RANKING AND PRIORITY TIERS	156
TABLE 64: PROJECT-LEVEL RISK DENSITY (TOP 10 BY SEVERITY-WEIGHTED SCORE).....	158
TABLE 65: TESTING ACTIVITIES RECOMMENDATIONS FOR ASPHALT CONSTRUCTION.....	162
TABLE 66: PRIORITY LEVELS FOR ASPHALT CONSTRUCTION INSPECTION ACTIVITIES.....	163
TABLE 67: TESTING ACTIVITIES RECOMMENDATIONS FOR SUBBASE, BASE, AND GRANULAR MATERIALS.....	164
TABLE 68: PRIORITIES FOR GRANULAR BASES AND SURFACING CONSTRUCTION INSPECTION ACTIVITIES	165
TABLE 69: TESTING ACTIVITIES RECOMMENDATIONS FOR SUBGRADE AND EARTHWORK CONSTRUCTION.....	166
TABLE 70: PRIORITIES FOR SUBGRADE AND EARTHWORK CONSTRUCTION INSPECTION ACTIVITIES	166
TABLE 71: TESTING ACTIVITIES RECOMMENDATIONS FOR PCC PAVEMENT CONSTRUCTION	167
TABLE 72: PRIORITIES FOR PCC PAVEMENT CONSTRUCTION INSPECTION ACTIVITIES	168
TABLE 73: TESTING ACTIVITIES RECOMMENDATIONS FOR PCC STRUCTURES CONSTRUCTION	168
TABLE 74: PRIORITIES FOR PCC STRUCTURES CONSTRUCTION INSPECTION ACTIVITIES	169
TABLE 75: TESTING ACTIVITIES RECOMMENDATIONS FOR MISCELLANEOUS INCIDENTAL MATERIALS	171
TABLE 76: PRIORITIES FOR INCIDENTAL CONSTRUCTION INSPECTION ACTIVITIES	172
TABLE 77: MATERIAL TESTING AND CONSTRUCTION INSPECTION STAFFING BY PROJECT TYPE.....	174
TABLE 78: PROGRAM-LEVEL WORKLOAD MEASURES (2020 – 2026) (N = 83 PROJECTS).....	179

LIST OF FIGURES

FIGURE 1: TYPICAL RISK-BASED INSPECTION PROCESS (AMERICAN PETROLEUM INSTITUTE, 2016)	33
FIGURE 2: RISK MATRIX EXAMPLE	34
FIGURE 3: TRADITIONAL INSPECTION VS. RISK-BASED INSPECTION (SOARES ET AL., 2015)	35
FIGURE 4: IDENTIFICATION OF INDOT CORE INSPECTION ITEMS (XU ET AL., 2019)	41
FIGURE 5: INDIANA DOT FLOWCHART FOR RISK ASSESSMENT OF CONSTRUCTION INSPECTION ACTIVITIES (XU ET AL., 2019)	42
FIGURE 6: INSPECTION PRIORITY LEVELS BY INDOT (MOSTAFAVI AND ABRAHAM, 2012)	43
FIGURE 7: KDOT QA ACCEPTANCE SYSTEM (KANSAS DOT, 2022)	44
FIGURE 8: SAMPLE OF KANSAS DOT INSPECTION AND TESTING ACTIVITIES (NASEM, 2023)	46
FIGURE 9: TYPICAL RISK-BASED INSPECTION PROCESS (NASEM, 2023)	56
FIGURE 10: OQASI RISK ASSESSMENT MATRIX (CALTRANS, 2023)	83
FIGURE 11: CALTRANS SOURCE INSPECTION FLOWCHART (CALTRANS, 2024)	88
FIGURE 12: OHIO DOT INSPECTION FREQUENCY TIER SYSTEM (RUSH, 2021)	98
FIGURE 13: CURRENT INSPECTION PRACTICE FLOWCHART AT SCDOT (CAI ET AL., 2022)	107
FIGURE 14: EXAMPLE LEVEL OF INSPECTION REQUIRED FOR SPECIFIED TYPE OF WORK (VIRGINIA DOT, 2018A)	110
FIGURE 15: WSDOT MATERIAL ACCEPTANCE RATING MATRIX (NASEM, 2017)	117
FIGURE 16: WSDOT INSPECTOR TRAINING PROGRAM (WASHINGTON STATE DOT, 2025A)	120
FIGURE 17: RISK RANKING AND FAILURE RATE FOR TOP 30 MATERIAL TESTING ACTIVITIES	138
FIGURE 18: UNDER-RANKED ACTIVITIES FROM THE FIELD EVIDENCE	155
FIGURE 19: CONSTRUCTION INSPECTION ACTIVITIES PRIORITY MATRIX	158
FIGURE 20: DISTRIBUTION OF CONSTRUCTION-INSPECTION HOURS BY PROJECT TYPE (N = 83 PROJECTS)	176
FIGURE 21: STAFFING BENCHMARK BY PROJECT TYPE (N = 83 PROJECTS)	177
FIGURE 22: MEDIAN NUMBER OF INSPECTORS PER PROJECT PER SDDOT REGION (N = 83 PROJECTS)	177
FIGURE 23: STAFFING INCREASE FOR HIGH, MEDIUM, AND LOW PROJECT PROFILE CLASSIFICATIONS	178
FIGURE 24: NUMBER OF PROJECTS STARTED IN EACH CALENDAR MONTH (N = 83 PROJECTS)	179

TABLE OF ACRONYMS

Acronym	Definition
AASHTO	American Association of State Highway and Transportation Officials
ACEC	American Council of Engineering Companies
ADOT	Arizona Department of Transportation
ACI	American Concrete Institute
AGC	Associated General Contractors
AI	Artificial Intelligence
AMG	Automated Machine Guidance
APL	Approved Products List
app	Application
ASTM	American Society for Testing and Materials
BIM	Building Information Modeling
Caltrans	California Department of Transportation
CDOT	Colorado Department of Transportation
CE&I	Construction Engineering and Inspection
CFR	Code of Federal Regulations
CI	Composite Index
CII	Construction Industry Institute
CIP	Cast In Place
CMGC	Construction Manager/General Contractor
CN	Construction
COC	Certificate of Compliance
CoQ	Cost of Quality
CQMP	Construction Quality Management Plan
CTMM	Concrete Temperature and Maturity Meter
CTR	Certified Test Result
DAPA	Dakota Asphalt Paving Association
DB	Design Build
DBB	Design Bid Build
DEM	Digital Elevation Modeling
DES	Division of Engineering Services
DIME	Data Interchange for Materials Engineering
DOE	Department of Energy

Acronym	Definition
DOT	Department of Transportation
DSLR	Digital Single-Lens Reflex
DSMs	Digital Surface Models
DTM	Digital Terrain Modeling
EBL	Eastbound Lanes
EV	Expected Value
FAA	Federal Aviation Administration
FC	Friction Course
FDOT	Florida Department of Transportation
FDR	Full Depth Reclamation
FHWA	Federal Highway Administration
FSTM	Florida Sampling and Testing Methods
FTE	Full Time Equivalent
GIS	Geographic Information Systems
GNSS	Global Navigation Satellite System
GPR	Ground Penetrating Radar
GPS	Global Positioning System
HDPE	High-Density Polyethylene
HEV	Highest Expected Value
HMA	Hot Mix Asphalt
IA	Independent Assurance
IC	Intelligent Compaction
IDOT	Illinois Department of Transportation
INDOT	Indiana Department of Transportation
KDOT	Kansas Department of Transportation
KYTC	Kentucky Transportation Cabinet
LiDAR	Light Detection and Ranging
LIMS	Laboratory Information Management System
LOIP	Levels of Inspection Presence
LPA	Local Public Agency
METS	Materials Engineering and Testing Services
MDOT	Mississippi Department of Transportation
MDSHA	Maryland State Highway Administration

Acronym	Definition
MnDOT	Minnesota Department of Transportation
MS	Microsoft
MS&T	Material Sampling and Testing
MSTR	Minimum Sample and Test Requirements
NASEM	National Academies of Sciences, Engineering, and Medicine
NCHRP	National Cooperative Highway Research Program
NHDOT	New Hampshire Department of Transportation
NHS	National Highway System
NS	Non-regulatory Supplement
NYSDOT	New York State Department of Transportation
ODOT	Ohio Department of Transportation
OQASI	Office of Quality Assurance and Source Inspection
P3	Public-Private Partnerships
PCC	Portland Cement Concrete
PCCP	Portland Cement Concrete Pavement
PCN	Project Control Number
PDF	Portable Document Format
PennDOT	Pennsylvania Department of Transportation
PMI	Project Management Institute
PMTP	Paver-Mounted Thermal Profiler
PPG	Project Procedures Guide
PWL	Percent Within Limits
QA	Quality Assurance
QAP	Quality Assurance Program
QASI	Quality Assurance and Source Inspection
QC	Quality Control
QMP	Quality Management Plan
QPL	Qualified Products List
RF	Risk Factor
RSTC	Required Samples, Tests, and Certificates
RTK	Real Time Kinematic
RTS	Robotic Total Station
SCDOT	South Carolina Department of Transportation

Acronym	Definition
SD	South Dakota
SDDOT	South Dakota Department of Transportation
SHRP2	Second Strategic Highway Research Program
SME	Subject Matter Expert
SP	Superpave
TMP	Transportation Management Plan
TQM	Total Quality Management
TRB	Transportation Research Board
TRID	Transportation Research Information Documentation
TxDOT	Texas Department of Transportation
UAS	Uncrewed Aircraft System
UAV	Uncrewed Aircraft Vehicle
UDOT	Utah Department of Transportation
UHPC	Ultra High Performance Concrete
VDOT	Virginia Department of Transportation
WAQTC	Western Alliance for Quality Transportation Construction
WBL	Westbound Lanes
WisDOT	Wisconsin Department of Transportation
WSDOT	Washington State Department of Transportation

EXECUTIVE SUMMARY

The South Dakota Department of Transportation (SDDOT) relies on a construction material testing and inspection program whose frequencies trace back to Project SD91-05, completed in the early 1990s. Because that study is more than 30 years old, SDDOT conducted this research to determine whether risk-based approaches could direct limited testing and inspection resources more efficiently. Risk-based testing and inspection approaches focus effort on the activities that deliver the greatest value and pose the greatest risk to quality and performance, thereby reducing impacts on cost, schedule, and safety. This executive summary presents the background, methods, findings, and recommendations developed to help SDDOT modify its material testing and construction inspection frequencies using risk-based approaches.

Background and Problem Description

SDDOT's testing and inspection requirements were established when the agency's workload, materials, and technologies differed substantially from those of today. Field personnel are a limited resource, and inspectors are routinely shared across several active projects, particularly during the spring and summer construction season, while the number and complexity of highway construction projects continue to grow. With limited resources, SDDOT needs to understand where testing and inspection efforts are essential, where they can be reduced, and how staffing strategies and emerging technologies can improve efficiency without compromising quality or safety. This research was undertaken to provide that understanding and to recommend modifications to the current program.

Research Objectives

The research included four objectives. The first objective was to review the requirements and practices commonly used by the FHWA, AASHTO, and state DOTs for construction material testing and inspection. The second objective was to review SDDOT's material testing and inspection activities and evaluate the level of risk associated with each. The third objective was to prioritize and recommend potential modifications to SDDOT's testing and inspection frequencies based on risk-based analysis. The fourth objective was to recommend ways to improve the efficiency of material testing and construction inspection while considering current and emerging technologies.

Research Approach

The research team completed ten tasks. The work began with a literature review of FHWA, AASHTO, and state DOT practices, focus-group interviews with SDDOT personnel, contractors, consultants, and material suppliers, and case studies with five state DOTs (California, Ohio, South Carolina, Virginia, and Washington State). A risk assessment was then conducted in which 19 experienced SDDOT field personnel rated material testing and construction

inspection activities, and an average expected value was calculated to rank them by their impact on cost, safety, and service interruption. The resulting rankings were validated quantitatively using material sampling and testing (MS&T) records from 189 projects, construction inspection daily diaries from 51 projects (287 documented field events from 2020 to 2026), and a field staffing analysis of 83 state-administered projects (96 projects were reviewed; 13 consultant-supported projects were excluded).

Requirements, Practices, and Technologies

The review of federal and state practice confirmed that risk-based approaches to material testing and construction inspection are established across the industry and have been implemented successfully by agencies with programs similar to SDDOT. Peer states use methods such as tiered verification testing, work-type-based inspection presence, and risk-categorized pay items to focus oversight where it matters most. The review also documented a range of existing and emerging technologies, including e-ticketing, mobile and laptop field applications, intelligent compaction, ground-penetrating radar, and uncrewed aerial systems, which can improve data quality and reduce the effort required for testing and inspection. SDDOT has already limited use of some of these tools, such as GPS positioning and e-ticketing, although adoption varies across the SDDOT Regions.

Risk Assessment and Stakeholder Input

The risk assessment revealed 72 material testing and 35 construction inspection activities identified as the highest-risk activities in each group. Fresh Concrete Tests and Compressive Strength Tests for PCC Structures ranked highest among material tests, while Structural Concrete and Temporary Traffic Control ranked highest among inspection activities. Interviews with SDDOT personnel, contractors, consultants, and material suppliers emphasized that collaboration and transparency are essential to the success of any program change, and that materials are often tested redundantly by suppliers, contractors, and the agency. Stakeholders also cautioned that any reduction in testing should be implemented carefully to avoid shifting perceived risk to contractors.

Material Testing Priorities

The analysis of 189 projects confirmed that risk is unevenly distributed across material tests and produced failure rates that, combined with the risk rankings, define testing priorities. High-priority tests combine top rankings with elevated failure rates. For example, Sieve Analysis and In-Place Density for Granular Bridge-End Backfill (ranked 5th and 6th, failing 11.4% and 6.7% of the time, respectively) should retain their full testing frequencies. Many low-risk activities such as Cement, Fly Ash, and several asphalt liquid tests recorded failure rates at or near 0.0% and are candidates for reduced frequency. A few low-ranked activities fail frequently (SS-1h or CSS-1h Asphalt for Fog Seal at 25.0% and Mineral Aggregate for

Microsurfacing at 19.5%) and should continue to be tested regularly. This demonstrates that both risk ranking and observed failure rate must be weighed together to determine material testing activity priorities.

Construction Inspection Priorities

Field evidence from project daily diaries confirmed nearly 90% of the highest-ranked construction inspection activities, validating the risk assessment while adding an important component: how often problems actually occur. Structural Concrete and Temporary Traffic Control are the most critical activities in terms of impact. However, Asphalt Concrete and Roadway and Drainage Excavation and Embankment Construction generated the most field events (43 and 25, respectively). Combining impact with event frequency into a relative score sorts the 35 construction inspection activities into critical, high, and standard tiers and points to four inspection strategies: continuous inspection with hold points for high-impact, high-frequency work; acceptance testing and process control for high-frequency, lower-severity work; targeted hold-point inspection for rare but severe work; and standardized checklists for routine, low-risk work.

Field Staffing and Workforce

The staffing analysis of 83 projects found that inspection effort tracks project size rather than activity risk. Most project categories average fewer than 1 full-time-equivalent (FTE) inspector, confirming that inspectors are routinely shared across projects and allocated to where they are needed the most. Demand is strongly seasonal, peaking at roughly 35 full-time-equivalent inspectors during the summer, when the most projects and the most high-risk work are active. The workload also rests on a small, experienced core: the busiest 10% of inspectors accounted for 58% of all hours across the 83 projects reviewed. Project-type and profile benchmarks developed in this research provide SDDOT with practical tools to forecast staffing needs and concentrate resources on bridge-heavy, multi-phase projects where testing and inspections are critical.

Recommendations

Based on these findings, the research team developed recommendations (See [Section 5.0](#)) for SDDOT to consider when modifying its material testing and construction inspection program. The recommendations fall into four areas as summarized below.

1. Implement Risk-Based Material Testing Priorities

SDDOT should set testing frequencies based on each activity's Task 3 risk ranking and Task 6 failure rate, rather than applying uniform requirements. High-priority testing activities should not be subject to reduced testing frequency. Low-risk, low-failure testing activities should be reduced to free up time for higher-value work, such as high-priority inspection activities.

However, low-ranked but frequently failing testing activities should continue at full frequency. Frequency decisions should be made at the project level, and duplicative testing across multiple parties should be reduced where results consistently meet specification.

2. Prioritize Construction Inspection by Impact and Frequency

SDDOT should prioritize the 35 inspection activities using a relative score that combines assessed impact with how often each activity generates field events. High-impact, high-frequency work such as Structural Concrete and Temporary Traffic Control warrants continuous inspection with hold points; high-frequency, lower-severity work such as Asphalt Concrete and Earthwork is best managed through acceptance testing and process control; and rare but severe work such as Drilled Shafts Construction warrants targeted hold-point inspection, retained through an impact floor even when field evidence is limited.

3. Plan Field Staffing Around Risk and Seasonal Demand

SDDOT should use the staffing benchmarks derived from the project types and profile classifications, along with the seasonal demand profile, to forecast inspector needs and concentrate resources on bridge/structure-heavy and multi-phase projects. Because inspection expertise is concentrated in a small, experienced core that is highly utilized during the summer peak, SDDOT should invest in cross-training and succession planning to maintain inspection quality when demand is highest.

4. Modernize Data Systems and Adopt Field Technologies

SDDOT should replace the legacy MS&T system with a modern tracking platform that improves data consistency and supports ongoing risk-based management, and should consider field technologies, such as e-ticketing, mobile inspection applications, intelligent compaction, ground penetrating radar, and non-destructive devices before full deployment. Furthermore, engaging contractors and consultants in developing and testing program changes will build buy-in and sustain a cooperative QA environment.

1.0 PROBLEM DESCRIPTION

The South Dakota Department of Transportation (SDDOT) completed the research project SD91-05: Effective Testing and Inspection Levels over 30 years ago. This project has served SDDOT well, but the realities of a constrained research environment warrant a re-examination of field material testing and construction inspection processes. This examination includes the possibility of implementing a construction material testing and inspection program using a risk-based analysis approach. Using a risk-based analysis would allow SDDOT to focus on the value of material testing and the type of inspection needed, directing limited human and financial resources to construction material testing and inspection activities that would provide the most value and reduce the risk to end quality and facility performance after completion. Risks considered, but not limited to, are factors related to cost, time, quality, safety, productivity, and efficiency. In addition, technological advancements since the SD91-05 project have significantly improved construction material testing and inspection processes. Therefore, this project assesses SDDOT's current material testing and construction inspection practices, as well as the associated frequencies for performing these activities across various highway construction projects. Using this assessment, along with the collected and analyzed data and information, recommendations and prioritizations are provided to SDDOT to implement a risk-based approach to material testing and construction inspection for highway transportation construction projects.

2.0 RESEARCH OBJECTIVES

This research project aims to assess the current construction material testing and inspection program, as well as the frequency and use of these tasks on highway construction projects. Strategies, recommendations, and priorities were developed to modify the frequency of material testing and construction inspection activities and to direct workforce resources to where they provide the most value for construction operations. The following objectives were addressed to accomplish this goal.

2.1 Review requirements and practices commonly used for construction material testing and inspection by the Federal Highway Administration (FHWA), American Association of State Highway and Transportation Officials (AASHTO), and state transportation agencies.

This objective investigates the commonly used practices and essential construction material testing and inspection requirements. Tasks 2, 3, and 4 of the Research Plan address this objective, and the information and data collected and analyzed in these tasks were summarized in Technical Memorandum 1 for SDDOT review. Additionally, the information collected to address this objective was used to develop the recommendations, prioritization, and strategies for SDDOT material testing and inspection for construction in Task 7.

2.2 Review SDDOT's material testing and inspection for all construction activities and evaluate the level of risk associated with each activity.

This objective focuses on investigating and assessing the current field material testing and construction inspection program used at SDDOT to determine approaches to risk-based material testing and inspection for construction. Task 3 of the Research Plan focuses on this objective. Furthermore, the review conducted in Task 3 was used to develop the recommendations, prioritization, and implementation strategies for Tasks 6 and 7.

2.3 Prioritize and recommend potential modifications to the SDDOT construction material testing and inspection frequencies based on risk-based analysis.

Based on the information and data collected, reviewed, and evaluated in the Research Plan, the research team used Tasks 6 and 7 to develop and prioritize recommendations for modifying the current SDDOT construction material testing and inspection frequencies using risk-based analysis.

2.4 Recommend ways to improve the efficiency of construction material testing and inspection while considering current and emerging technologies.

This objective is the culmination of the research process, and our team focused on developing recommendations, strategies, and prioritization of material testing and inspection

for construction using a risk-based approach. Task 7 addresses this objective and was summarized in Technical Memorandum 2 for SDDOT review. The final report and associated deliverables will include the strategies and guidance for implementing a risk-based approach to construction material testing and inspection at SDDOT.

3.0 TASK DESCRIPTIONS

This section describes the ten individual research tasks. The SDDOT provided an outline of the tasks to be completed. Each task designates the lead research team member and the scope of work performed.

3.1 Meet with the project technical panel to review the project scope and work plan.

The research team met with the project technical panel on February 28, 2025, online using Microsoft (MS) Teams. The meeting was organized to introduce the research team to the project technical panel, review the project scope, address any questions the panel may have, and finalize the work plan.

3.2 Perform a literature review of relevant information from the FHWA, AASHTO, and surrounding state transportation agencies.

The objective of this task was for the research team to collect and review documents from the FHWA, AASHTO, and state transportation agencies to determine construction material testing and inspection practices and requirements. The review included construction material testing and inspection frequencies, who performs the testing or inspections, expected end-quality benefits, potential risks, and prioritizations based on a risk-based analysis. Additionally, current and emerging technologies that improve the efficiency of construction material testing and inspections were reviewed. [Appendix A](#) includes an annotated bibliography of documents, reports, manuals, and articles related to risk-based material testing and construction inspection.

3.3 Review SDDOT's construction material testing and inspection program.

The objective of this task was to investigate the state of practices in the construction material testing and inspection program in use at SDDOT. The investigation included reviewing relevant SDDOT documents, reports, and manuals, as well as conducting interviews with selected SDDOT personnel, general contractors who work for SDDOT, and South Dakota material suppliers. The interview questions were developed based on the literature review conducted in Task 2 and the investigation of the current SDDOT material testing and inspection program documents. The questions focused on identifying material testing and construction inspection priorities, failure rates for material testing and inspection, potential risks, resource and staffing needs, and the current technologies used by SDDOT for material testing and inspection. The questions were used to guide the interviews and to ensure consistency. The technical panel reviewed and approved the interview questions before conducting any interviews. In addition, SDDOT research staff provided the research team with names and contact information for SDDOT personnel, contractors, and materials suppliers. The interview questions are provided in [Appendix B](#) (SDDOT Personnel Interviews),

Appendix C (Contractor and Consultant Interviews), and Appendix D (Material Supplier Interviews).

3.4 Conduct case studies with state transportation agencies.

Upon approval by the technical panel, the research team conducted case studies with five state transportation agencies (California, Ohio, South Carolina, Virginia, and Washington State) on current practices for construction material testing and inspection frequencies, risk-based considerations, staffing needs, and the use of current and emerging technologies. This task aimed to investigate state transportation agencies with experience in risk-based inspection and field materials testing for construction projects to support the development of a risk-based inspection program at SDDOT. Current practices related to construction material testing and inspection frequencies were collected and discussed with state transportation agency personnel. Staffing needs and the use of emerging technologies for material testing and inspection were also investigated.

The data collection from state transportation agencies included conducting interviews with agency representatives at each case study DOT and reviewing documents, manuals, guides, and project information in which risk-based material testing and inspection were performed during construction. The questionnaire used for the case studies, as approved by the SDDOT Technical Panel, is found in Appendix E. A content analysis was then performed on the collected documents to identify common themes and nuances in risk-based field material testing and construction inspection. The interviews were transcribed to review content and collect relevant information supporting the overall research project's objectives.

3.5 Submit Technical Memorandum #1.

The research team developed Technical Memorandum #1 detailing the results of research Tasks 4.2, 4.3, and 4.4. Technical Memorandum #1 was provided electronically in Microsoft (MS) Word and Portable Document Format (PDF) formats to the project technical panel for review of the research results and findings to date. The research team scheduled a meeting with the technical panel to present the results and address any questions or concerns to date. Technical Memorandum 1 was presented to the project technical panel at a virtual meeting on October 14, 2025. A final Technical Memorandum #1 was then developed using the feedback from the panel meeting.

3.6 Identify and evaluate the level of risk with the current SDDOT construction material testing and inspection program.

Once Technical Memorandum #1 was reviewed and approved by the technical panel, the research team identified and evaluated the risk levels and testing frequencies associated with current material testing and construction inspection activities, as well as the staff and

resource needs for construction. The research team developed the initial risk-based analysis in three steps:

1. Developing a core list of material testing and inspection activities.
2. Conducting a risk assessment of material testing and construction inspection activities.
3. Verification of risk assessment by reviewing construction project testing and inspection data (Test results from the MS&T and project daily diaries).

Step 1 – Developing a core list of material testing and inspection activities. Building upon the findings from Tasks 1 through 5, this phase utilized the identified core list of construction material testing activities, shown in [Appendix E](#), and inspection activities, shown in [Appendix G](#). This stage included a top-down identification of construction material testing and inspection activities that can be conducted either as a programmatic exercise, including all the material testing activities requiring an inspection, or a more focused exercise limited to a core list of the key inspection and material testing activities. Additionally, material testing and construction inspection priorities, failure rates for testing and inspection activities, potential risks, resource/staffing needs, and current technologies used by SDDOT were identified.

The research team used expected value and benchmark data obtained through a rigorous research process for the material testing and construction inspection-related risk items. Expected value is defined as the product of the probability of occurrence of a risk event (in this case, a quality defect) and the risk impact (for example, cost of rework, safety concern, or reduction in performance or service life). The expected value is calculated by using Equation 1.

$$\text{Expected Value} = \text{Probability of Occurrence} \times \text{Risk Impact} \quad \text{Equation (1)}$$

For construction inspection-related risk items, the research team categorized the core construction inspection item list according to the Minimum Sample and Test Requirements (MSTR) section of the SDDOT's Materials Manual. The following construction practices were used in the categorization process:

1. Asphalt construction
2. Subbase, base course, and cushion construction
3. Miscellaneous granular materials
4. Subgrade construction
5. Portland Cement Concrete (PCC) paving construction

6. PCC concrete structure construction
7. Miscellaneous incidental and manufactured or fabricated items
8. Pavement restoration
9. Bridge deck restoration

Step 2 – Conducting risk assessment. Step 2 involves analyzing and evaluating risk for construction material testing and inspection activities. The research team conducted a qualitative risk assessment of the Step 1 testing and inspection activities/items list. The likelihood of failure or noncompliance for the work item and its impacts was rated. Typically, risk-based material testing and inspection assessment includes two main components:

1. The probability (or likelihood) of risk occurring (for example, material failing to meet specification) and
2. The impact (or consequence) of risk (for example, increased maintenance or realized safety issues).

A specific range of probability and impact is defined and used during the assessment. Establishing this range upfront lends structure to the analysis exercise and ensures that all participants view probability consistently.

Step 3 – Verifying Risk Assessment with Project Data. To confirm the risk assessment for material testing activities (See [Appendix I](#)), quantitative project information was collected and reviewed. For material testing activities, the Material Sampling and Testing (MS&T) system was used to review projects across each of the nine categories listed above. A total of 189 projects were reviewed, and information collected included the total tests, total passing tests, total failed tests, and total corrected tests. Failure and correction rates were then calculated for each testing activity in each project. The risk assessment and project analysis were then combined for each activity to assign whether the activity is high (Top 10 risk assessment ranking), moderate (11-30 risk assessment ranking), or low risk (31 and lower risk assessment ranking) and whether the activity has a high (Greater than 10%), (6-10%) moderate, or low (5% or less) failure rate.

To confirm the risk assessment for construction inspection activities (See [Appendix J](#)), the research team reviewed daily construction diaries from selected projects provided by SDDOT. The daily diaries provide details on construction inspections and observations that are not found in the MS&T. The daily diaries documented inspection events related to construction inspection activities that were ranked in the risk assessment.

3.7 Develop recommendations, prioritization, and implementation strategies for the frequencies of SDDOT construction materials tests and inspections.

The research team developed recommendations, prioritization, and implementation strategies for the frequencies of SDDOT construction material testing and inspections, as well as staffing needs. Additionally, the research team provided SDDOT with recommendations to enhance efficiency by using current and emerging technologies for material testing and construction inspection.

3.8 Submit Technical Memorandum #2.

The research team developed the second technical memorandum, which details the results of research Tasks 4.6 and 4.7. Technical Memorandum #2 was provided electronically in Microsoft Word and Portable Document Format (PDF) to the project technical panel for review of the research results and findings to date on February 23, 2026. A Panel meeting occurred on March 2, 2026, at 10 a.m. Central Time. Technical Memorandum #2 was presented to the project technical panel during this meeting. The technical panel provided initial comments, and the research team subsequently developed a revised Technical Memorandum #2. The Revised Technical Memorandum #2 was submitted on May 29th, 2026. Final comments were then provided to the research team, and a final revised Technical Memorandum #2 was submitted and accepted on June 15, 2026.

3.9 Prepare final report and associated deliverables.

In conformance with the Guidelines for Performing Research for the South Dakota Department of Transportation, the research team prepared a final report and executive summary of the literature review, research methodology, findings, conclusions, recommendations, and prioritization strategies. The final report was delivered electronically as an MS Word and PDF document to the project technical panel for review on July 1, 2026.

3.10 Make an executive presentation to the SDDOT research review board.

For this Task, Dr. Harper led the research team and traveled to the SDDOT headquarters in Pierre, SD, to present the findings and recommendations on July 29, 2026. After the presentation, the research team compiled all comments from the presentation and the comments from the technical panel members. The draft final report was updated to include the feedback from the reviews and the presentation. The final revised report was provided to the SDDOT in August 2026.

4.0 FINDINGS AND CONCLUSIONS

The data collected and analyzed provide the findings and results for this study. The information in this section is presented based on the four research objectives as outlined in Section 3.0.

Research Objective #1 focused on reviewing current practices in field materials testing and construction inspection, and the research team reviewed information on risk-based approaches and practices for testing and inspection activities.

Research Objective #2 emphasized investigating the current SDDOT program for field material testing and construction inspection. This entailed reviewing SDDOT manuals and reports related to construction material testing and inspection, as well as interviewing SDDOT personnel, contractors, and materials suppliers who work with SDDOT. An initial risk assessment was also conducted on specific material testing and inspection activities that occur during construction on SDDOT highway projects.

Research Objective #3 used the information and data collected, reviewed, and evaluated to develop prioritizations and recommendations for modifying the SDDOT material testing and construction inspection frequencies and priorities using risk-based approaches. Quantitative project information for material testing and daily diaries for construction inspections were reviewed to develop the recommendations and prioritizations based on the Task 3 risk assessment of testing and inspection activities.

Research Objective #4 focused on developing guidance and strategies to improve the efficiency of material testing and construction inspection. The data collected and analyzed, along with consideration of material testing and inspection technologies, enabled the research team to develop guidance, recommendations, and prioritization to help SDDOT implement a risk-based approach to material testing and construction inspection.

4.1 Research Objective #1: Review Requirements and Practices Commonly Used for Material Testing and Construction Inspection

A comprehensive literature review was conducted to capture the state of practice in material testing and construction inspection from the FHWA, AASHTO, and other state Departments of Transportation (DOTs), and to collect existing risk-based inspection methodologies and practices. The literature searches focused on identifying documents that would support the development of a risk-based material-testing and inspection approach for highway construction. A deep pool of reference materials related to requirements and practices commonly used for construction material testing and inspection by the FHWA, AASHTO, and state DOTs was reviewed. The review included construction material testing and inspection frequencies, who performs the testing or inspections, expected end-quality benefits, potential risks, and prioritizations based on a risk-based analysis. Additionally, current and

emerging technologies that improve the efficiency of construction material testing and inspections were reviewed. An annotated bibliography is included as [Appendix A](#) to summarize the key findings from selected reports, manuals, and research articles reviewed.

This section is organized into four main areas:

- Federal regulations related to construction material testing and inspection processes
- Overview of risk-based inspection methods
- The current state of practices of construction material testing and inspection from state DOTs
- An overview of current and emerging testing and inspection technologies

4.1.1 Federal Regulations

The CFR, Title 23, Part 637 – Construction Inspection and Approval, is a baseline document related to materials acceptance procedures. 23 CFR 637 requires each state DOT to develop and implement a Quality Assurance (QA) program to ensure that materials and workmanship incorporated into federal-aid highway construction projects conform to the requirements of the approved plans and specifications. Typically, the six core elements of a construction QA program include: quality control (QC), acceptance, independent assurance (IA), dispute resolution, personnel qualifications, and laboratory accreditation/qualification (FHWA, 2012b; NASEM, 2017). Subpart B – Quality Assurance Procedures for Construction, 23 CFR 637, defines the six required core elements as shown in [Table 1](#).

Table 1: Core elements of a construction QA program

Core Element	Description
Quality Control (QC)	The contractor performs all operational techniques and activities to fulfill the contract requirements.
Acceptance	All factors that comprise the state DOT's determination of the quality of the product as specified in the contract requirements. These factors include verification sampling, testing, and inspection, and may include QC sampling and testing results.
Independent Assurance (IA)	Activities that are an unbiased and independent evaluation of all the sampling and testing procedures used in the acceptance program. Test procedures used in the acceptance program performed in the state DOT's central laboratory would not be covered by an IA program.
Dispute Resolution	The state DOT shall establish a dispute resolution system. The dispute resolution system shall address discrepancies between the verification sampling and testing and the QC sampling and testing. The dispute resolution system may be administered entirely within the DOT.
Personnel Qualifications	Personnel are capable as defined by appropriate programs established by the DOT. The sampling and testing are performed by qualified personnel.
Laboratory Accreditation/Qualification	Laboratories are capable, as defined by appropriate programs established by the DOT. As a minimum, the qualification program includes provisions for checking test equipment, and the laboratory shall keep records of calibration checks.

While all state DOTs incorporate these six core components in their QA programs, their specific practices can differ significantly. A method deemed acceptable by one DOT may not be acceptable to another. For instance, for materials fabricated or manufactured, such as precast concrete and structural steel, some DOTs determine acceptance through plant inspections, while others increasingly rely on certification programs and approved product lists. Furthermore, for on-site materials, such as pavements and structures, some DOTs permit modifications to the standard inspection, sampling, and testing frequencies based on factors such as material quantity, project delivery method, or material criticality, while others maintain fixed requirements (NASEM, 2023).

FHWA QA requirements and contractor testing can also heavily influence the DOT's QA practices, particularly those used for acceptance. Over the years, these requirements have been adjusted to reflect the industry's growing role in ensuring material quality. As contractors took on greater responsibility for sampling and testing—often as part of statistically based QA specifications and alternative contracting methods that shifted more performance risk to the contractor—traditional acceptance testing conducted by DOTs became somewhat redundant. FHWA's sampling and testing regulation, "QA Practices for Construction," was revised in 1995 to expressly allow the use of contractor QC test results in a DOT's acceptance decision, provided that:

- Sampling and testing are performed at qualified laboratories by qualified sampling personnel.
- The DOT, or its designated agent – such as a consultant under direct contract with the DOT – validates the contractor's test results by performing independent sampling, testing, and verification. Using a third-party testing and inspection firm hired by the contractor does not relieve the agency of its responsibility for verification. Splits of contractor-obtained samples cannot be used for verification purposes.
- The QC sampling and testing are evaluated under an IA program.
- The DOT has a dispute-resolution system to address potential discrepancies between the contractor's QC and the agency's verification data.

FHWA provided guidance and recommendations related to the use and validation of contractor test results in Technical Advisory T6120.3: Use of Contractor Test Results in the Acceptance Decision, Recommended Quality Measures, and the Identification of Contractor/Department Risks (FHWA, 2004), and the Tech Brief entitled Construction Quality Assurance for Design–Build Highway Projects (FHWA, 2012b). Additional guidance on the CFR requirements was provided through Federal Aid Policy Guide Non-regulatory Supplement NS 23 CFR, Part 637B, issued on July 19, 2006, which clarified the following key points:

- Sampling and testing frequencies differ among state DOTs due to variations in material quality and consistency. DOTs have some discretion to adjust testing frequencies for materials with a “history of accurate, uniform test results that consistently meet specification requirements. The testing rate should be higher on newly developed material sources, sources with questionable quality, sources with a wide range of test results, and sources with failing test results.”
- If contractor QC test results are considered for acceptance but do not align with DOT test results, the DOT should increase the frequency of its verification testing.
- A DOT's acceptance program should go beyond testing and include a sufficient level of inspection to effectively evaluate key attributes that indicate the quality of the final product. This inspection should encompass component materials during placement or installation, as well as the workmanship and overall quality of the completed project.
- The provisions in 23 CFR 637 were designed specifically for project-produced materials and were not intended to apply to manufactured items. To establish an acceptance program for manufactured products, the supplement advises DOTs to conduct a risk analysis that considers factors such as the product's application, historical quality, safety, and cost.

Incorporating validated QC data into the acceptance process can reduce the frequency of DOT testing, helping to optimize agency resources, even if the total testing effort remains unchanged. However, a DOT should conduct sufficient verification sampling and testing to detect statistically significant differences between its results and the contractor's results. Common methods for validating contractor test data include the F-test (for variance comparison) and the t-test (for mean comparison). While no universal standard exists, a general guideline suggests that DOT verification testing should be at least 10% of the contractor's testing rate. The FHWA (2012b) acknowledges that verification testing rates may vary depending on the associated risks. For example, structural concrete typically requires more verification testing than embankment materials. When dealing with small quantities, where contractor and DOT test data are insufficient for statistical comparison, acceptance decisions are often based solely on DOT test results.

4.1.2 Risk-Based Inspection Methods

Risk-based inspection is widely used in oil and gas, refining, petrochemicals, and power generation industries. However, its application in highway construction remains relatively new. A risk-based approach represents an advanced inspection method to ensure the safety and reliability of operational facilities (American Petroleum Institute, 2016). Research has shown that risk-based inspection offers practical strategies for implementing inspection

processes (Kamsu-Foguem, 2016). It provides a framework for assessing the likelihood and impact of failures, determining risk levels, and developing appropriate risk management measures. As a result, risk-based inspection is seen as a promising shift from reactive to proactive inspection practices across various industries (Kamsu-Foguem, 2016). Figure 1 shows a typical risk-based inspection process adapted from the latest edition of the American Petroleum Institute Recommended Practice (American Petroleum Institute, 2016). The risk-based inspection approach systematically reduces inspection risk and continuously improves inspection practices.

A risk-based inspection methodology requires assessing and evaluating several main steps, including data and information collection; a risk assessment process composed of the probability of failure occurrence rating and the risk impact of failure rating; risk ranking; an inspection plan; mitigation (if needed); and reassessment. Benefits of using risk-based inspection include:

- Identifying critical inspection and maintenance activities;
- Facilitating the development of optimized inspection and mitigation plans;
- Understanding the current risk and providing overall risk reduction;
- Allocating inspection resources properly; and
- Generating cost savings (American Petroleum Institute, 2016).

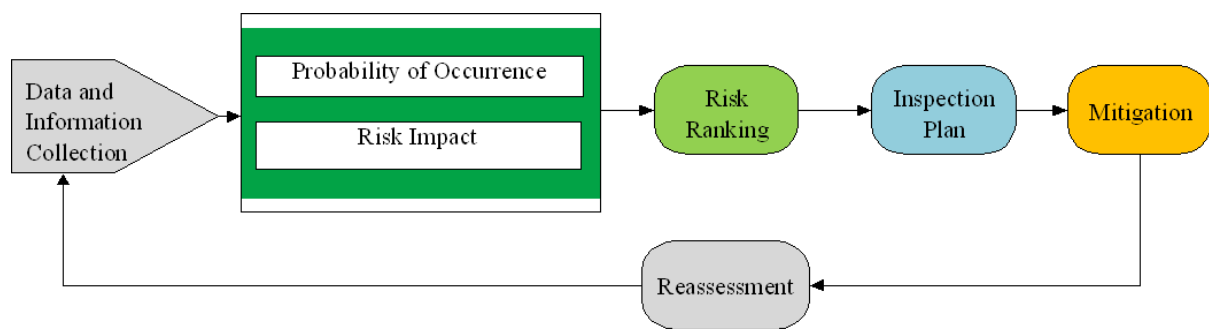


Figure 1: Typical risk-based inspection process (American Petroleum Institute, 2016)

The likelihood of risks and associated impacts can be evaluated using either quantitative or qualitative methods, depending on the specific project or system characteristics and the availability of testing and inspection data. Qualitative assessments rely on a risk matrix, such as the example shown in Figure 2, which categorizes probability and impact as high, medium, or low. The existing literature indicates that qualitative risk representation is a widely used and effective method for assessing and evaluating risks. (NASEM, 2014). The overall concept of risk assessment can be illustrated as follows:

- **Red = High Risk:** The upper-right section of [Figure 2](#) indicates a scenario where both the probability of occurrence and the impact severity are high, resulting in a significant risk level. In most cases, such high risks are deemed unacceptable, necessitating actions to mitigate them by lowering the probability of occurrence or reducing the risk impact. Regarding inspection strategies, high-risk items should be given priority, requiring more frequent and thorough inspections to effectively manage and minimize risk and uncertainty.
- **Yellow = Medium Risk:** The medium-risk zone lies between the low- and high-risk areas in terms of impact severity. The primary consideration for medium-risk items is determining the acceptable risk level and identifying suitable risk mitigation strategies.
- **Green = Low Risk:** The lower-left section of [Figure 2](#) depicts a low-risk scenario, with a minimal probability of occurrence and limited potential impacts. Low risk is usually considered acceptable and requires little to no intervention. As a result, items classified as low risk may undergo less frequent inspections or follow less stringent inspection protocols.

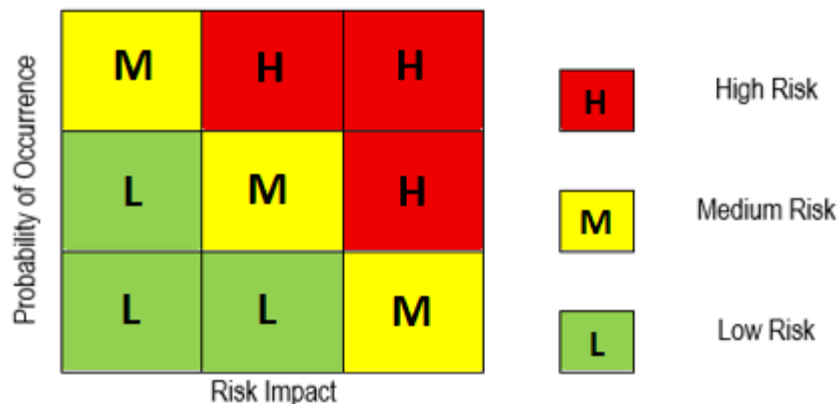


Figure 2: Risk matrix example

The level of risk is defined by two key factors: probability and impact. For instance, an item with a high probability of occurrence does not necessarily pose a high risk if the impacts are minimal. Similarly, an item with severe impacts may not be classified as high risk if the likelihood of failure is low. The risk-based inspection approach prioritizes not only the items most likely to fail but also those whose failure would have the greatest impact, accounting for both probability and impact (NASEM, 2014).

The traditional inspection program follows a fixed schedule, with inspection timing not adjusted to account for the probability of failure due to human error, design limitations, or unforeseen events (Soares et al., 2015). Thus, the program can experience extended periods

in which risk exceeds the unacceptable threshold before the next scheduled inspection, resulting in inefficient resource allocation and unnecessary exposure to high-risk conditions. On the other hand, the risk-based inspection program introduces a proactive approach to risk management based on the probability of failure and potential impact (Soares et al., 2015). When risk begins to rise significantly, inspections are scheduled earlier to prevent items from reaching critical levels. This proactive approach results in a smoother risk curve with lower peaks compared to the traditional method. The risk-based inspection program cannot eliminate the residual risk but aims to minimize controllable risks. The key difference is that RBI leverages inspection strategies to actual risk profiles, rather than applying a one-size-fits-all schedule. Figure 3 shows that eliminating risk is virtually impossible due to factors such as design flaws, natural disasters, and human mistakes and errors. These factors contribute to residual risk that persists and cannot always be fully addressed through inspections. However, risk-based inspections emphasize identifying key drivers prior to construction to prioritize testing and inspection efforts to reduce overall risk to the lowest possible level (Soares et al., 2015).

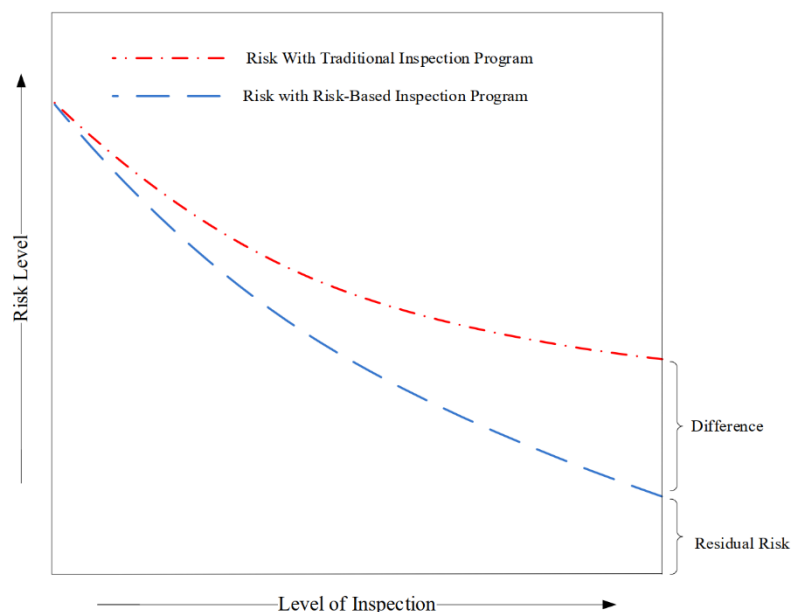


Figure 3: Traditional inspection vs. risk-based inspection (Soares et al., 2015)

4.1.2.1 Risk Assessment Approaches

Risk assessment is generally categorized into three main approaches: qualitative, quantitative, and semi-quantitative. The quantitative risk assessment method generally demands a more in-depth analysis than semi-quantitative or qualitative methods.

All three risk assessment approaches share a common process: identifying key areas of concern, assessing associated risks, screening them, and creating a prioritized list of

inspection items for further analysis. Choosing an appropriate risk assessment method depends on several factors, including the number of inspection items, available resources, data quality, the complexity of inspection procedures, and other considerations. A key outcome of risk assessment in risk-based inspection is gaining the knowledge necessary to develop a prioritized inspection list (FHWA, 2006). This list should be created by evaluating the probability and impact of risk (Soares et al., 2015; American Petroleum Institute, 2016). Details of the three risk assessment approaches are summarized below.

4.1.2.1.1 Qualitative Approach

The qualitative risk assessment approach evaluates the probability and impact of a risk event using descriptive information from subject matter experts (SMEs), relying on their engineering judgment and experience (Mostafavi & Abraham, 2012). The accuracy of this method depends on factors such as expertise, collective experience, and background knowledge. This approach typically categorizes risk using qualitative terms such as “low,” “medium,” or “high,” or assigns numerical values, such as a Likert scale with ratings from 1 (low) to 5 (high). Although the qualitative approach is less precise than the quantitative method, it remains an effective and valuable tool for identifying and prioritizing risks and formulating appropriate risk mitigation and allocation strategies (FHWA, 2006). This approach can be applied to various aspects of testing and inspection plan development and is often used as a preliminary step to inform and guide the quantitative risk assessment process.

4.1.2.1.2 Quantitative Approach

The quantitative risk assessment approach relies on detailed numerical data derived from probability models, failure databases, and historical performance records. The quantitative approach involves measuring the probability and the impact of potential damage. For instance, the probability of failure occurrence for an inspection item can be quantified based on past occurrences and the actual impact of past failures. The quantitative risk assessment approach provides a numerical, more objective evaluation of the probability and impact of risk events, but it depends on the accuracy and frequency of the data collected. Depending on the quality of available data, various statistical modeling techniques—such as Monte Carlo simulation, sensitivity analysis, decision trees, and other stochastic methods—can determine the probability and impact of testing and inspection items.

While the quantitative assessment offers valuable insights and produces precise, objective results, it also has several limitations. NCHRP Report 782 (NASEM, 2014) emphasized that "the effort required to collect and analyze quantitative risk testing and inspection data may far outweigh the value of the data in estimating future performance, particularly when the data are sparse, including significant uncertainty, or when design characteristics are continuously evolving."

4.1.2.1.3 Semi-Quantitative Approach

The semi-quantitative approach balances the data requirements and speed of qualitative analysis with the precision and rigor of quantitative evaluation (American Petroleum Institute, 2016). Additionally, when quantitative data are available, they can be integrated with qualitative assessments to enhance inspection activities (NASEM, 2014). The qualitative, quantitative, and semi-quantitative approaches should complement one another (American Petroleum Institute, 2016). A qualitative approach may be the most effective at the program level for identifying high-risk items that require further evaluation. At the project level, a semi-quantitative approach may be appropriate for assessing higher-risk items. A quantitative approach may yield the most thorough risk analysis when sufficient, high-quality data are available at the activity level. However, NCHRP Report 782 (NASEM, 2014) emphasized that quantitative analysis is not necessarily more accurate than qualitative methods unless supported by accurate data.

4.1.2.2 Key Elements of Risk-based Inspection

Risk-based inspection is applied in the construction industry for items such as structural engineering and maintenance, water supply, and sewer networks. The existing literature shows the following key takeaways from the use of risk-based inspection approaches:

- Risk-based inspection is typically used to optimize QA inspection by prioritizing activities based on criticality when resources are scarce, such as staff and funding.
- The criticality of a component is measured by assessing the risk impact of failure.
- Expected Value is a product of two parameters: the probability of failure occurrence and the impacts of element failure in terms of cost, safety, and service interruption.
- Impacts of failure may include costs, safety, service life, and social consequences, such as end-user satisfaction.
- Two types of data are collected: quantitative data, such as historical records, and qualitative data, such as opinions of subject matter experts.
- The appropriate assessment technique is selected depending on the type and availability of data.

NCHRP Report 782 outlines three essential components for reliability-based bridge inspection practices:

1. Probability of occurrence factors,
2. Risk impact factors, and
3. An assessment panel (NASEM, 2014).

Although the report primarily addresses the reliability evaluation of bridge elements, its principles can also be applied to highway project inspections. This section provides a brief overview of these three key elements.

4.1.2.2.1 Probability of Occurrence Factor

The probability of occurrence factor estimates the probability of significant damage occurring within an inspection period by addressing the question: “What can go wrong, and how likely is it?” Any previously discussed risk assessment approaches—qualitative, quantitative, or semi-quantitative—can be used to predict the expected performance of components. NCHRP Report 782 (NASEM, 2014) employs a four-level scale to classify likelihood, as shown in [Table 2](#).

Table 2: Rating scale for occurrence factor (NASEM, 2014)

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

4.1.2.2.2 Risk-Impact Factor

The primary goal of inspections is to ensure the safety and functionality of highway elements. The risk impact factor helps classify the impact of an element’s failure based on anticipated or expected outcomes (NASEM, 2014). This factor can be assessed by considering physical conditions, material properties, service disruptions, safety concerns, and other relevant issues. Similar to probability of occurrence factors, risk-impact factors can be evaluated using qualitative, quantitative, or semi-quantitative risk assessment methods. NCHRP Report 782 emphasizes that, in many cases, qualitative assessments based on engineering judgment and documented experience are sufficient for evaluating risk-impact factors (NASEM, 2014).

NCHRP Report 782 employs a four-level scale to classify impact factors, ranging from "low" to "severe," as shown in [Table 3](#). A "low" rating indicates scenarios where failure is unlikely to have a significant impact on safety (short-term effects) or serviceability (long-term effects). Conversely, a "severe" rating represents major safety or serviceability consequences.

Table 3: Rating scale for impact factors (NASEM, 2014)

Level	Category	Impact of Safety	Impact of Serviceability	Description
1	Low	None	None	Minor effect on serviceability, no effect on safety
2	Moderate	Minor	Minor	Moderate effect on serviceability, minor effect on safety
3	High	Moderate	Moderate	Major effect on serviceability, moderate effect on safety
4	Severe	Major	Major	Structural failure or collapse/loss of life

4.1.2.2.3 Risk Assessment Panel

A key element of risk-based inspection is establishing a well-qualified risk assessment panel. The panel should consist of SMEs with relevant experience in areas such as design features, construction specifications and practices, materials, and the operational environment. Gathering expert judgment from an SME panel is straightforward and aimed at creating a structured framework for objective analysis. This systematic approach facilitates the efficient collection of insights into the probability of failure occurrence and its potential impacts (NASEM, 2014).

4.1.3 Current Construction Material Testing and Inspection Practices at State DOTs

This section summarizes the current state of risk-based construction material testing and inspection practices at state DOTs. A comprehensive analysis of construction manuals, standard specifications, and related documents from all state DOTs was conducted. The state DOTs in this section represent different geographic areas and have experience with implementing risk-based testing or construction inspection programs. The documents were collected from DOT websites, the FHWA library, and other relevant publications. These state DOTs were identified through synthesizing and screening the key documents from the literature. The following sections briefly summarize the findings from state DOTs.

4.1.3.1 Colorado DOT (CDOT)

CDOT's QA procedures describe the requirements of 23 CFR 637. Sections 105 and 106 of the CDOT Standard Specifications detail information about statistically based acceptance and pay factors for specific materials. Information on materials sampling and testing is provided, along with detailed requirements for tiers representing different material types (Colorado DOT, 2026). Form 250 is used to develop the project-specific minimum sampling and testing requirements. The field materials manual details the CDOT Qualified Manufacturers' List and the Approved Products List (APL). Due to limited internal resources, the CDOT outsources testing and inspections to consultants. The CDOT staff performs the IA testing for its projects (NASEM, 2023). CDOT allows certificates of compliance (COCs) and certified test reports (CTRs) for various products that are listed in the Field Materials Manual (Colorado DOT,

2025). The COCs and CTRs are stamped documents that contain information about the item and its quantity, which the contractor completes and submits as part of the documentation.

4.1.3.2 Florida DOT (FDOT)

The Standard Specifications for Road and Bridge Construction include the requirements for QC testing, verification testing, and a resolution process for QA-related issues. For certain materials that demonstrate consistent quality at the production facility, FDOT may reduce sampling and testing frequency (Florida DOT, 2025). For example, materials like structural concrete, excavation, and embankment undergo a 50% reduction in inspection frequency when 12 or more QC tests confirm compliance within tolerance limits. This reduction is based on the lower perceived risk due to reliable contractor QC performance. However, inspections remain more critical for high-risk structural elements such as pre-stressed beams, piles, drilled shafts, and steel beams, where safety considerations are paramount.

FDOT primarily differentiates between critical and non-critical materials based on safety-related criteria, adjusting sampling and testing frequencies accordingly. Additionally, FDOT employs various QA strategies for projects using alternative contracting methods. In design-build (DB) contracts, contractors are responsible for QC, while FDOT inspectors conduct QA. In Public-Private Partnerships (P3) projects, verification responsibilities shift to the developer, with FDOT conducting risk-based audits. FDOT tailors its inspection strategies to optimize inspection frequency while considering material criticality and structural safety. However, FDOT does not explicitly implement a risk-based QA inspection approach for its projects.

The Florida DOT uses visual inspection rather than sampling and testing for smaller quantities of specific material types, including when less than 2,000 tons of hot-mix asphalt (HMA) is used for specified friction courses (FC) and Superpave (SP) asphalt mixtures. Further, FDOT may reduce the frequency of sampling and testing for small or low-risk projects costing less than \$2 million. Also, FDOT may reduce the sampling and testing frequency (or increase the lot size) for certain materials from the same production facility that are shown to be under control. For example, if ten consecutive concrete strength tests attain an average strength greater than two standard deviations above the specified minimum, the lot size can be doubled. FDOT engineers can accept asphalt mixes based on visual inspection and require the contractor to run QC and independent verification tests at its discretion.

FDOT distinguishes between more and less critical materials, primarily based on safety-critical criteria. For example, FDOT conducts more rigorous inspections for prestressed beams, piles, drilled shafts, steel beams, and similar safety-critical structural elements. Sampling and testing frequencies are also increased or reduced based on the criticality of the materials.

4.1.3.3 Indiana DOT (INDOT)

INDOT's Standard Specifications (Indiana DOT, 2026) and the Manual for Frequency of Sampling and Testing and Basis for Use of Materials (Indiana DOT, 2025) contain specific guidance on both construction inspection and material testing (Xu et al., 2019). Starting with these two documents and the QA implementation, 333 material testing and inspection items were extracted. With the help of INDOT experts and industrial partners, the list was narrowed to 126 core items. All these core items were aligned with the construction process to facilitate risk assessment. [Figure 4](#) illustrates the process for identifying core items.

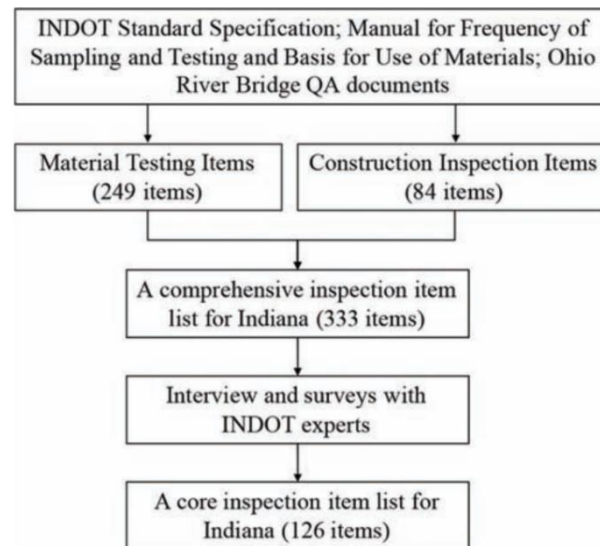


Figure 4: Identification of INDOT core inspection items (Xu et al., 2019)

INDOT adopted a three-step protocol to prioritize critical inspection items based on associated risks, as shown in [Figure 5](#). INDOT categorizes each construction activity and assigns a risk value to it using a risk matrix. Specifications and QA reports are used to compile a list of construction activities. Failures are categorized as having micro- or macro-consequences. Micro-consequences are small issues (for example, asphalt cracking). However, combining several micro-consequences could produce a macro-consequence (for example, short-term failure or reduced design life). Risk levels for different activities were derived from a survey of practitioners across 23 state DOTs. Respondents rated two factors:

1. The severity of the risk consequences if an inspection does not meet requirements, and
2. The probability of an inspection not meeting requirements.

A scale of 1 to 3 was used for each question. The three-by-three matrix illustrates how the risk of each activity was set. Activities were then grouped into four categories: earthwork, Portland Cement Concrete Pavements (PCCP), HMA pavement, and bridge decks. Using the matrix, the risk of each construction activity is categorized as high, medium-high, medium,

medium-low, or low. By linking the risk value and specifications, inspection frequencies were set for each activity. The result is a table listing the construction activity, its priority, the macro-consequences of missed/reduced inspections, critical items to be monitored, and inspection frequency.

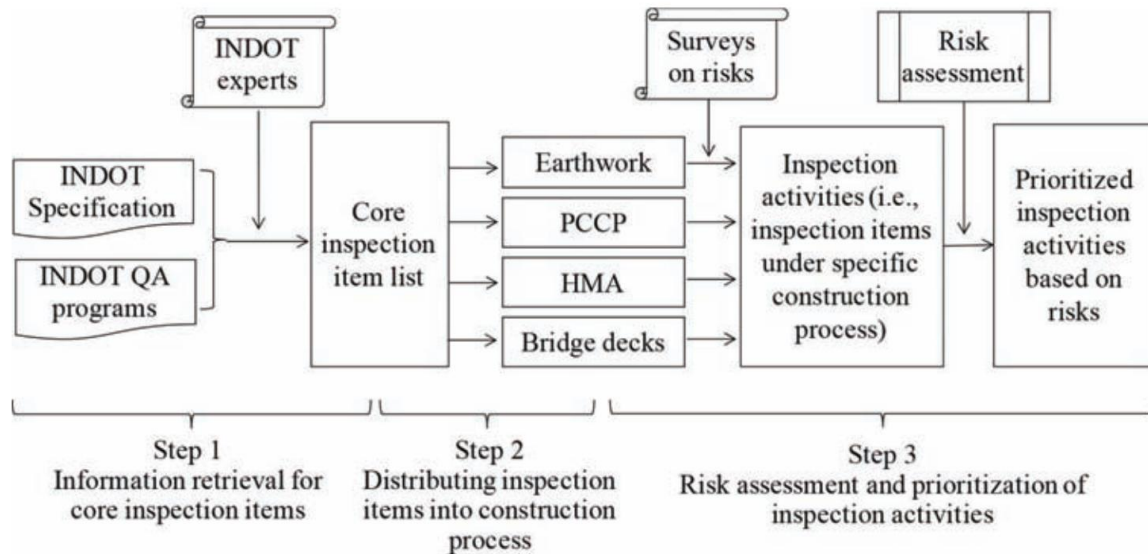


Figure 5: Indiana DOT flowchart for risk assessment of construction inspection activities (Xu et al., 2019)

In 2011, Purdue University conducted a study to assess INDOT's existing inspection practices (Mostafavi & Abraham, 2012). The research team surveyed 101 experts, including professionals from INDOT, other state DOTs, and consultants. The study revealed that inspection practices vary across different states and identified a prioritized list of construction activities. These activities were categorized into five priority levels:

- High
- Medium-high
- Medium
- Medium-low
- Low

The study emphasized that as the inspection priority level increases, the potential risk impact from reduced inspection also rises (Mostafavi & Abraham, 2012). [Figure 6](#) presents a sample of the prioritized construction activities for inspection.

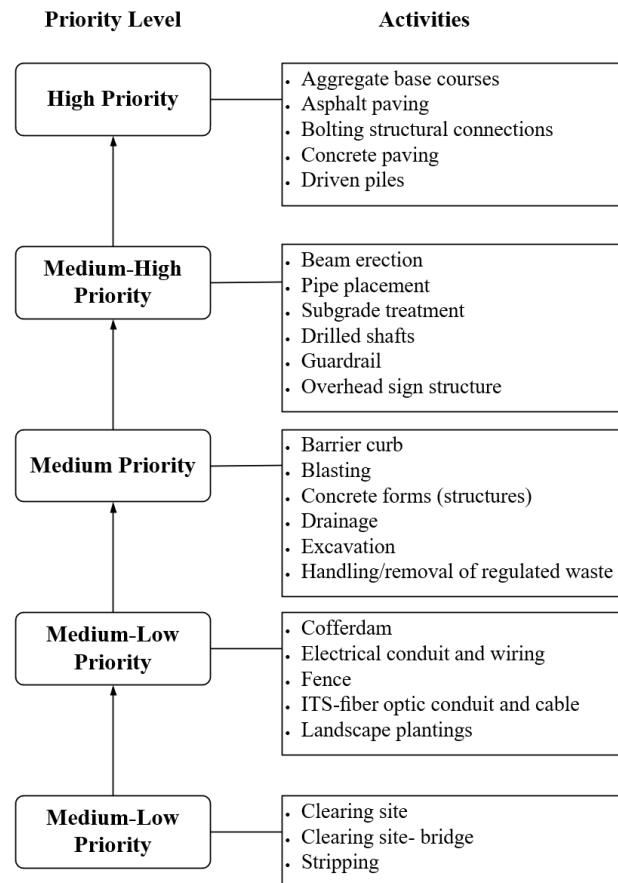


Figure 6: Inspection priority levels by INDOT (Mostafavi and Abraham, 2012)

Yuan et al. (2018) recently conducted a study for INDOT to develop a risk-based approach for prioritizing QA inspection activities. The study evaluated two key risk factors: the likelihood of failing to meet specification requirements and the severity of the consequences in terms of quality, cost, time, and safety. Based on input from six experts, 126 core inspection items were initially selected from earthwork, bridge decks, and rigid and flexible pavements. However, 28 low-risk inspection activities were later excluded. As a result, a practical protocol was established to assess the risks associated with various inspection tasks during construction, ultimately identifying 90 critical inspection activities.

4.1.3.4 Kansas DOT (KDOT)

KDOT's Construction Manual and Standard Specifications, Part V, outline the provisions for its QC/QA program (Kansas DOT, 2022). KDOT utilizes two procedures to ensure the quality of project-produced materials:

- 1) Method Specifications – This is the traditional approach in which KDOT's test results are the sole basis for material acceptance, and contractors are not required to perform QC testing.

- 2) QC/QA Specifications – A more modern approach where contractors conduct QC testing, and their results may be used for acceptance, provided they are verified through KDOT’s QA process.

Under the QC/QA specification, all technicians must be qualified for each relevant test group (Kansas DOT, 2022). Figure 7 shows the QA acceptance process at KDOT.

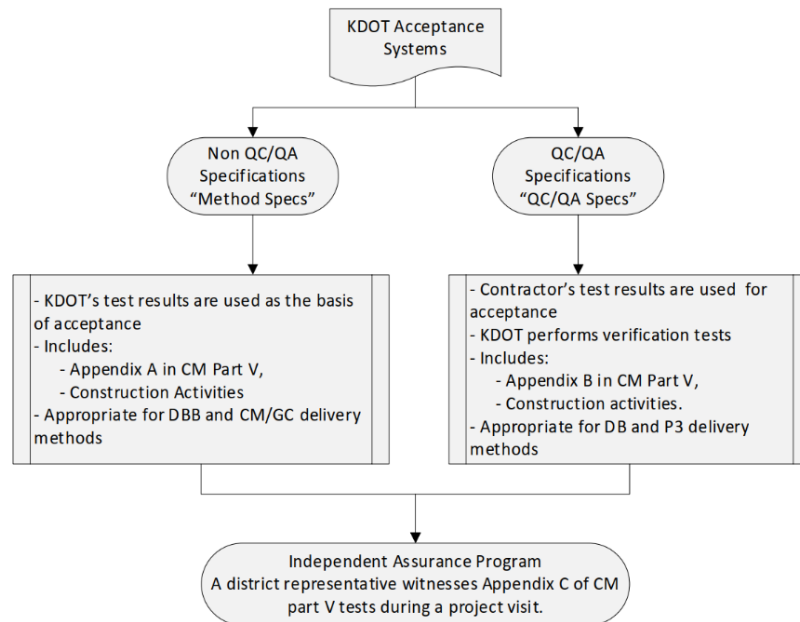


Figure 7: KDOT QA acceptance system (Kansas DOT, 2022)

KDOT utilizes a qualitative risk assessment method using two risk assessment factors:

1. The probability of an inspection not meeting requirements and
2. The consequences of an inspection not meeting requirements (See Table 4) (Tran and Mohamed, 2021). Three performance metrics (cost, safety, and service interruption) were used to evaluate the consequences of an inspection failing to meet requirements.

Both probability and consequences of each core inspection activity were rated based on a six-point scale:

- A value of 0 was available to indicate that activity was not applicable and was excluded from scoring. For example, inspecting asphalt binder content during a PCC pavement project does not apply since asphalt binder is not used with PCC pavement.
- A value of 1 represents a very low risk that has a remote likelihood of occurrence. If a risk occurs at this level, the consequences are typically very minor. For example, a

minor deviation in the aggregate gradation of shoulder material has a negligible effect on service life and only a slight slowdown in traffic.

- A value of 2 represents low risk with a low likelihood of occurrence. If a risk occurs at this level, the consequences are typically minor. For example, slight moisture variations in lime-treated subgrade result in minor repair costs and a short-term slowdown in highway service.
- A value of 3 represents moderate risk with a moderate likelihood of occurrence. If a risk occurs at this level, the consequences can be considerable. For example, improper compaction of the granular base reduces pavement durability, requiring a partial lane closure for corrective work and posing a risk of injuries if left unaddressed.
- A value of 4 represents high risk and high likelihood of occurrence. If a risk occurs at this level, the consequences can be major or severe. For example, incorrect air content in PCC pavement mix causes structural weakness, leading to major repairs, short-term highway closures, and the potential for injuries during failure.
- A value of 5 represents very high risk and very high likelihood of occurrence. If a risk occurs at this level, the consequences can be severe. For example, failure to verify the field density of embankment fill can result in catastrophic slope failure, causing a full highway closure for an extended period and possible loss of life.

Table 4: Risk assessment factors (Tran and Mohamed, 2021)

No.	Category	Probability of an inspection not meeting requirements	Cost Consequences	Safety Consequences	Service Interruption Consequences
0	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
1	Very Low	Remote Likelihood	Very minor effect on achieving the remaining service life	Very minor injuries	Minor slowdown of the highway service
2	Low	Low Likelihood	Minor effect on achieving the remaining service life	Minor injuries	Considerable slowdown of the highway service
3	Moderate	Moderate Likelihood	Considerable effect on achieving the remaining service life	Considerable injuries	Partial closure of the highway
4	High	High Likelihood	Major effect on achieving the remaining service life	Severe injuries	Major closure of the highway for a short time
5	Very High	Very High Likelihood	Severe effect on achieving the remaining service life	Loss of life	Full closure of the highway for a long time

KDOT uses optimization strategies for QA acceptance to reduce inspection resources. A strategy is to utilize a pre-approved list of materials and suppliers, emphasizing reducing material quantities, volumes, and inspection frequency. [Figure 8](#) shows an example of an inspection activity for HMA pavement material. Furthermore, KDOT accepts contractor QC test results as a basis for approval, with verification conducted in accordance with KDOT's QA procedures. KDOT also decreases testing frequency for non-QC/QA processes by increasing lot sizes and accommodating larger material volumes. For non-QC/QA specifications, the District Materials Engineer can reduce sampling and testing frequency on a project-by-project basis, provided that production remains consistently satisfactory and uniform.

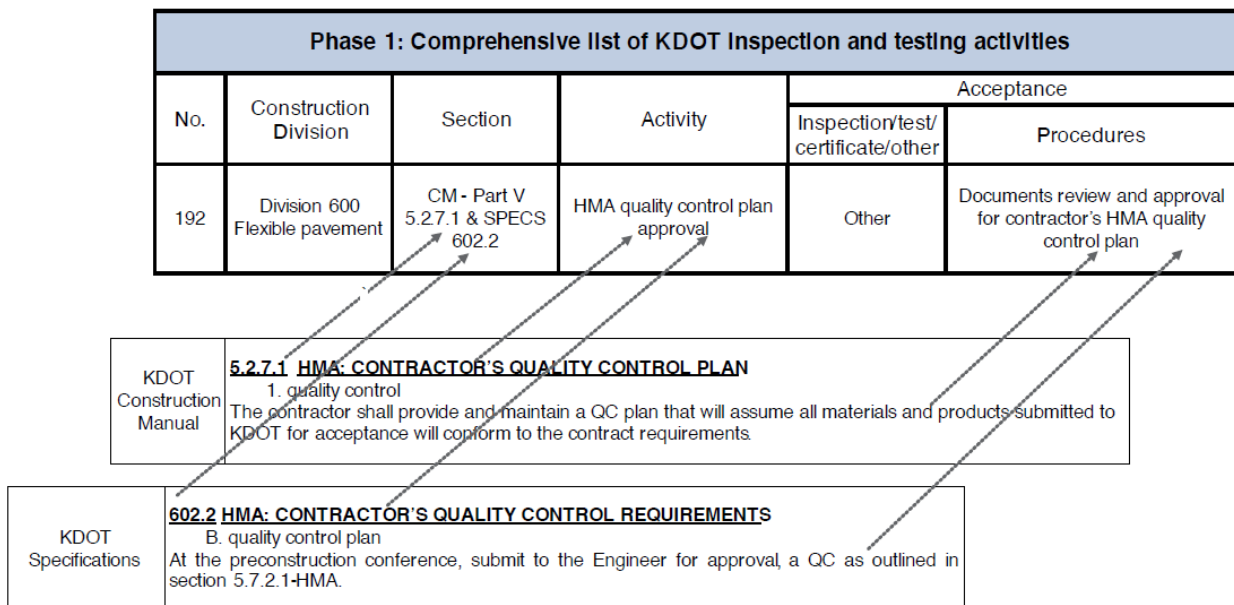


Figure 8: Sample of Kansas DOT inspection and testing activities (NASEM, 2023)

4.1.3.5 Kentucky Transportation Cabinet (KYTC)

The current QA/QC program for concrete specifications at KYTC was evaluated for its development of concrete QC/QA specifications for highway construction in Kentucky (Rush, 2021). The QC/QA: Evaluation of Effectiveness in Kentucky manual focuses on evaluating the current process rather than analyzing its origin (Mahboub et al., 2008). The study includes recommendations such as adding more training on inspection skills, defining responsibilities for collecting and handling lab and field specimens more clearly, using a database for performance tracking, expanding non-invasive, non-destructive material testing, and implementing bonuses or penalties.

At KYTC, inspection activities are outsourced to cover the required inspections. Approximately 10-20% is outsourced to consultants (NASEM, 2023). Producers provide letters of certification in accordance with industry standards. The Laboratory Information Management System (LIMS) tracks the certification of materials. It covers the construction

and materials management system process from contract award to finalization. It explains the general workflow for product approvals, materials sampling and testing, and materials inspection requirements.

KYTC implements a risk-based construction inspection program, including the following:

- Heat maps that qualitatively rate the levels of risk for different construction activities;
- Guidance on the level of inspection presence required for each activity
- A staffing guidance tool that facilitates the preparation of inspection staffing plans (and a macro-enabled MS Excel worksheet);
- Inspection checklists that can be used in the field to standardize workflows; and
- A mobile-friendly website that provides ready access to Tools 1 through 4 (Taylor et al. 2021).

The information in [Table 5](#) quickly lets users identify the level of risk posed by under-inspection of a construction activity, based on project category, region, and area type (urban, suburban, rural). KYTC also uses guidance based on levels of inspection presence (LOIP). After cataloging risk levels using [Table 5](#), the LOIP for each activity, ranging from full-time to sporadic inspections, was determined.

Table 5: Inspection presence for risk-based inspection of major work types (Taylor et al., 2021)

Inspection Presence	New Road Construction or Expansion	Roadway Rehabilitation & Resurfacing	Bridge – New or Replacement	Bridge Rehabilitation
High	Pipe/Drainage	Temporary Traffic Control	Structural Foundation	Superstructure
High	Structural Foundation	Structural Foundation	Superstructure	Structural Foundation
High	Excavation/Embankment	Pavement Surface	Substructure	Substructure
High	Temporary Traffic Control	Superstructure	Temporary Traffic Control	Temporary Traffic Control
Moderate	Subgrade	Pavement Base	Excavation/Embankment	Pavement Surface
Moderate	Pavement Surface	Pipe/Drainage	Subgrade	Subgrade
Moderate	Superstructure	Subgrade	Pavement Surface	Pavement Base
Moderate	Pavement Base	Substructure	Pavement Base	Pipe/Drainage
Moderate	Substructure	Excavation/Embankment	Pipe/Drainage	Excavation/Embankment
Low	Utilities	Stripes, Signs, Signals	Utilities	Stripes, Signs, Signals
Low	Stripes, Signs, Signals	Roadside	Stripes, Signs, Signals	Roadside
Low	Roadside	Utilities	Roadside	Utilities
Low	Roadway Lighting	Roadway Lighting	Roadway Lighting	Roadway Lighting

Inspection Presence	New Road Construction or Expansion	Roadway Rehabilitation & Resurfacing	Bridge – New or Replacement	Bridge Rehabilitation
Low	Intelligent Transportation Systems	Intelligent Transportation Systems	Intelligent Transportation Systems	Intelligent Transportation Systems

4.1.3.6 Mississippi DOT (MDOT)

MDOT outsources inspection activities when internal staffing resources are insufficient to cover the work (NASEM, 2023). Contractors perform QC at a prescribed frequency. The DOT performs QA to verify QC results at approximately every 10th QC test. Some materials are accepted based on manufacturer certification. Final acceptance of the material is not complete until it is observed to be successfully installed on the project. MDOT maintains a list of materials and the quantities in which the sampling and testing requirements are modified when a small quantity of material is used on the project.

MDOT's manual for Construction Engineering, Inspection, and Testing requirements for Local Public Agency (LPA) projects exhibits QA inspections for locally administered federal aid projects (Mississippi DOT, 2021). The manual provides a risk-based optimization system for inspection, material sampling, and testing with implementation recommendations. Project components are classified as high, moderate, or low risk. See [Table 6](#) below for a summary of project components and risk levels. MDOT establishes the risk level during the design phase of project development. Low-risk projects will normally be off major roadways, and high-risk projects will normally be National Highway System (NHS) roadway and bridge projects. The recommendations are based on project type and items of work.

Table 6: Project components and risk levels categorized by MDOT (Mississippi DOT, 2021)

Project Type	LPA Project Components	Risk Level
Roadway and Bridge	New Construction	High
Roadway and Bridge	Reconstruction	High
Roadway and Bridge	Pavement Preservation	Moderate
Roadway and Bridge	Mill and Overlay	Moderate
Roadway and Bridge	Full-Depth Pavement Rehabilitation	High
Roadway and Bridge	Interchange Modifications	High
Roadway and Bridge	Lane Addition (Through and Auxiliary)	High
Roadway and Bridge	Trench Widening	Moderate
Roadway and Bridge	Drainage Improvements	Moderate
Roadway and Bridge	Bridge Construction/Replacement	High
Roadway and Bridge	Bridge Repair	Moderate
Traffic	Traffic Signal Installation	Moderate

Project Type	LPA Project Components	Risk Level
Traffic	ITS Implementation	Moderate
Traffic	Signing	Low
Bike and Pedestrian	Sidewalks/Multiuse Pathways	Low
Bike and Pedestrian	ADA improvements	Low
Bike and Pedestrian	Bike and Pedestrian Bridge	High
Site Development	Landscaping	Low
Site Development	Lighting	Low
Site Development	Fencing	Low
Site Development	Parking Lots	Low
Site Development	Building Projects (Depots/Pavilions/Museums)	Moderate
Site Development	Recreational Facilities	Low
Safety	Rail Crossing Closures/Improvement	High
Safety	Guardrail	Low
Safety	Intersection Improvement/Signalization/J-Turn	Moderate
Safety	Traffic Calming/Road Diet	Moderate

A progress schedule is generated by the LPA or consultant firm using the MDOT format, submitted to the MDOT District LPA Engineer, and approved by the MDOT Construction Division. The construction schedule should include seven phases of work, regardless of whether a project includes those components. The progress schedule will identify a construction phase for each pay item of work and establish a duration for each phase. Table 7 places pay items into the seven phases of work. The risk associated with the item in each phase is used to establish the appropriate construction, engineering, and inspection level of effort.

Table 7: Pay items in specific project phase with risk level (Mississippi DOT, 2021)

Phase of Work*	Pay Item Number	High Risk Level*	Moderate Risk Level*	Low Risk Level*
Miscellaneous	201-202, 210-249, 607, 611-614, 617-622, 699	Intermittent	Intermittent	Intermittent
Excavation and Drainage	203-209, 601-605, 623	Full Time	Part Time	Part Time
Base and Pavement	300, 400, 500, 614	Full Time	Part Time	Part Time
Pedestrian Facilities	200, 304, 403, 407, 608, 614	Full Time	Part Time	Intermittent
Traffic Safety	606, 609-610, 615-616, 629-665, 680-686	Full Time	Part Time	Intermittent
Pavement Markings	625-628	Intermittent	Intermittent	Intermittent
Bridge/Retaining Walls	800	Full Time	Full Time	Part Time

* Project phases and inspection levels based on project components

4.1.3.7 New Hampshire DOT (NHDOT)

NHDOT performs sampling and testing at the job site, as well as preliminary acceptance at the source of materials (such as aggregates) and at manufacturing sites (such as concrete pipe and structural steel). Section 700 of the Standard Specifications describes the range of acceptance methods, which, in addition to sampling and testing, also includes COCs and an APL. For small projects, sampling and testing requirements are modified accordingly. Details on the testing frequencies for a wide range of materials are provided in Section 703.3 of the Standard Specifications. The agency supplements its field staff on projects with consultant inspectors and material testers, but these consultants work under agency employees (NASEM, 2023).

4.1.3.8 New York State DOT (NYSDOT)

NYSDOT, in the Quality Assurance Plan Program Guide established for the Kosciuszko Bridge Design-Build Project, applied a three-tiered, risk-based approach to verification testing similar to that implemented by Texas DOT (TxDOT) (NYSDOT, 2013). NYSDOT defines these levels (or Risk Factors) as follows:

- Risk Factor 1 (RF-1) provides continuous analysis using statistical testing (F-tests and t-tests) for those categories of materials and associated test methods that are strong indicators of long-term performance. These are typically considered high-risk, high-volume type materials incorporated into a design-build project. Examples include compressive strength for hydraulic or Portland cement concrete (PCC), soil compaction for embankment, and percent asphalt content for hot-mix concrete. The design builder's QC testing frequency complies with various NYSDOT documents, and the Agency's verification sampling and testing frequencies should be at least 25% of the QC testing frequency. Acceptance is based on the validation of statistical analysis of the complementary QC test data population and the QA verification test data populations. Both test results meet acceptable material acceptance limits defined in the contract documents.
- Risk Factor 2 (RF-2) provides independent verification of the materials and associated test methods that serve as secondary indicators of material performance, in addition to confirming that all QC test results are within specification limits. Verification testing, whether independent verification sampling or split sampling with the QC test, ensures that the test results fall within specification limits and is typically appropriate. These materials/material tests are considered to pose a reduced risk relative to RF-1. An example is the slump test for concrete. Approved list products that require more than the manufacturer's certification of compliance to assure quality are covered under this verification level. The QA verification sampling and testing frequency should be at least 10% of the QC testing frequency. Acceptance is based on the

results of the verification test method that meet the specification limits. No statistical validation is required.

- Risk Factor 3 (RF-3) provides observation verification for materials that require only a few QA tests to comply with various agency documents, or for materials accepted based on their inclusion in the NYSDOT-approved list of materials. For these materials, the risk of failure does not affect the long-term performance of a facility. The design builder should still perform QC testing as required. Under the RF-3 approach, the department oversight does not perform tests but observes QC test performance for equipment and procedural compliance for a product and possibly performs an audit of project procurement records to verify compliance with the agency's approved product list, certification of compliance on record, and Buy America requirements. This testing must be performed at least once per calendar year for each test method and/or product, or at a random frequency determined by the NYSDOT project manager.

NYSDOT reviewed its standard specifications and determined the overall risk and associated QA level of effort for particular materials. An example of this analysis is shown in [Table 8](#).

Table 8: NYSDOT analysis categories for verification testing (NASEM, 2017)

Specification Section	Risk Factor (RF), applications, and hold points (as appropriate)	QA Actions and Testing
201: Clearing and Grubbing	RF-3: All work	Materials QA: N/A CI QA: random verification of QC records for work documented as progressed, verify adherence to work limits, and compliance with planned/required protection/restoration
202: Removal of Structures and Obstructions	RF-3: All work	Materials QA: N/A CI QA: random verification of QC records for work progressed, adherence to safety requirements, and adherence to WZTC per 619 requirements as appropriate.

Specification Section	Risk Factor (RF), applications, and hold points (as appropriate)	QA Actions and Testing
203: Excavation and Embankment	Compaction and density: RF-1, high-volume embankment construction of 10,000 cubic yards or more placed per day, or where structural elements will be constructed atop the embankment RF-1, pipe or structural backfill of any quantity RF-2, embankment construction quantities less than 10,000 cubic yards placed per day, and where no structural elements will be constructed atop the embankment RF-3, embankment construction quantities less than 1,000 cubic yards placed per day, where no structural elements will be constructed atop the embankment	Materials QA: Random verification of test result sheets from QC testing, at a rate of 1 check per 10 completed. CI QA: Observe design-build embankment sampling and testing to include density, gradation, pH, sulfate, and soundness, as required per spec—daily inspection of lift thickness, material placement, and compaction operations for all embankment construction.

4.1.3.9 Pennsylvania DOT (PennDOT)

Approximately 50% of inspections at PennDOT are performed by consultants (NASEM, 2023). When a project involves small quantities of asphalt material, the producer must include certain QC test data in their daily certification of the material. PennDOT staff noted that they distributed tablets to field personnel for use during project construction to access agency-developed apps to assist with construction and inspection processes (NASEM, 2017). The tablet devices contained either PennDOT-developed applications (apps) or third-party apps that the agency tested and verified. One such app that helped with pile installation and inspection could measure the pile hammer's ringing frequency as it struck a pile to indicate the pile depth. The app provided accurate measurements and showed potential for further use. PennDOT developed another app to conduct construction inspections electronically. The app, called MCDocs, provided construction and contract documents electronically for review during inspection. Then, the inspector recorded the inspection report in the app; once an inspection was complete, the inspector submitted the report electronically. With the move to tablets in the field, PennDOT developed an app to create electronic heat-sticker barcodes for inspection samples. PennDOT also allows contractors to use nondestructive tests for QC to measure concrete pavement thickness.

4.1.3.10 Texas DOT (TxDOT)

TxDOT implements two types of acceptance procedures within its QA program. The first approach relies solely on TxDOT-performed acceptance testing and inspection, with acceptance decisions based solely on TxDOT's testing and inspection results. This method follows a traditional acceptance approach (Texas DOT, 2022). The second approach, contractor-performed acceptance, incorporates contractor-conducted QC testing and inspection as the basis for acceptance. This method explicitly integrates risk management principles. Material property analyses help determine the necessary level of owner

verification testing to validate contractor test results for materials primarily accepted through sampling and testing (Texas DOT, 2022).

TxDOT employs a three-tiered owner verification testing system for specific materials and properties, adjusting verification levels based on the perceived residual risk after construction completion. The three tiers of verification tests based on material and test methods are shown in [Table 9](#).

Table 9: TxDOT's three tiers of verification tests (Texas DOT, 2017)

Level	Description
Level 1	Testing is performed to analyze parameters that are strong indicators of performance (For example, compressive strength for structural concrete and percent soil compaction).
Level 2	Testing is for parameters that are secondary performance measures (For example, concrete slump test).
Level 3	Includes observation verification for materials whose risk of failure does not affect the completed facility's long-term performance or materials requiring minimum QA tests for compliance.

[Table 10](#) shows an example of TxDOT owner verification for embankment works associated with these three levels. The TxDOT Material Inspection Guide provides detailed sampling, testing, and inspection procedures, along with instructions for specific roadway materials (Texas DOT, 2025).

Table 10: Example of TxDOT analysis categories for owner verification for embankments (cuts and fills)

Test for	Test No.	TxDOT Acceptance Levels
Liquid Limit	Tex-104-E	Level 2
Plasticity Index	Tex-106-E	Level 1
Linear Shrinkage	Tex-107-E	Level 2
Gradation	Tex-110-E	Level 2
Moisture/Density	Tex-114-E	Level 3
In-Place Density	Tex-115-E	Level 1

TxDOT also developed two acceptance procedures for DB projects with optional maintenance agreements (Texas DOT, 2017). The first type uses TxDOT-performed acceptance testing and inspection, where only TxDOT testing and inspection results are used in the acceptance decision. The second type of acceptance is contractor-performed acceptance, where the contractor performs frontline testing and inspection. Under this approach, the contractor must submit a Construction Quality Management Plan (CQMP). Under contractor-performed acceptance, statistically based owner-verification tests and periodic TxDOT-independent audits of the contractor's CQMP serve as the basis for acceptance (Texas DOT, 2017).

4.1.3.11 Wisconsin DOT (WisDOT)

WisDOT addresses material acceptance requirements in the Standard Specifications. Guidance for materials sampling, testing, and inspection for the engineering, testing, and inspection staff is found in the Construction and Materials Manual, Chapter 8: Materials Testing, Sampling, and Acceptance (Wisconsin DOT, 2025). The Construction and Materials Manual includes documentation requirements for different acceptance types and differentiates between approved materials from an approved source or supplier and acceptance of materials through inspection or testing when incorporated into the project. Different frequencies and scopes of sampling, testing, and inspection are applied as needed or appropriate for adequate QC and compliance with specifications. WisDOT maintains a list of low-risk or non-critical materials that may be accepted through visual inspection and do not require documentation.

The WisDOT Construction Critical Inspection Manual outlines minimum inspection requirements used to prevent high-risk failure impacts (Wisconsin, 2018). It details key factors for each construction operation, including inspection level, priority, inspector experience, inspection objectives, and activities before and during work, based on the typical size and complexity of a project. While the manual does not cover all construction activities, it excludes those not classified as critical inspection items, such as the removal of existing structures and roadways. However, it recommends that certain aspects of these removal activities be intermittently reviewed and monitored. Table 11 provides an example of the inspection process for traffic control operations.

Table 11: Example of WisDOT construction inspection operations (Wisconsin DOT, 2018)

Before Work Begins	Inspection During Work Activity
• Ensure a copy of the Transportation Management Plan (TMP) is available in the field office. • Review and be familiar with the TMP requirements. • Verify Lane Closure System requirements for the project. • Ensure the contractor has staked each sign location and that each meets field conditions.	• Monitor and manage work zone impact on traffic during the initial setup. (Continuous) • Monitor and manage work zone traffic impacts during stage changes. (Daily, as needed) • Monitor and manage the impact of the work zone on pedestrians during construction. (Daily, as needed) • Monitor and manage the impact of the work zone on traffic safety and mobility during construction. (Daily, as needed) • Perform and document daytime and nighttime inspections to verify proper illumination. (Daily, as needed) • Verify that the retroreflective sheeting on drums, barricades, and other devices is clean. (Daily, as needed) • Ensure the contractor repairs scratches, rips, and tears in the sheeting. (Daily, as needed) • Ensure the contractor replaces devices with large abrasion areas, missing reflective sheeting, asphalt splatter, concrete slurry, or other residue. (Daily, as needed) • Ensure contractors remove devices from the project when they are no longer needed. (Continuous) • Measure and document the quantities of traffic control items. (Daily, as needed)

4.1.3.12 DOT State of Practice Summary

State DOTs are increasingly incorporating risk assessment into their QA practices. Various risk-based inspection approaches focus on evaluating material testing and workmanship inspection based on their criticality. These methods help improve field inspections and laboratory tests, ultimately enhancing construction quality and reducing life-cycle costs. [Figure 9](#) illustrates a typical risk-based inspection process for highway construction activities. The process includes fundamental elements such as:

1. Identifying acceptance requirements as outlined in project specifications,
2. Conducting a risk assessment, which evaluates the probability of inspection failure and the consequences of element failure, and
3. Developing an inspection protocol where activities are prioritized based on criticality.

The risk-based inspection plan also determines when, where, and how inspections should be conducted to ensure efficiency and effectiveness.

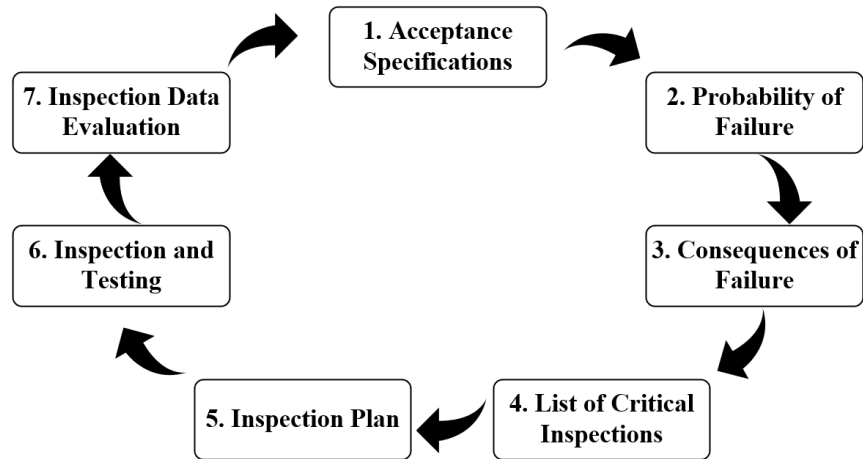


Figure 9: Typical risk-based inspection process (NASEM, 2023)

Construction inspection primarily involves visual field examinations and ensuring compliance with project specifications and plans, such as verifying dimensions and elevations. On the other hand, material inspection involves three acceptance methods. The first method relies on sampling and testing to verify compliance. The second method involves manufacturer certification, ensuring that materials meet the standards outlined in a quality system plan. The third method is based on visual inspection.

The current state DOT risk-based inspection practices indicate that materials and workmanship are typically assessed based on two primary risks:

1. Failure to meet project specifications or plan requirements, and
2. The potential impacts from a failure.

These impacts can include safety concerns, cost implications, and service interruptions. [Table 12](#) presents a sample of state DOTs using risk-based material testing and construction inspection. Some state DOTs typically conduct risk-based inspections through their materials and QA divisions. Other state DOTs incorporate risk-based inspection within their construction divisions or utilize a combination of both QA and construction divisions.

Table 12: Sample of risk-based material testing and construction inspection in use by DOTs (NASEM, 2023)

DOTs Using Risk-Based Material Testing	DOTs Using Risk-Based Construction Inspection
California	California
Florida	Indiana
Illinois	Kansas
Indiana	Kentucky
Kansas	Mississippi
Kentucky	Virginia
New York State	Wisconsin
Ohio	
Pennsylvania	
South Carolina	
Texas	
Utah	
Washington State	

Table 13 shows the grouping of state DOTs based on similarities between their inspection plans. Most state DOT inspection protocols are summarized in a table or matrix that links construction materials to their testing frequencies based on their specifications. This strategy focuses specifically on the construction material but does not necessarily address the risk posed by the construction activity itself. The second most common procedure was a tier-level system, in which activities are categorized into specific tiers indicating risk levels.

Table 13. State DOT inspection programs

Risk Analysis Strategy	States that Implement the Strategy
A table/matrix that associates materials with testing frequency and specifications.	Arkansas, California, Connecticut, Delaware, Hawaii, Maryland, Michigan, Missouri, Montana, Nevada, Ohio, Oklahoma, South Carolina, Texas, Utah, Vermont, Virginia, West Virginia
A tiered or level system that designates each construction activity with a risk level and testing frequency.	California, Ohio, Texas, Vermont
Describes who is responsible for determining the amount of inspection.	Nebraska, Vermont, Washington State
An annual risk-based model that evaluates the quality of construction.	New Hampshire
Determines the resident engineer's required level of experience using a risk matrix. The engineer then leads a risk analysis team.	Utah

4.1.4 Existing and Emerging Inspection Technologies

Adopting existing and emerging technologies can enhance construction inspection processes while reducing the resources and effort required for inspections. These technologies help

bridge the gap between the growing number of highway construction projects and the decreasing availability of inspection resources. For example, WSDOT explored opportunities for process improvements and evaluated the impact of integrating mobile digital tools into project inspections (Snow et al., 2013; Yamaura et al., 2015). Three key projected benefits were identified: increased productivity, improved data quality, and enhanced availability. Additionally, various characteristics were analyzed to assess other aspects of using mobile tools for inspections, with particular focus on how agencies implement mobile technology. A pilot program was conducted, using field trials to evaluate the effectiveness of a mobile technology solution and measure its outcomes (Snow et al., 2013).

NCHRP Synthesis 534 (NASEM, 2019) and NCHRP Synthesis 582 (NASEM, 2022) found that emerging advanced construction technologies have the potential to streamline testing and inspection efforts while enhancing the quality of the final constructed products. [Table 14](#) summarizes existing and emerging inspection technologies, listed alphabetically. Further details of each testing and inspection technology are available in [Appendix H](#).

Table 14: Emerging material testing and construction inspection technologies

Technology	Definition and Usage
Concrete temperature and maturity meter (CTMM)	Maturity testing is defined as the relationship between concrete temperature, time, and strength gain and is represented by an index that can be measured in the field in real time. This technology involves monitoring concrete temperatures to improve overall QA, prevent cracking, estimate strength, and determine the optimal time for surface texturing, post-tensioning, joint sawing, opening to traffic, and form removal. Maturity meters have been used to measure and log internal concrete temperature and time. They have been used for two purposes: (1) recording temperatures in mass concrete for the purpose of determining temperature gradients and (2) implementing the maturity method for evaluating early-age strength.
Digital terrain modeling (DTM)	DTM, sometimes called digital elevation modeling, is the development of a digital surface representation of bare-ground topography and terrain for an area. DTMs are produced via multiple methods, but often via remote sensing methods, such as photogrammetry, rather than traditional surveying methods. DTMs are the cornerstone of moving into digital construction management and 3D engineered models. They have applications in various divisions of the DOT, from planning to asset management. Many DOTs incorporate DTM use as standard practice because it can benefit many areas of a project.
e-Ticketing	The e-ticketing technology replaced the traditional ticketing process by using the Global Positioning System (GPS) and software to track and record the delivery of materials to the construction site. E-ticketing simplifies ticketing by enabling electronic and digital exchanges. It records and documents the amount of construction materials that each truck delivers to the construction site or operation. The materials tracked by this technology include HMA, PCCP, and earthwork.
Electronic field books	Electronic field books are a collection of handheld devices that are self-contained and can run multiple software applications, as well as store and retrieve text and graphical data remotely. Electronic field books, as an application included with portable devices, allow construction staff to complete their daily field reports remotely and to access project information, helping provide more timely and accurate responses to contractor inquiries.

Technology	Definition and Usage
Geographic information system (GIS)	A computer-based system that provides a data-rich environment for the geographic information of assets. It is also a spatial system that creates, manages, analyzes, and maps all data types. It connects data to a map, integrating location data (where things are) with all descriptive information. GIS helps reduce the size of the inspection workforce needed on projects by automating mapping and monitoring, especially when DOTs have limited staff or skills required for the project.
Global navigation satellite system (GNSS)	GNSS is a satellite system that provides geospatial positioning anywhere on Earth. GNSS can gather and analyze important location-based data when connected to cloud technology. Significant research and development have enabled GNSS measurements to produce survey-grade results in real time or through post-processing.
Ground-penetrating radar (GPR)	A nondestructive testing technique that operates by transmitting electromagnetic waves (from 10 to 1000 Hz) into the probed or Earth material and receiving the reflected pulses as they encounter discontinuities. The discontinuity could be a boundary or an interface between materials with different dielectric constants. The amplitudes of the received echoes and the corresponding arrival times can then be used to determine the nature and location of the discontinuity. GPR determines pavement layer thickness, an important consideration for construction QA of new pavements and for structural capacity estimation of existing pavements. GPR detects objects or singular elements hidden in a homogeneous medium.
Intelligent compaction (IC)	IC has been described as an equipment-based technology for improved QC, resulting in longer pavement life. IC machines include vibratory rollers with accelerometers mounted on the drum axles, a GPS device, infrared temperature sensors, and onboard computers that can display color-coded maps in real time to track roller passes, surface temperatures, and the stiffness of compacted materials. Current procedures using conventional compaction machines may result in inadequate and/or non-uniform material densities, which can be a major factor in premature pavement failure. IC determines and achieves the optimal number of roller passes to prevent under- or over-compaction, translating into fuel/operation savings and improved quality.
Light detection and ranging (LiDAR)	LiDAR is a remote sensing method that uses a pulsed laser to measure distances (ranges). It is a geospatial technology that efficiently acquires critical geometric information with exceptional detail for construction projects. LiDAR can support construction and maintenance inspections in several ways, including providing data for analysis and simulation, determining repair and maintenance requirements for each project, and delivering quick, precise surveys from the start of the project.
Mobile technology and laptop applications	Refers to hardware and software used in the field to access and gather project-related information. Portable devices, such as tablets, laptops, and smartphones, and their applications are handheld electronic tools that are self-contained and can run multiple software applications. Portable devices and their applications enable inspection staff to complete their daily field reports remotely and to access real-time project information, helping provide more timely and accurate responses to contractor questions. The mobile applications also help inspectors manage and report inspection processes of different construction operations in a paperless format.
Paver-mounted thermal profiler (PMTP)	PMTP includes two major components: 1) Infrared sensors, or a thermal camera mounted high up on a paver, and 2) A radar system for testing the entire surface area of the paved material. PMTP is mounted to a paver, providing professionals with real-time two-dimensional infrared thermal maps of the mat behind it. Its non-contact surface-temperature measurements can help detect thermal segregation.

Technology	Definition and Usage
Remote video monitoring	Remote video monitoring provides real-time monitoring of construction project site conditions, work progress, security, and safety. Remote video systems use Internet protocol (IP) cameras and video management software to monitor specific locations. Project managers, engineers, executives, and security personnel can use remote video monitoring systems to monitor jobs remotely.
Robotic total stations (RTS)	RTS is an enhanced total station allowing a single operator to conduct site layout measurements. The use of RTS supports e-Construction and paperless data collection. RTSs can be used in any situation that typically involves a conventional total station. Using an RTS instead of a conventional total station provides benefits when resources constrain the workload needs of surveying operations.
Sensors	A device used to measure a property, such as pressure, position, temperature, or acceleration, and respond with feedback. It is a technology that converts heat, light, sound, and motion into electrical signals. It could be integrated with other technologies such as drones, GPR, and visualization models. Sensor and health-monitoring technologies provide real-time reporting, which may assist construction inspectors in assessing construction performance and quality. Sensor technologies collect real-time data on the condition of construction elements and use them for real-time evaluation. Sensors also provide project staff with alerts and the actions that may be taken to address the issue before significant downtime or catastrophic failure occurs.
Uncrewed aircraft systems (UAS)	UAS consists of an uncrewed aircraft vehicle, also referred to as a drone, its control system, ground and satellite communications, and an operator. Currently, UAS use may be considered where construction inspection staff could benefit from alternative methods for surveying, visual data capture, quantity measurements, and remote inspection.
3D, 4D, and 5D Visualization and modeling technologies	Provides a virtual representation and visualization of project components and work progress. 3D engineered models consist of points, lines, and surfaces that depict a highway project and its relevant associated aspects of the project environment in three dimensions. It can also include project schedule data (4D) or project schedule and cost data (5D). Assist construction inspectors in completing field tasks and collecting visual inspection data electronically. Can be used to alleviate inspection risks and staffing shortages for various work and project types.

4.2 Research Objective #2: Review SDDOT's Construction Material Testing and Inspection Program

In addition to reviewing documents, reports, and manuals from the FHWA, AASHTO, and state transportation agencies, SDDOT materials were reviewed to capture the current processes for material testing and inspection for construction activities. Then, a risk assessment was conducted for material testing and construction inspection activities to evaluate the associated risks. The assessment included rating each activity based on its probability of failure and the impact of a failure on costs, safety, and service interruptions. Finally, interviews were conducted with SDDOT personnel, contractors, material suppliers, and consultants. A summary of findings is provided in the subsequent sections.

4.2.1 SDDOT Reports and Manuals Used for Construction Material Testing and Inspection

SDDOT has established a material testing process, documented in the SDDOT Materials Manual, Standard Specifications for Roads and Bridges, Construction Manual Project Management Section Chapter 3, Materials, SDDOT Materials Testing and Inspection Certification Program Manual, SDDOT Required Samples, Tests and Certificates (RSTC), and the SDDOT Minimum Sample and Test Requirements (MSTR). These documents describe the methods for controlling work, material testing, the frequency of sample collection, and the qualified personnel responsible for sample collection. SDDOT also uses a tiered certification system to identify quality assurance requirements based on material and has a certification process in place for those performing inspection, acceptance, and testing. For example, the minimum testing standard states that reinforcing steel will not be used until certification records have been received or tests have been completed. Also, sample bars are not to be larger than #8 size for testing. Further, reinforcing steel must conform to the parameters outlined in Division 1010 of the Standard Specifications for Roads and Bridges Manual. As per Section 6 of the SDDOT Standard Specifications for Roads and Bridges Manual, the contractor will supply the material to the DOT engineer before delivering it to the worksite (South Dakota DOT, 2025a).

Testing and inspection are conducted in accordance with contract requirements, the required minimum testing as stated in the MSTR, and the contractor's schedule. If a discrepancy exists in sample collection methods, the order of precedence is: first, the SDDOT Materials Testing and Inspection Certification Program Manual; second, AASHTO guidelines; and lastly, the American Society for Testing and Materials (ASTM) standards. For example,

- The theoretical weight will be used to measure reinforcing steel. The weights identified for each bar size are found in Division 480 of the SDDOT Standard Specifications for Roads and Bridges Manual.
- Epoxy coatings on dowel bars must conform to AASHTO M254 Type B, and the film thickness will be 5-13 mils after curing. All other epoxy-coated steel will conform to ASTM A775. Acceptance of the material is at the engineer's discretion and depends on the tier level at which it is classified.

Similar to many state DOTs, the SDDOT uses 23 CFR 637 to determine the requirements for individuals to become certified to perform testing, inspection, and acceptance duties during construction. The materials testing and inspection program dictates the certification of the individuals who perform inspection duties. The SDDOT defines a failing acceptance sample or test as one that yields results outside the specified requirements. Some materials used in highway construction pose greater risks if they fail. To assess material risk levels, SDDOT implements certification processes, including a material certification program and the SDDOT

APL. Certification involves a contractor, manufacturer, or supplier verifying and guaranteeing that specific products, materials, or items comply with established specifications.

SDDOT, as described in the RSTC of the Materials Manual, implemented a 3-tiered process for the certification of materials, ranging from critical to non-critical (South Dakota DOT, 2024). The three tiers are:

- **Tier 1** – Critical materials: Materials considered critical to safety or costly to replace. Critical materials are not placed unless they have been certified by the SDDOT engineer.
- **Tier 2** – Normal materials: Materials that can be installed when the contractor satisfies the conditions of furnishing the documents specified in the Material Manual or using a material listed on the approved product list. Tier 2 materials are not as severe as Tier 1 but must still be obtained from an approved material supplier or certified by the SDDOT engineer.
- **Tier 3** – Noncritical materials, require no documentation. Tier 3 materials have no certification requirements and may be accepted after only a visual inspection. The contractor may install Tier 3 material on the project at any time.

The certification requirements vary from certificates of compliance supported with test results to certified suppliers to umbrella certificates for component products of a system or assembly. Certification verification methods range from sampling and testing to documented inspection, random audits, and supplier inspections.

4.2.1.1 Quality Assurance Guidelines and Practices

Establishing the tier level (1, 2, or 3) from the SDDOT Materials Manual is a risk-mitigation mechanism to identify the potential impact a material could have on construction if it should fail. The SDDOT Standard Specifications for Roads and Bridges specify methods to ensure material quality, requiring that materials obtained from approved sources be tested and inspected by SDDOT field personnel (South Dakota DOT, 2025a). The SDDOT field personnel obtain samples in accordance with the standards established in the SDDOT Materials Testing and Inspection Certification Program Manual, as well as AASHTO and ASTM standards.

4.2.2 Risk Assessment of Construction Material Testing and Inspection Activities

In reviewing the SDDOT Construction Manual and Materials Manual, the research team established lists of field material testing and construction inspection activities. The list of material testing activities is shown in [Appendix F](#) and contains 273 activities across 19 categories. The list of construction inspection activities is provided in [Appendix G](#) and contains 74 activities across six categories.

Due to the numerous activities, the research team conducted a risk assessment across two rounds, with expert input from SDDOT personnel provided in each round. Round one was to review the lists of material testing and construction inspection activities and determine the core activities typically performed on any highway construction project. A “Yes” or “No” assessment was used, in which a “Yes” response meant that the testing or inspection activity could potentially add risk to a project. A “No” response indicates that an activity is not considered critical to testing and inspection operations because it poses minimal risk to the project. Round one reduced the number of material testing activities to 72 and the number of construction inspection activities to 35. These core material testing and inspection activities were then compiled for the second round of the risk assessment.

In round two, SDDOT personnel reviewed the core material testing and inspection activities lists from round one and rated each activity's probability of failure and its impact on cost, safety, and service interruption if it failed, using the risk matrix illustrated in [Table 15](#). The numbers in each cell represent the rating used for an activity. For example, if a reviewer uses their expertise to rate the safety impact of a failed fresh concrete test, they may select low probability of a failure occurring, but the impact would be very high. The rating then for safety impact for the reviewer is 10.

Table 15: Risk matrix used for the Task 3 round two risk assessment

Probability	Very Low Impact	Low Impact	Moderate Impact	High Impact	Very High Impact
Very High Probability	5	10	15	20	25
High Probability	4	8	12	16	20
Moderate Probability	3	6	9	12	15
Low Probability	2	4	6	8	10
Very Low Probability	1	2	3	4	5

A total of 18 SDDOT personnel completed the round two risk assessment, providing probabilities of occurrence and risk impacts for each material testing and construction inspection activity. The expected value (EV) from these assessments was calculated using Equation (1). Averages were then calculated to determine the EV for each material testing and construction inspection activity. The material testing activities list with calculated average EV is found in [Appendix I](#), while the construction inspection activities list with calculated average EVs is found in [Appendix J](#). [Table 16](#) outlines the top ten average EVs for material testing activities, where the higher the risk impact, the higher the risk to a project. [Table 17](#) outlines the top ten average EVs for construction inspection activities.

Table 16: Top 10 highest expected values for material testing activities

Category	Quality Assurance (QA) Sub-Category	MSTR Testing Activity	Cost Impact EV	Safety Impact EV	Service Interruption Impact EV	Highest Expected Value (HEV)	Task 3 Risk Rank
6. PCC Structure Construction	6.3 Fresh (Plastic) Concrete Tests	Air Content, Unit Weight, Slump, and Temperature	8.69	7.38	7.50	8.69	1 st
6. PCC Structure Construction	6.2 Strength Tests	Compressive Strength	7.75	6.94	6.88	7.75	2 nd
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	In-Place Density	7.44	2.50	5.75	7.44	3 rd
5. PCC Paving Construction	5.3 Fresh (Plastic) Concrete Test	Air Content, Unit Weight, Slump, and Temperature	7.25	4.50	5.25	7.25	4 th
3. Miscellaneous Granular Materials	3.4 Granular Bridge End Backfill	Aggregate Sieve Analysis	6.38	3.25	4.50	6.38	5 th
3. Miscellaneous Granular Materials	3.4 Granular Bridge End Backfill	In-Place Density	6.38	3.19	4.81	6.38	6 th
4. Subgrade Construction	4.1 Specified Density (In-Place)	Bridge End Embankment	6.38	3.06	4.38	6.38	7 th
4. Subgrade Construction	4.1 Specified Density (In-Place)	Berms	6.31	2.75	5.13	6.31	8 th
6. PCC Structure Construction	6.1 Materials	Aggregate, Fine and Coarse Sieve Analysis	5.19	4.31	6.19	6.19	9 th
3. Miscellaneous Granular Materials	3.10 Salvaged and Full-Depth Reclamation Materials	In-Place Density	6.13	2.88	4.50	6.13	10 th

Table 17: Top 10 highest expected values for construction inspection activities

Division	Inspection Activity	Cost Impact EV	Safety Impact EV	Service Interruption Impact EV	Highest Expected Value (HEV)	Task 3 Risk Rank
Structures Construction	Structural Concrete	8.81	8.81	9.81	9.81	1 st
Incidental Construction	Temporary Traffic Control	4.81	9.31	5.69	9.31	2 nd
Structures Construction	Drilled Shaft Construction	7.69	6.88	8.56	8.56	3 rd
Structures Construction	Timber, Prestressed, and Steel Piles	6.13	6.44	7.44	7.44	4 th
Structures Construction	Steel Structures	6.31	6.44	6.88	6.88	5 th
Structures Construction	Bridge Deck Preparation and Resurfacing	6.75	4.88	6.69	6.75	6 th
Rigid Pavement	Portland Cement Concrete Pavement	6.25	4.56	6.19	6.25	7 th
Structures Construction	Precast and Pretensioned Prestressed Concrete	5.38	5.94	5.50	5.94	8 th
Structures Construction	Pipe Culverts	4.75	4.63	5.44	5.44	9 th

Division	Inspection Activity	Cost Impact EV	Safety Impact EV	Service Interruption Impact EV	Highest Expected Value (HEV)	Task 3 Risk Rank
Structures Construction	Bridge Deck Polymer Chip Seal	5.44	2.81	4.31	5.44	10 th

The risk assessment allowed qualitative classification of risk for categories of material testing and construction inspection activities, along with the impact on a project if a failure happens, in terms of cost, safety, and service interruptions. The average results were used to develop the classifications and impacts, as shown in [Table 18](#) for material testing and in [Table 19](#) for construction inspection. These tables were used during interviews with SDDOT personnel, contractors, suppliers, and material testing consultants to gather comments and feedback.

Table 18: Risk assessment results for material testing categories

Material Testing Category	Risk Classification	Major Project Impact
Asphalt Construction	Moderate	Cost
Subbase, Base Course, and Cushion Construction	Moderate	Cost
Miscellaneous Granular Materials	Moderate	Cost
Subgrade Construction	Moderate	Cost
PCC Paving Construction	Moderate	Cost, service interruption
PCC Structure Construction	Moderate	Cost, service interruption
PCC Miscellaneous Construction – Class M	Low	Cost
Roadway Lighting and Traffic Control	Low	Cost
Miscellaneous Incidental and Manufactured or Fabricated Items	Low to Moderate	Cost, safety, service interruption
Pavement Restoration	Low to Moderate	Cost
Bridge Deck Restoration	Low	Cost

Table 19: Risk assessment results for construction inspection categories

Construction Inspection Category	Risk Classification	Major Project Impact
Earthwork	Low to Moderate	Cost
Granular Bases and Surfacing	Low to Moderate	Cost
Asphalt Construction	Low to Moderate	Cost
Rigid Pavement	Low to Moderate	Cost
Structures Construction	Low to High	Cost, safety, service interruption
Incidental Construction	Low to High	Safety, service interruption

4.2.3 Interviews with SDDOT Personnel, Contractors, and Material Suppliers

Interviews were conducted with SDDOT field personnel, including technicians, project engineers, and engineering supervisors. A breakdown of the number of interviewees is provided in [Table 20](#). In addition to interviewing SDDOT personnel, the research team

interviewed two contractors, two material suppliers, and one material testing consultant who works on SDDOT highway construction projects.

Table 20: Number of Interviewees from Each SDDOT Region

Region	Technicians	Project Engineers	Engineering Supervisors
Mitchell	5	2	1
Aberdeen	2	1	1
Pierre	1	2	1
Rapid City	3	2	1
TOTAL	11	7	4

4.2.3.1 SDDOT Field Operations

SDDOT field personnel conduct materials testing and construction inspections in accordance with the project plans and SDDOT specifications. Field staff are typically project- and resource-based, and field personnel may work across projects when resources are limited, depending on project locations. Most technicians work on a single project until it is completed. Typically, field personnel perform about 70% of the material testing and 30% of the construction inspection on any given day.

Table 21 summarizes the roles of SDDOT field personnel. Technicians perform the bulk of material testing and inspections, but inspection duties depend on the technician's experience. Project engineers inspect work and fill in for technicians when testing is needed. Typical testing responsibilities include density tests, moisture content tests, asphalt and concrete sampling and testing, gradation/sieve analysis, and laboratory coordination, among other duties. Typical inspection activities include quantity verification, monitoring/observing the construction process, compliance with specifications, traffic control and safety, environmental and labor compliance, and documentation and reporting.

Table 21: Role descriptions for SDDOT technicians and project engineers

Journey Technicians	Project Technicians	Project Engineers
Performs mainly testing operations and documentation	More responsibilities than journey technicians; perform most testing and inspection tasks	Oversight responsibilities for multiple concurrent projects
Routine materials testing procedures with some supervision; limited inspection tasks	Performing material testing and construction observations/inspections daily	Contract administration and stakeholder communication; Quality assurance verification
Responsibilities based on experience level	QA documentation, contractor liaison, and support	Technical problem solving and decision making

As mentioned in the interviews, field personnel resources are prioritized to ensure critical construction components are the primary focus. However, the difficulty lies in the fact that testing protocols are understood and have defined testing frequencies and tracking

requirements. On the other hand, inspections are more experience-driven and can be more subjective than materials testing. Therefore, the less experienced field personnel tend to perform more testing than inspection. In addition, testing operations are time-sensitive, which limits the time available for inspection. Travel time to deliver samples to a lab for testing also takes away from inspecting the work.

4.2.3.2 Tracking Material Testing and Inspection

The formal SDDOT material testing and inspection tool is the Materials, Samples, and Testing (MS&T) system. This system, introduced in 2001, is the official tracking system used in all regions of SDDOT. The MS&T is integrated with the Construction Measurement & Payment (CM&P) system. In addition to MS&T, other tools used, which are less formal, include spreadsheets, daily diaries, MS Access databases, MS Word documents, and hard-copy three-ring binders. Spreadsheets were mentioned in all interviews as useful tools. Project-specific spreadsheets for project components are typically developed before construction.

SDDOT personnel noted drawbacks to the MS&T application. First, the user interface is not intuitive, so training is required. Second, when multiple users access the MS&T application for the same project, data overwriting occurs, causing documentation issues. SDDOT personnel mentioned that the agency is developing a new material testing and inspection tracking system, which should be implemented over the next couple of years.

4.2.3.3 Training and Certification

Certification and qualification status are not the same, where certification indicates successful completion of formal training, while qualification requires demonstrated field competence through practical application and experience. The certification process operates on sequential cycles to address changing testing and inspection requirements. Recertification occurs on a four-year cycle through written competency exams, while complete retraining requirements occur every eight years to ensure updates are received by all field personnel.

SDDOT conducts formal annual winter training programs at the Pierre headquarters, providing intensive four-to-six-week programs for new technicians and three-to-five-day training for all other field personnel. The SDDOT maintains internal training for approximately twelve distinct testing and inspection certification classes, supplemented by external partnerships with recognized organizations, including the American Concrete Institute (ACI) for concrete certification and the Dakota Asphalt Paving Association (DAPA) for asphalt-related certifications.

Informal on-the-job training (OJT) and mentoring are used at SDDOT. Less-experienced field personnel shadow experienced personnel to learn how to take samples and conduct tests, observe construction placement, and identify what is critical and less critical to the quality and functionality of a highway construction project. These informal approaches to training

operate continuously in the field, based on staffing availability. One SDDOT field staff member stated, “Everyone is willing to help someone new.”

As evident from the interviews, testing procedures follow standardized protocols with clear guidance, while inspection activities require greater experiential judgment and the ability to accurately identify issues as the work is being constructed. Additionally, material testing requires certification, while inspection typically relies on field personnel's experience, with more experienced personnel performing inspections of critical components. For a risk-based material testing and construction inspection program to work effectively, training needs to incorporate comprehensive risk-based decision-making frameworks for inspection and material testing.

4.2.3.4 QA and QC Data

SDDOT implements formal QC and QA protocols exclusively for asphalt paving operations, making it the only construction activity within SDDOT's construction testing and inspection program to follow such protocols. The contractor is responsible for QC and performs field material testing and verification. Contractors are required to perform one test for every 1,000 tons of asphalt. The SDDOT area office is responsible for QA by verifying testing and compliance. The SDDOT is required to perform one test for every 5,000 tons of asphalt. Independent assurance (IA) uses regional material engineers to verify test accuracy and equipment calibration.

Statistical tests (t-test and F-test) are used by central office personnel to compare the contractor's and SDDOT's testing results. Projects demonstrating sustained compliance through statistical verification may qualify for reduced testing intervals while maintaining QA effectiveness. No other material in the SDDOT specifications allows reduced testing frequency, but SDDOT field personnel suggested adding specifications for reduced testing frequency for more materials, especially those that consistently pass tests and rarely fall outside of specifications.

The evaluation of quality for a project focuses primarily on compliance with plans and specifications rather than on comprehensive data analysis. Field personnel review test results and flag potential issues that are then communicated to supervisors. For borderline passing materials, communication with contractors is used to address quality concerns and establish monitoring protocols for future material deliveries and placements.

4.2.3.5 Sampling and Probabilistic Inspection Processes

While SDDOT has the MSTR for material testing and sampling, construction inspection has fewer clear processes, as visual inspection frequencies are undefined for many construction activities. Typically, inspection sampling is based on available staff and the field personnel's experience. Experience helps identify highly critical areas of work – such as concrete

structures, bridge decks, and paving – that require more field observations and testing than less critical areas, such as striping, fencing, and seeding. The critical work has a greater impact on the project, including costs, safety, and service interruptions, if something fails or is constructed incorrectly. The less critical items are easier to remedy and have a smaller impact on the project.

Project complexity is considered when coordinating field staff for highway construction projects. Projects with greater complexity require experienced field personnel to handle inspections, while less experienced personnel typically handle testing and routine operations. To determine field staffing requirements, engineering supervisors and area engineers evaluate project complexity for the upcoming construction season. For understaffed projects, critical activities are prioritized over routine tasks, which may result in skipped tests in favor of observing critical work being put in place simultaneously. For example, bridge deck pours receive priority over sidewalk installation because of the complex corrective actions and the cost implications if the bridge deck fails, compared to the sidewalk. Irreversible work is prioritized over easily corrected deficiencies.

SDDOT has inspection checklists for highly critical activities, including bridge deck pours, drilled shaft construction, and other structural elements, to assist with inspections, as found in Chapter 18 of the SDDOT Construction Manual. These checklists provide systematic inspection procedures for critical work. However, the interview feedback revealed that the checklists may not be consistently used throughout the DOT regions. In addition, SDDOT personnel noted that the checklists need to be updated and formalized for consistent use, and that additional checklists for other inspection components would be helpful.

4.2.3.6 Material Testing and Construction Inspection Technologies

SDDOT has implemented GPS for testing and inspection, using GPS rovers acquired through grant funding. The Trimble GPS Rovers provide field positioning verification, though access is constrained by equipment availability (only three are available across the department) and location within the state. Implementation of technologies varies across the regions. All regions noted using the OnStation app, which provides accurate coordinates and field positioning, but requires cell service for accurate information. The Rapid City Region mentioned using Sight Vision for augmented reality capabilities, allowing a model to be overlaid at the project site to visualize how the project should be constructed. Traditional surveying equipment (rods, levels, total stations) is used for elevation verification and QC, while GPS devices can be used in tandem to point out potential issues. SDDOT has also conducted limited trials with the Inroads software, which achieves five-foot accuracy tolerances, making it suitable for utility structures but insufficient for precision applications such as curb installations. Electronic ticketing (e-Ticketing) systems are being used but

remain optional. Photos and videos are field recording methods. [Table 22](#) lists categories and examples of technologies used on SDDOT highway construction projects.

Table 22. Technologies used to support material testing and construction inspection

Category	Technology Used
GPS	Trimble Rover Devices, OnStation
Augmented Reality	Trimble Sight Vision
Surveying and Work Verification	Rods, Levels, and Total Stations
Batch Material Deliveries/Quantity Tracking	e-Ticketing
Field Recording and Documentation	Photos and Videos
CAD Design	Inroads

Contractors extensively use GPS-guided machine control for grading operations and paving layout, reducing the need for traditional staking. This has shifted liability for positioning accuracy from SDDOT to contractors, with department personnel verifying contractor-provided staking rather than conducting original surveying. In addition, project management platforms such as Procore are increasingly used by contractors, with SDDOT personnel granted selective access for project coordination and real-time information sharing.

Cost constraints limit technology implementation at SDDOT, particularly for equipment with seasonal or project- or task-specific applications. The variable nature of construction work across seasons makes it difficult to justify investments in specialized technologies that may have limited utilization rates. SDDOT typically invests in technologies for everyday use. Geographic coverage requirements across the state create additional challenges for equipment distribution and maintenance, limiting technology access for field personnel on remote projects with no cell or internet service.

4.2.3.7 Material Testing Risk Assessment

The risk assessment results for material testing activities were reviewed in each interview (See [Table 18](#)). The technicians, project engineers, and engineering supervisors generally agreed with the initial risk assessment results for material testing activities. A summary of the common feedback collected from the interviews is presented in [Table 23](#).

Table 23: Feedback on the initial risk assessment for material testing

Common Topics	Feedback
Structural Elements	Field personnel identified PCC structures as high- or critical-risk activities rather than the moderate risk provided in the risk assessment results. In the event of a failure, PCC components such as foundations, abutments, girders, and bridge decks entail extremely high costs and significant time delays in implementing corrective actions, with potential remove-and-replace scenarios for specification failures (which are rare). In addition, structural concrete work faces elevated schedule risks due to SDDOT construction seasons, during which delays may push the work into unfavorable conditions or require seasonal shutdowns with associated cost impacts. Field personnel also mentioned that all structures construction work should have a safety impact.

Common Topics	Feedback
Traffic Control and Roadway Lighting	As interviewees mentioned, traffic control and roadway lighting risk levels vary based on project characteristics. Urban and high-volume traffic areas pose a greater risk to traffic control than rural applications. In addition, stand-alone projects in these categories require higher risk classification than when these elements comprise minor components of larger or more complex projects. Regardless, traffic control should always have a safety impact on workers and the traveling public.
Subgrade construction	Subgrade construction received consistent feedback that it was a moderate to high risk rather than a low risk. The justification for this is that foundation failures cascade upward, compromising subsequent construction phases, reducing the overall project lifespan, and potentially increasing maintenance costs. Interviewees noted that inspection frequency should be increased for this type of work.
Repetitive Testing	Field personnel stated that over-testing occurs for materials that consistently pass. Technicians and project engineers mentioned that moisture content testing is required every two hours. That frequency cannot be adjusted even if tests are consistently passing. One project example cited 1,350 moisture content tests on a 15-mile reconstruction project with only four failures.
Travel Times to Laboratories	Testing frequency requirements create significant travel time burdens when project locations are distant from testing laboratories. Additional time is also needed when samples require delivery to the central office in Pierre, which can be substantial depending on the project's location in the state. SDDOT field personnel may spend substantial time transporting samples instead of inspecting construction activities.
Natural Materials	Natural quarry materials typically have consistent testing results over extended periods, suggesting reduced testing frequency. In addition, concrete plant operations have been modernized with advanced technologies, reducing the need for continuous monitoring and testing compared to the testing frequency required before suppliers adopted advanced digital sensors and systems. One option would be to create a database of approved quarries and concrete plants so that when materials are sourced from them, material testing can be reduced or eliminated.
Low and Moderate Risk Materials	While low- and moderate-risk materials receive less attention, failures in low-risk categories may still shorten service life. Additionally, moderate-risk failures may lead to more costly, longer-lasting consequences, such as increased maintenance and a shorter life span. Interviewees emphasized that it is still important to test these items in certain situations to minimize impact on service life.

Interviewees suggested using project- and construction component-dependent approaches to material testing. The MSTR provides a specific, yet rigid, approach to materials testing that may or may not be critical to any project. The idea of using project-specific material testing approaches should be explored. Project specific material testing needs to consider the project type (new construction, reconstruction, rehabilitation), scope (structures, paving, incidentals), location of the project (urban vs. rural, proximity to SDDOT offices or laboratories), where materials are coming from (in state or out of state), and who is performing the work (a high-performing contractor vs. a marginal contractor). Adaptive testing approaches could also be explored for material testing, where testing frequencies can be adjusted to reduce testing when consistent results are found and increase testing when test results start to show issues.

Another potential approach to risk-based material testing is to reduce testing based on the frequency of consistent test results. SDDOT personnel mentioned that, for example, asphalt operations include plant pre-inspection and calibration testing, which help ensure the quality of the material. In addition, contractors conduct five times as many tests on the asphalt

material as the DOT. Therefore, specifications allow for reduced testing when results consistently pass for asphalt construction.

4.2.3.8 Construction Inspection Risk Assessment

The interviewees were shown the results of the construction inspection risk assessment (See [Table 19](#). To capture the themes and trends in the information collected from the interviews, [Table 24](#) summarizes the findings. In general, interviewees agreed with the initial risk assessment of construction inspection activities. However, many factors can increase or decrease the risk of inspecting construction work. Traffic volume, early issue detection, contractor performance, project location, scope of work, and project type are examples from the interviews that can definitely change a project's risk and impact. Therefore, risk levels are not typically fixed for all projects and vary based on these factors. Additionally, field personnel noted that testing should be used to verify inspection results, so that if an issue is observed, testing can help confirm it. As several field personnel stated, “We should not be testing just for the sake of testing.”

Table 24: Feedback on Construction Inspection Risk Assessment

Inspection Characteristic	Feedback
Structures Construction	Most field personnel agreed that structures are never low risk for inspection. About half of the interviewees consider structures construction to have a high probability and impact, because if something is wrong or missed, it can compromise the entire project. Also, if something is missed early on, it can compound the cost of remedying the situation. Structural work should require continuous inspection, which is considered more critical than material testing.
Pavements	Asphalt and rigid pavements should be considered moderate to high risk due to the cost of removing and replacing work. Continuous inspection is needed to prevent costly issues and ensure the long-term performance of the pavement.
Risk Classifications	In many cases, any construction inspection can be high-risk. Experienced personnel know what to look for, but less experienced field personnel may miss problems or not know where they arise. Therefore, less experienced inspectors may increase the risk that inspections are not conducted correctly or in a timely manner.
Traffic Volume and Project Location	Risk classifications can be affected by traffic volume and a project's location. Field personnel noted that projects along high-volume traffic corridors or in urban areas pose a higher risk to performing construction inspections than projects along low-volume roads or in rural areas. For example, a failure of a bridge deck on a low-volume road is less impactful than a failure on a high-volume road. Field personnel focus on inspecting the more critical elements (high risk) of a project rather than the less critical ones (low risk).
Prioritization	Interviewees mentioned that prioritization is used on a project to determine what needs to be inspected and tested, and what takes precedence if both need to occur simultaneously. When critical work is being placed, inspections take precedence over testing. However, the reason for the missed test will be discussed.
Detecting Issues Early	Timing of inspections is critical, and inspections are key to construction, as testing alone typically does not detect issues. Field personnel pointed out that catching issues early tends to lessen the impact of remedying the issue. When issues are not detected early, they can compound the project's risk and drastically increase its impacts. One example provided was with grading operations. If grading is not properly done, this can lead to structural issues in subsequent activities.

Inspection Characteristic	Feedback
Contractor Impact	The risk level of any inspection component increases depending on the contractor's performance and cooperation. Field personnel who worked with experienced contractors noted improved collaboration and the ability to resolve issues together in the field, thereby reducing risk. Less experienced or non-collaborative contractors tend to increase risk and require more frequent inspections, which require more resources.

4.2.3.9 Checkpoints and Hold Points

Pre-inspection protocols are required before placing any critical work, which includes major elements such as drilled shafts and bridge decks. In these cases, the central office participates in pre-inspection meetings that include field personnel, contractors, and representatives from the central bridge office. These mandatory meetings establish inspection requirements, identify critical control points, and verify material certifications before concrete placement operations. The contractor must also complete paperwork and verify with field personnel before any work can occur. Pre-inspection meetings may be held for asphalt and concrete paving and will include the regional materials engineer. The contractor can lay a test paving strip before operations, but this is typically not required.

There are also prerequisites regarding material certifications and submittals that must be submitted, reviewed, and approved before placing any materials. Steel work requires certification and approved shop drawings before any work can proceed, while aggregate and asphalt materials undergo preliminary quality testing before operations begin. These processes help ensure proper construction and reduce the risk to the project. In addition, SDDOT has specifications stating that subsequent work cannot proceed until quality standards for the current work are met. As examples from field personnel, grading operations cannot proceed to aggregate placement until grade stability and density requirements are satisfied, and concrete operations require strength verification before subsequent construction activities.

4.2.3.10 Corrective Actions

In most cases, SDDOT field personnel do not want to slow down or shut down a project, as this would impede the contractor's progress. However, SDDOT has specifications that dictate whether corrective actions or a shutdown should be implemented due to failed tests or inspections. Asphalt testing results in two out of five tests failing results in a work shutdown. Concrete operations contain similar specifications for air content failures and gradation non-conformance. Supervising personnel at SDDOT are involved in any decisions for a potential shutdown case. Major structural component issues typically mandate removal and replacement due to safety and long-term implications. Other materials include pay deductions for missing specifications, but do not result in removal, replacement, or shutdown. These are typically less critical items that result in a deduction, but the work

continues. Field personnel also pointed out that minimal deducts may not be worth it, as the time and documentation required may cost SDDOT more than the minimal deduct applied to the contractor.

To avoid major corrective actions (for example, removal and replacement of work) and potential shutdowns, SDDOT field personnel noted that continuous monitoring and open communication with the contractor allow the contractor to know of issues as they occur and to make adjustments to get back in line with the specification and tolerances before a failure occurs. This reinforces the fact that detecting issues early is key to avoiding major disruptions to the project.

4.2.3.11 Adjusted Testing and Inspection Frequencies

Field personnel follow the MSTR as the baseline for testing on a project. When a specification failure occurs, the work is stopped to take corrective actions, or a payment deduction is issued. When a failure occurs, the MSTR does not determine whether additional testing is needed; that decision is left to field personnel and supervisors. Also, the MSTR designates the minimum sampling and testing for materials, and reducing the sampling and testing below the minimum is difficult to do, as many SDDOT field personnel stated.

High-traffic urban areas like Sioux Falls and Rapid City require enhanced traffic control monitoring to address high volumes and public safety concerns. Construction season restrictions and special events (such as the Sturgis Rally) create schedule pressures that may result in specification flexibility through informal guarantees and adjusted expectations. In addition, a few SDDOT field personnel provided examples of situations in which regional materials engineers may approve reductions or eliminations of testing, with appropriate justification. Examples include visual-only inspections for solid rock excavation and adjusted pipe testing schedules based on contractor logistics.

Inspection frequency correlates inversely with contractor reliability. Trusted contractors receive reduced oversight while problematic contractors face enhanced scrutiny and testing requirements. Inspection intensity increases for marginal contractors or those performing unfamiliar work types. In general, field personnel would like to see an increase in inspections with a justifiable reduction in testing.

4.2.3.12 Incorporating Risk into Material Testing and Inspection

From the discussions with SDDOT personnel, the following information provides ideas for improving the current materials testing and inspection program by incorporating risk-based approaches:

- Field personnel support reduced testing frequencies for materials that demonstrate consistency, provided the reallocation of resources enables greater inspection

coverage. This approach requires specific identification of testing protocols suitable for frequency reduction while maintaining QA protocols.

- Field personnel also advocate that testing should validate inspection observations rather than serve as standalone compliance measures. Therefore, more inspections should be performed.
- Implementing risk-based approaches should optimize the balance between mandatory testing compliance and critical inspection activities to achieve overall project quality objectives within existing resource constraints.
- The MSTR establishes minimum testing frequencies without risk-based considerations. This approach potentially diverts personnel from critical observation activities to routine testing protocols.
- Compaction testing should be prioritized to critical locations (pipe and box culvert areas) where settlement issues commonly occur, rather than following random sampling protocols. This targeted approach addresses known failure points while optimizing resource utilization.
- Inspection protocols should accommodate varying project conditions, contractor performance history, and resource constraints. This would provide more flexible approaches to inspection rather than rigid procedural requirements.
- Moderate- and low-risk failures typically result in reduced service life rather than immediate failure, with cost impacts occurring over extended timeframes rather than immediate project costs. Therefore, even if a material or element is deemed low risk, that does not mean no testing or inspection is needed; it may result in less testing and inspection if deemed less critical to project quality and functionality.
- Testing frequency should correlate with material consistency and failure probability rather than rigid scheduling. Materials demonstrating consistent compliance over extended periods warrant reduced testing frequency, allowing resources to be reallocated to higher-priority inspection activities.
- Personnel work-life balance issues arise from rigid testing requirements that sometimes unnecessarily extend work hours, even though consistent passing results suggest reduced oversight would maintain quality while improving personnel retention.
- Field personnel would like to see "more robust inspection guides" and "checklists or matrices of information," such as "top 10 things to look for when installing pipe."

Checklists and matrices would help less experienced field personnel know what to look for when conducting field observations of the work.

- Field personnel identify systematic redundancy in which SDDOT conducts duplicate testing of materials that are already subject to continuous QC at source facilities. Natural rock materials from quarries are tested "hundreds of times at the plant," but are still subjected to additional field testing despite demonstrated consistency. The frequency of testing natural materials taken from a quarry should be investigated.
- Personnel report materials that "never fail" continue receiving full testing frequency requirements. One suggestion is to use empirical failure analysis to correlate testing intensity with actual risk exposure to determine the required testing frequency.
- Less experienced technicians prefer testing activities over inspection duties, potentially to avoid interpersonal conflict and decision-making responsibilities. This creates workforce development challenges where personnel gravitate toward objective testing rather than subjective inspection skills.
- Additional training is needed in inspection, communication, and conflict resolution so technicians know how to properly inspect work and work with the contractor.

Overall, SDDOT personnel interviewed are in favor of reducing material testing using a risk-based approach, particularly for critical construction activities such as structures construction work, where visual oversight provides greater QA value than material testing. The interviews with SDDOT personnel reveal that current testing protocols may be compliance-driven rather than quality-driven, and there are opportunities to modernize the testing and inspection program through contractor QC integration and risk-based resource allocation.

4.2.4 Interviews with Contractors, Consultants, and Material Suppliers

Two contractors were interviewed, both of whom have years of experience working on SDDOT projects. Each contractor stated that, as the contractor, they are responsible for QC and ensuring materials and workmanship meet or exceed project quality standards. Each also noted that a risk-based approach to material testing and inspection would represent a significant change from the current process. However, they would be interested in knowing more before agreeing that it would improve testing and inspection operations. In addition, the contractors stated challenges with testing and inspection, and they indicated that risk-based approaches could possibly address these challenges; if so, they would be more inclined to consider them. Despite SDDOT moving to a risk-based approach for material testing and construction inspection, contractors stated they will continue testing based on their QC program requirements.

The two material suppliers interviewed mentioned that they primarily provide materials (For example, aggregates, concrete, asphalt) but also self-perform some work as a contractor for SDDOT. Suppliers operate plants and quarries to provide the materials. QC is paramount to the suppliers, so they continuously test their materials to ensure quality materials are delivered and installed at the project site. Material suppliers were less opinionated about risk-based approaches to field testing and construction inspection, stating they would not reduce their own testing, as doing so might compromise their goal of providing consistent, specification-ready materials.

The material testing consultant interviewed stated that they are contracted to perform material testing, such as concrete density and non-destructive testing, when SDDOT does not have enough field personnel for a project. The consultant has an on-call contract and is called in whenever SDDOT needs them. They follow the specifications and MSTR while also inputting information into the MS&T, just like SDDOT field personnel. As a consultant who performs testing and inspection, just like SDDOT field personnel, the interviewee noted that risk-based approaches could be a good idea, especially for certain materials perceived as being over-tested.

4.2.4.1 QC Testing

In discussions with contractors, consultants, and material suppliers regarding QC, testing, and inspection, each of these parties works together with one another. The contractor uses material suppliers to obtain various construction materials. The consultant material testing firm performs QC testing for the contractor or QA testing for SDDOT. The consultant interviewed worked for SDDOT on the QC side, but contractors hire testing firms to perform QC in the field as required. Contractors also mentioned that consultants help with asphalt and concrete mix designs, which the contractor relies on to meet specifications. Once approved by SDDOT, the mix designs are provided to material suppliers. Suppliers will then run test batches to create the required mix design that meets specifications before mass production and delivery of the material to the site.

One of the primary items each of these parties stated is that they need to provide ample notification to the SDDOT about upcoming work so that adequate testing and inspection staff are available. The contractor's superintendent communicates with SDDOT about upcoming work and what needs testing and inspection. In addition, the superintendent directs the contractor's QC consultant to perform QC checks to ensure items such as reinforcement and formwork are installed per the plans and specifications. This process helps to reduce errors before placing work and DOT inspections. Material supply plants and quarries are also tested and inspected by SDDOT before materials are delivered to a site, again to ensure that materials within specifications are used.

As the contractors, suppliers, and consultants mentioned numerous times in the interviews, clear and consistent communication with SDDOT is critical. Contractors share their schedules with SDDOT to align inspection and testing needs, such as bridge placements, depth checks, reinforcement inspections, and falsework reviews. Pre-pour meetings are conducted before concrete work to confirm readiness, ensure certified testers are available, and verify that necessary testing and inspection resources are secured. Many specifications require 48 hours' notice before performing work that requires testing and inspection, but the interviewees noted that they try to notify SDDOT two weeks in advance.

To ensure quality in materials and work, contractors, material suppliers, and consultants use processes and specific resources. The pre-construction meeting and pre-inspection meetings are key to understanding the quality expectations and when SDDOT field personnel will be needed for testing and inspection throughout the project schedule. Contractors pointed out that they ensure their field staff understands the contract requirements and all project details, and that field staff keep detailed daily diaries/logs. The contractor also conducts QC before placing critical components. Contractors and suppliers agreed that having experienced staff, working with good subcontractors and suppliers, completing the submittal process in a timely manner, and the contractor and supplier performing QC testing prior to placing critical materials. Suppliers also noted using technologies to monitor and track materials continuously. For example, one supplier stated that all their concrete mixer trucks have real-time tracking to monitor material conditions (slump and air content) and the truck's location.

4.2.4.2 Technologies

Contractors, suppliers, and consultants are using various technologies in the field that impact testing and inspection. Contractors mentioned using automated machine guidance (AMG) (or machine-controlled guidance) and real-time kinematic (RTK) rover devices to check layouts. While contractors do not rely on staking, SDDOT does, and the contractor provides staking when necessary. Building information modeling (BIM) is also used by contractors to model challenging or complex construction components. Tablets are used in the field for real-time data and information sharing, as well as for viewing the project model. Drones are used for inventories, measuring quantities, tracking progress, and marketing. One contractor recently purchased a concrete scanner that can reveal steel reinforcement within a concrete structure without using destructive methods. Material suppliers mentioned using digital processing, advanced software, and sensors to manage material and product quality. The consultant material testing firm uses nuclear gauges and some nondestructive testing devices.

4.2.4.3 Risk-Based Testing and Inspection

In terms of risk, contractors and suppliers discussed that inspection and testing risk is a function of project type, location, and the experience of the SDDOT's and the contractor's

field personnel. Rural projects may need less traffic control, but may be far from material supply plants or quarries. As a material supplier stated, there are rock quarries in the eastern and western parts of South Dakota, but none in the middle of the state, and this complicates bringing aggregates to projects in the central parts of the state. A contractor also stated issues with using concrete plants in another state for an SDDOT project. The example provided was a concrete paving project in the northern part of the state, for which the closest concrete plant was in North Dakota. However, the concrete plant in North Dakota understands the requirements and specifications for the North Dakota DOT, but not necessarily for the SDDOT. This complicated the project due to the additional testing and certification needed for this concrete plant to provide the concrete. However, the other option was to use a South Dakota concrete plant that was 100 miles away. It is a significant risk for suppliers and contractors to transport ready-mixed concrete long distances without having issues with the material.

The experience of QC and SDDOT field personnel also affects risk. Contractors and material suppliers noted that testing risks increase when tests are not conducted correctly or when equipment is not accurately calibrated. Risk increases for inspections when less experienced field personnel do not know what to look for to catch errors early. When errors go undetected during inspections, they can compromise subsequent work, leading to major rework and higher costs than if they had been caught sooner. Contractors and material suppliers agreed that projects run smoothly when working with knowledgeable and experienced SDDOT field personnel.

In reviewing the risk assessment of material testing activities ([Table 18](#)) and construction inspection activities ([Table 19](#)), contractors and material suppliers agreed with most of the risk classifications and impacts. One common discussion was that contractors and material suppliers opined that concrete testing and structures construction are typically high-risk. The reason is that these materials and structures are expensive. If anything is wrong, that could lead to rework and significant cost impacts on the contractor and material supplier. All other categories of material testing and inspection activities can be at any level of risk, and impacts can be minimal to significant depending on the project, the experience of field personnel, and how well the contractor, material supplier, consultant, and SDDOT communicate with each other. The earlier errors or out-of-specification work are found, the lower the risk. In addition, safety is always a concern; if testing or inspection reveals a safety issue, contractors will pause work until it is resolved. Safety is always a possible impact of any construction work.

Regarding concrete work, formwork and reinforcement, and earthwork, the interviewed contractors, suppliers, and consultants provided specific examples of challenges in testing and inspection for these key construction elements of a project. [Table 25](#) outlines the risks,

causes, impacts, and mitigation techniques associated with testing and inspection challenges.

Table 25: Challenges in testing and inspection of key construction elements

Work Element	Risk	Causes	Impacts	Possible Mitigation
Concrete Work	Low break strength and specification non-conformance	Differences in sampling locations (chute vs. pump) Long-haul distances to laboratories for remote projects Improper handling of test cylinders (For example, left in the sun, left on the bridge deck, transported without protection)	Failed strength tests increase the contractor's and material supplier's liability, delay the project, and potentially result in costly rework.	Secure a mix design from the supplier in advance and obtain approval from SDDOT (Submittal process) Provide adequate notes to SDDOT for scheduling field personnel Provide exact sampling locations and procedures Protect and transport samples properly Utilize experienced SDDOT technicians for critical concrete testing and inspection.
Formwork and Reinforcement	Undetected deficiencies in reinforcement and formwork before concrete placement	If QC checks are not performed, field personnel may not capture errors. Outdated or incomplete drawings	Structural nonconformance increases the likelihood that SDDOT will reject the work, leading to costly rework.	Perform QC inspections before concrete placement Keep drawings up to date Share QC inspection results with SDDOT Incorporate joint contractor-SDDOT review before concrete placement.
Earthwork	Compaction failures due to improper testing and adjustment	A trial-and-error approach to moisture and density testing is often due to inexperienced personnel running the tests.	Project delays and increased cost for retesting and associated rework Reduced long-term performance of subgrades/ embankments	Implement clear testing protocols for moisture and density testing. Clear communication between the contractor's superintendent and DOT field personnel

Based on the challenges and discussions with the interviewed contractors, the following outlines recommendations for SDDOT to consider in developing and implementing a risk-based approach to materials testing and construction inspection:

- Utilize experienced staff, work with good subcontractors and suppliers, follow the submittal process, and ensure the contractor performs QC testing prior to placing critical materials.

- Contractor interviewees suggested that SDDOT consider making a risk-based testing and inspection approach optional for contractors to choose.
- Development and implementation need to be a joint effort among SDDOT, contractors, consultants, and material suppliers. Working with South Dakota Associated General Contractors (AGC) is a good starting point.
- Consider performance-based specifications, allowing test reduction if materials are consistently within specification.
- Risk-based approaches could potentially raise pricing if contractors feel more risk is being placed on them. Furthermore, if contractors do not buy into risk-based approaches, then pricing will increase.
- Contractor interviewees agree with pay deducts but suggested SDDOT investigate deducts to improve pricing.
- Reduce duplication in testing. Suppliers are testing materials before they leave the plant or quarry. Contractors are performing QC tests on the material in the field. Then, the SDDOT performs its QA testing. If testing results are consistent and within specification from the supplier's and contractor's tests, the DOT may consider reducing or eliminating testing by using the contractor's and material supplier's test results.

4.2.5 Case Studies with State DOTs

Case studies were conducted with five state DOTs to support the development of a risk-based testing and inspection program at SDDOT. These five agencies have implemented risk-based field material testing and inspection for construction projects. The five agencies used as case studies are as follows:

- California Department of Transportation (Caltrans)
- Ohio Department of Transportation (ODOT)
- South Carolina Department of Transportation (SCDOT)
- Virginia Department of Transportation (VDOT)
- Washington State Department of Transportation (WSDOT)

The research team collected in-depth information and held discussions with state transportation agency personnel from each case study agency regarding construction material testing and inspection frequencies, staffing needs, and the use of emerging technologies.

4.2.5.1 Caltrans

4.2.5.1.1 General Information on Field Material Testing and Construction Inspections

The QA Program at Caltrans is designed to ensure that materials and workmanship conform to approved plans and specifications and meet the criteria in 23 CFR part 637.207 for safety, durability, and economy of maintenance. The Office of Quality Assurance and Source Inspection (OQASI), which is part of the Division of Engineering Services (DES) under Materials Engineering and Testing Services (METS), is responsible for QA of Caltrans projects. The program's foundation is a risk management approach that scales QA activities based on the project's size, complexity, and criticality.

OQASI owns and maintains the Quality Assurance and Source Inspection (QASI) Manual, which includes all current requirements for QA source inspection, sampling, and testing of materials for Caltrans projects. Similar documents are maintained by other responsible branches within METS for other materials, such as electrical items. Caltrans also has a Construction Manual (Caltrans, 2024a) that identifies QA activities for the jobsite and a Construction Quality Assurance Program (QAP) Manual (Caltrans, 2023) that defines IA, lab disputes, QA/QC, and lab certifications.

The agency is required to meet minimum inspection levels outlined in the construction manual, while contractor QC testing requirements are specified in the standard specifications (Caltrans, 2024b). Caltrans ensures equivalent QA standards for projects managed by local agencies within its right-of-way by requiring local agencies to source an inspection quality management plan (Caltrans, 2022). Additionally, resident engineers have the authority to adjust QA requirements as needed to address specific project conditions, design limitations, or scheduling constraints.

4.2.5.1.2 Risk-based Material Testing

Caltrans uses a risk-based approach to determine the level of QA activities for different materials. The Construction Manual, Chapter 6, and the QAP Manual provide detailed sampling and testing frequencies based on material risk profiles (Caltrans, 2023; Caltrans, 2024a). High-risk materials, such as structural steel, prestressed concrete elements, and mechanical couplers, require frequent testing and continuous inspection. Acceptance methods include the following:

- 1) Source inspection performed at manufacturing plants.
- 2) Field sampling and testing for job-produced materials.
- 3) Certificates of compliance for low-risk items.

4) Authorized material lists for pre-approved products.

Caltrans has its Data Interchange for Materials Engineering (DIME) system to track sampling, testing, and certification data, supporting real-time decision-making. IA programs verify that all testing is performed by qualified personnel using calibrated equipment.

The cornerstone of the risk-based approach at Caltrans is a qualitative risk matrix, which calculates risk as the product of the probability of failure and the severity of its impact. Risk management is a scalable approach that adjusts effort levels based on a project's size and complexity. When a Notice of Materials to be Used (CEM-3101) form is received, the METS Representative uses the QQASI risk matrix to determine the resources required for the source inspection, as shown in [Figure 10](#).

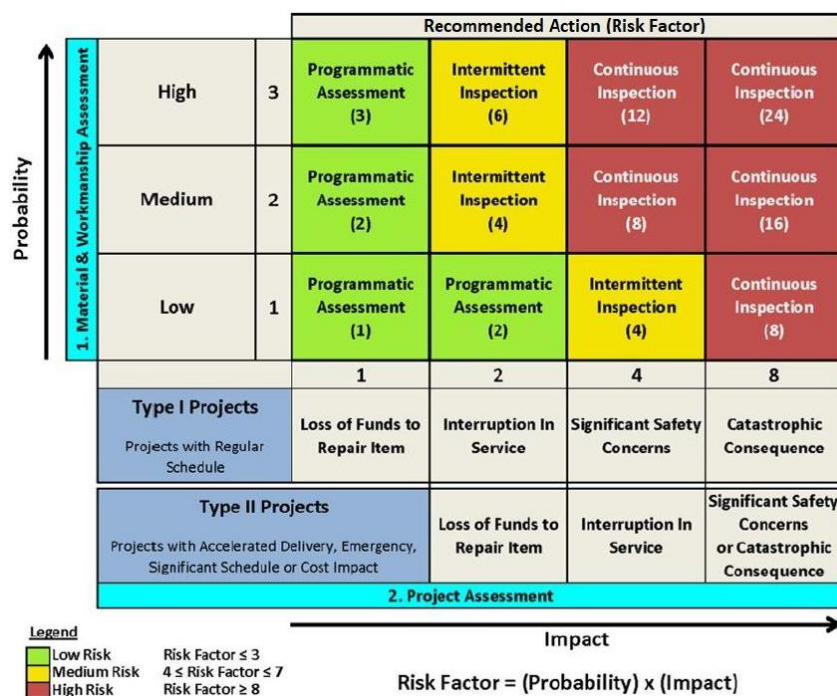


Figure 10: QQASI risk assessment matrix (Caltrans, 2023)

Materials are evaluated along both axes of the risk matrix: the probability of failing to meet specifications and the impact (consequences) if such a failure occurs. This two-dimensional assessment creates categories ranging from low-risk items that require minimal oversight to high-risk materials that demand more testing and inspection. The genius of this approach lies in its ability to distinguish between materials that rarely fail but would be catastrophic if they did, materials that frequently require correction but with minimal consequences, and everything in between. By multiplying probability and impact, the system appropriately escalates attention to items that score high on either dimension, while allowing reduced oversight for items that score low on both. The Division of Construction at Caltrans has established a risk-based decision-making approach that includes four tiers of construction

materials based on their criticality, namely catastrophic (tier 1), safety (tier 2), interrupt service (tier 3), and monetary (tier 4), as shown in [Table 26](#).

Table 26: Tier levels based on impact of failure (Caltrans, 2023)

Tier	Impact	Examples
Tier 1 – Catastrophic	The greatest consequence of failure. Failure is likely to cause serious injury or loss of life.	Structural steel, precast girders, and prestressing.
Tier 2 – Safety	Failure creates a safety hazard for workers or the traveling public.	Delineation, safety barriers, lighting, and signal controllers.
Tier 3 – Interrupt Service	Failure or repair work may cause service interruptions or environmental impacts.	Pavements, bases, embankment, and stormwater pollution prevention plan best management practices devices.
Tier 4 – Monetary	Monetary loss only – the consequence of failure is considered minimal in terms of project performance.	Grass seed, drainage and irrigation products, and fencing.

The practical application of Caltrans' risk-based approach becomes evident in its treatment of materials with catastrophic impact potential or safety impact classifications that create hazards for employees or the public. These materials receive the highest level of scrutiny throughout fabrication and installation. The list of materials with catastrophic impacts reflects structural criticality and failure consequences: steel girders that support bridge decks carrying thousands of vehicles daily; prestressed precast elements including girders, box girders, voided slabs, and precast piles where prestressing failures could cause sudden collapse; overhead sign structures, poles, and standards where failures could drop heavy objects onto traffic; anchor bolts that secure critical structural connections; prestressing strands that provide the tensile capacity for precast concrete members; coated structural steel members where coating failures could lead to accelerated corrosion and structural degradation; and mechanical rebar couplers and splices that transfer forces between reinforcing bars in critical structural locations.

Caltrans has developed specific inspection protocols, testing frequencies, and acceptance criteria for each material category. The risk-based framework does not eliminate testing and inspection but ensures resources are concentrated where they matter most. Lower-risk items may be accepted based on manufacturer certifications, periodic audits of production facilities, or reduced sampling frequencies, while high-risk items receive intensive oversight. This differentiation allows Caltrans to maintain rigorous QA for critical materials without expending equivalent resources on every material regardless of risk. In addition, Caltrans has also implemented programmatic approaches that leverage risk-based approaches to improve efficiency in material testing, as shown in [Table 27](#).

Table 27: Caltrans programmatic approaches to material testing

Programmatic Approach	Description
Authorized Materials List	Allows commonly used materials with good performance history to be accepted without project testing and evaluation. Once a material and manufacturer demonstrate consistent quality over time, they can be added to this list, reducing redundant testing across multiple projects.
Authorized Facility Audit List	Enables continuous evaluation of facility QC programs rather than project-specific inspections. Facilities demonstrating robust QC systems and consistent production of materials meeting specifications can receive audit-based oversight rather than continuous inspection, applying risk-based principles to efficiently allocate inspection resources.
Authorization to Delivery List	Represents continuously produced products such as epoxy-coated reinforcing bars and prestressing strands. These products, manufactured through highly controlled industrial processes by established producers, can be delivered to projects based on periodic audits and QC documentation rather than project sampling and testing at each jobsite.

Caltrans maintains flexibility within its structured QA framework. Resident engineers possess the authority to adjust prescribed QA requirements to accommodate specific project needs, design constraints, and schedules. Field personnel with detailed knowledge of specific project conditions make informed risk-based adjustments within the established framework. A bridge constructed in a remote location with limited traffic might justify different inspection protocols than an identical bridge on a major urban freeway. A contractor with demonstrated quality performance might receive less intensive oversight than one without such a history. This flexibility prevents the risk-based system from becoming rigid while maintaining overall consistency.

Caltrans actively solicits input from industry on materials-related issues through various partnering committees. These interactions range from routine discussions about current practices to performing evaluative studies on pilot projects. This industry's engagement serves multiple purposes: it provides Caltrans with insights into manufacturing capabilities and constraints; it allows the industry to understand agency expectations and risk concerns; and it facilitates collaborative problem-solving when issues arise. The partnership approach recognizes that materials quality results from shared responsibilities between suppliers, contractors, and the DOT rather than adversarial oversight.

4.2.5.1.3 Risk-based Construction Inspection

Caltrans' inspection strategy prioritizes safety-critical operations. Activities such as mass concrete placements, ultra-high-performance concrete (UHPC) keyways, post-tensioning of bridge girders, ground anchor tensioning, and field welding of non-redundant components are subject to heightened oversight. This oversight ensures that potential defects are detected early, reducing the risk of structural failures that could endanger the traveling public. Construction materials have been categorized by risk level in the construction manual (Caltrans, 2024a). All materials are assessed based on risk level, as documented in Chapter 2

of the construction QAP manual. Section 3.4 of that manual also clarifies that Caltrans has a long-range objective for increasing risk-based acceptance criteria (Caltrans, 2023).

The Division of Construction also uses the construction manual, Section 6, to make risk-based inspection decisions (Caltrans, 2024a). For example, higher-risk items that pose a greater risk to the traveling public (in the event of failure) receive a greater degree of inspection than lower-risk items, which may be accepted based on a certificate of compliance (COC). This approach explicitly acknowledges that not all construction activities carry equal consequences if performed incorrectly, and that finite inspection resources should be allocated to maximize safety and quality outcomes rather than distributed uniformly regardless of risk.

Section 6-107 of the construction manual establishes minimum inspection requirements developed through risk-based analyses accumulated over time (Caltrans, 2024a). These requirements reflect decades of experience with construction defects, failure investigations, litigation, and quality problems, and they inform which activities require intensive oversight. The manual provides detailed guidance about inspection frequencies and methodologies for various construction components, creating a structured framework that field personnel follow while retaining flexibility to adjust based on project-specific conditions.

Structural cast-in-place concrete for bridge members receives intensive inspection because concrete quality directly affects structural capacity, and post-construction verification or remediation proves extremely difficult and expensive. Structural concrete in bridge girders, pier caps, foundations, and deck slabs provides the fundamental load-carrying capacity. Concrete strength, consolidation, curing, or reinforcement placement defects could compromise structural integrity with catastrophic potential consequences.

In addition, non-redundant field-welded steel pipe piling represents another high-risk component requiring elevated inspection. Pile foundations transfer loads from bridge superstructures and substructures to competent bearing soils or rocks. When pipe piles are field-welded to extend to required depths or connect to structural elements, weld quality becomes critical. The term "non-redundant" highlights that these are single-load-path elements; if a pile weld fails, there is no alternative load path, and progressive collapse could occur. Field welding introduces particular risks compared to shop welding, including exposure to the weather, less controlled positioning, variable welder skill, and difficulty with inspection access. Therefore, Caltrans subjects these welds to intensive inspection, including visual examination, non-destructive testing, and documentation of welding procedures and welder qualifications. Field-welded column casings receive similar scrutiny. These permanent steel forms or encasements for concrete columns require sound welds to maintain structural integrity and provide corrosion protection for the concrete core. Weld failures could allow

water intrusion, leading to concrete deterioration, compromise the casing's structural contribution, or, in extreme cases, allow casing failure and concrete spalling.

UHPC possesses exceptional strength, durability, and ductility compared to conventional concrete but requires precise mixing, placement, and curing procedures. Keyway connections between precast girders carry shear forces and provide structural continuity across the bridge superstructure. Deficient keyway concrete could compromise load distribution and bridge performance. The specialized nature of UHPC and the structural criticality of keyways justify elevated inspection attention.

Mass concrete pours, including cast-in-place pier caps and bridge foundations, require intensive inspection. Mass concrete elements, defined by dimensions large enough that the heat of hydration significantly raises internal temperatures, face risks of thermal cracking if not properly controlled. Pier caps support multiple bridge girders, transferring loads to columns and piers. Foundations carry loads from the entire structure to the ground. Deficiencies in either element could jeopardize structural stability. The construction complexity of large concrete placements, managing concrete supply logistics, ensuring proper consolidation throughout large volumes, maintaining appropriate concrete temperatures, and implementing curing procedures creates multiple opportunities for problems that inspection helps prevent or detect early.

Post-tensioning of concrete bridge girders involves high-strength steel strands stressed to place the concrete in compression, allowing longer spans and more efficient structural designs. Errors in post-tensioning, overstressing, under-stressing, improper anchorage seating, and incomplete grouting could cause immediate failure during stressing or long-term structural deficiency. The high-energy process and structural criticality justify continuous inspection during post-tensioning operations. Tensioning of ground anchors or tiebacks used for permanent earth retention systems requires similar oversight. These systems, commonly used for retaining walls adjacent to excavations or stabilizing slopes, involve drilled anchors extending into stable soil or rock and stressed to counteract earth pressures. Anchor failures could cause wall movement or collapse, significantly harming safety and property. Testing and inspection during anchor installation and tensioning ensure systems perform as designed.

Risk-based construction inspection at Caltrans also integrates with the source inspection program as shown in [Figure 11](#). Many materials and components undergo intensive inspection during fabrication at manufacturing facilities, rather than, or in addition to, field inspection during construction. Structural steel fabrication inspection, precast concrete element inspection, prestressing strand manufacturing inspection, and other source inspection activities allow verification under controlled conditions where access, lighting, and inspection capability often exceed what is possible in field construction environments.

Components that successfully pass rigorous source inspection may require reduced-field inspection, focusing on proper installation rather than manufacturing quality. This integration of source and field inspection reflects sophisticated risk-based thinking about where and how to apply inspection resources effectively.

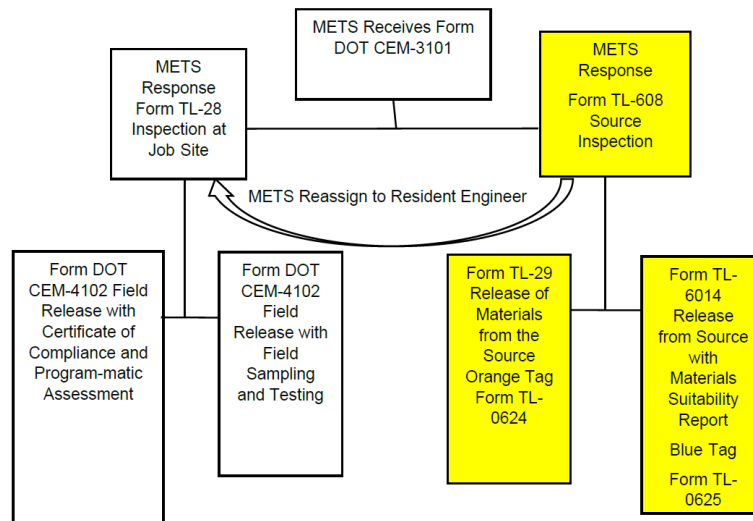


Figure 11: Caltrans source inspection flowchart (Caltrans, 2024)

4.2.5.1.4 Staffing for Material Testing and Construction Inspection

Staffing for QA and inspection is determined by project complexity, with each project assigned a resident engineer and supporting personnel. This project-specific construction staffing provides continuity throughout construction, allowing inspectors to develop detailed knowledge of project-specific conditions, contractor capabilities, and evolving construction issues. Caltrans did not provide detailed criteria for determining appropriate staffing levels, noting that complexity drives these decisions. Project complexity might encompass multiple dimensions: technical complexity of construction methods and structural systems; logistical complexity from concurrent activities and multiple subcontractors; geographical complexity from distributed work locations; schedule complexity from accelerated or phased construction; and risk complexity from work on in-service facilities or other high-consequence environments.

When additional resource capacity is needed, Caltrans supplements its workforce with consultant inspectors and engineers, while retaining full QA responsibility. Using consultants provides workforce flexibility, allowing Caltrans to scale inspection capacity to match construction workload without maintaining a permanent staff size for peak demand. Construction activity fluctuates seasonally with funding cycles and over longer periods with infrastructure investment levels. Permanent staff sized for peak demand would be underutilized during lower-activity periods, creating inefficiencies and morale challenges. Conversely, permanent staff sized for average or minimum demand would be insufficient

during peaks. Consultant supplementation allows a core of permanent staff to be supplemented by consultant personnel during high-activity periods, providing flexibility while maintaining institutional knowledge and continuity within the permanent inspection workforce. However, consultant reliance creates its own challenges, such as:

- Consultant personnel may lack the institutional knowledge and organizational commitment of permanent staff. Training investments in consultant personnel benefit consulting firms as much as the agency.
- Consultant loyalty is divided between the hiring agency and the employer.
- Consultant costs typically exceed the fully loaded costs of permanent staff, due to profit margins and overhead.
- Quality consistency may vary across consultant firms and individuals.
- High-quality consultant inspectors become sought after and may not always be available when needed.

Despite these challenges, consultant supplementation remains essential for Caltrans given the mismatch between workforce stability needs and workload variability.

Caltrans invests in inspector training and qualifications, sponsoring continuous education and training of its inspectors and testing personnel to obtain and maintain their inspection and testing qualifications. The agency handles this training through two primary mechanisms: internal training delivered by Caltrans IA personnel and external training through nationally recognized certification programs, including the ACI, Precast/Prestressed Concrete Institute, American Welding Society, and others. This dual approach leverages Caltrans-specific knowledge about agency procedures, specifications, and policies delivered through internal training, as well as technical expertise in materials testing and inspection methods delivered through industry-recognized programs.

The nationally recognized certification programs provide important benefits. They establish baseline competency standards accepted across the industry rather than agency-specific qualifications that lack external validation. They connect Caltrans personnel with broader professional communities, exposing them to practices and innovations from other agencies and private sector firms. They provide training infrastructure that would be expensive for individual agencies to replicate. However, they also require ongoing investment in certification fees, training course costs, travel expenses, and staff time away from regular duties.

Caltrans tracks all certifications through the statewide independent assurance database, providing centralized management of inspector qualifications. This database allows

verification that inspectors performing specific testing or inspections possess required certifications, supports scheduling by identifying qualified personnel for particular assignments, enables tracking of certification expiration dates to ensure timely renewals, and provides data for workforce planning on qualification gaps and training needs. The database represents the infrastructure investment necessary to manage a large, geographically distributed workforce with diverse technical qualifications.

4.2.5.1.5 Emerging Technologies for Risk-Based Testing and Inspection

Technology plays a critical role in Caltrans' risk-based testing and inspection program. The agency emphasizes non-destructive testing and evaluation methods, including concrete maturity testing, ultrasonic shear-wave tomography, phased array ultrasonic testing, magnetic particle testing, borescopes, GPR, ultrasonic pulse velocity, and impact-echo techniques. Furthermore, Caltrans is advancing its data interchange for materials engineering platform to enable real-time data integration and automated risk-based decision-making, such as dynamically adjusting testing frequencies or rejecting materials based on live QC/QA data.

Specific examples of Caltrans' non-destructive testing shifts include maturity testing of concrete rather than relying solely on traditional cylinder break testing. Concrete maturity testing uses embedded sensors to measure the temperature history of in-place concrete, with maturity indices calculated from time-temperature relationships that correlate with strength development. This allows real-time assessment of whether concrete has achieved sufficient strength for formwork removal, post-tensioning, traffic loading, or other critical construction activities without waiting for cylinder break results. Maturity testing evaluates in-place concrete in the structure rather than separately cured cylinders, which may experience different thermal histories. It provides continuous monitoring rather than discrete data points. However, maturity testing requires proper calibration relating maturity indices to strength for specific concrete mixtures, reliable sensor installation and data collection, and acceptance of indirect strength inference rather than direct measurement.

Ultrasonic shear-wave tomography represents another non-destructive alternative that Caltrans employs instead of traditional core sampling. This geophysical method transmits ultrasonic shear waves through concrete and measures wave velocities at multiple sensor locations, with tomographic reconstruction algorithms creating two-dimensional or three-dimensional images of internal concrete conditions. The technique can detect voids, honeycombing, delamination, cracking, and variations in concrete quality throughout structural members without extracting core samples. Core sampling provides direct material samples for testing but damages structures, creates waterproofing vulnerabilities at core locations, evaluates only discrete points, and cannot comprehensively assess large volumes. Ultrasonic tomography provides spatial mapping of conditions but requires sophisticated

equipment and interpretation expertise, and provides indirect assessment rather than direct material samples.

Phased-array ultrasonic testing uses high-frequency sound waves to detect internal weld discontinuities, including cracks, lack of fusion, porosity, and inclusions invisible to visual inspection. Phased array ultrasonic testing is an advanced technique that uses multiple ultrasonic elements and computer-controlled timing to create focused, steerable beams, improving defect detection and characterization compared to conventional ultrasonic testing. In addition, magnetic particle testing detects surface and slightly subsurface discontinuities in ferromagnetic materials by magnetizing the material and applying iron particles that accumulate at discontinuity locations, creating visible indications. These non-destructive welding testing methods provide quality verification that is not possible through visual inspections alone and are critical for high-risk structural welding, where internal defects could compromise load-carrying capacity.

Caltrans uses borescopes to visually inspect hard-to-access areas, including the interior cavities of structural members, confined spaces, areas behind installed components, and other locations where direct visual access is virtually impossible. Modern video borescopes with articulating tips, LED illumination, and digital image capture allow detailed examination and documentation of conditions in spaces inaccessible to inspectors. This technology extends visual inspection capability beyond directly accessible surfaces, supporting condition assessment without destructive disassembly.

Looking ahead, Caltrans seeks to leverage technology to provide automated risk-based decision support. The agency wants to use real-time QC/QA test data to automate risk-based decisions (For example, requesting additional testing, rejecting material, and increasing or decreasing future testing levels) based on pre-selected criteria. This vision represents the sophisticated integration of data systems, risk assessment frameworks, and decision algorithms. Real-time test data from e-ticketing systems, laboratory information management systems, and field test equipment would feed decision algorithms that compare results against pre-established acceptance criteria, historical performance data, and risk thresholds. The system would automatically trigger actions requesting additional testing when results approach specification limits or show high variability, rejecting materials failing specifications, increasing future testing frequencies for suppliers showing quality declines, or decreasing frequencies for suppliers demonstrating consistent quality.

However, this automated decision-making vision requires substantial infrastructure: comprehensive data collection systems capturing all relevant testing data; data standardization allowing algorithmic analysis; risk-based decision rules codifying when various actions should be triggered; integration with procurement and project management systems to implement triggered actions; and QA oversight ensuring automated decisions

function appropriately. Caltrans identifies improving its material testing and inspection database so QC/QA test results can more easily be used to make risk-based decisions for certain materials and fabricators as a priority toward this vision. The DIME database stores materials testing data, but current systems may lack interfaces, analytics capabilities, or data structures needed for automated risk-based decision support.

4.2.5.1.6 Lessons Learned

Lessons from Caltrans' experiences highlight the importance of flexibility and scalability in QA programs. The agency uses authorized materials lists, authorized facility audit lists, and authorized to deliver programs to streamline acceptance for low-risk materials, reducing unnecessary testing while focusing resources on high-risk items. This approach demonstrates how a mature risk-based framework can improve efficiency and safety. Caltrans emphasizes flexibility, allowing its testing and inspection system to vary the types, frequencies, locations, and durations of required field testing and construction inspections. This recommendation reflects the understanding that overly rigid systems cannot accommodate the tremendous variation in materials, projects, contractors, suppliers, and conditions encountered across a state DOT construction program. What is appropriate in one situation may be excessive or insufficient in another. Flexibility enables field personnel to adjust oversight intensity based on specific circumstances while working within risk-based frameworks.

However, flexibility without boundaries risks inconsistency and potential quality compromises. Caltrans addresses this through its second recommendation to develop both internal and external audit list programs, so that all participants meet minimum entry requirements while allowing for reductions (or increases) in inspection and testing, if warranted by risk-based analyses. This recommendation captures sophisticated thinking about balanced systems.

Materials that repeatedly demonstrate compliance through testing across multiple projects and applications can be placed on the authorized materials list, allowing specification and acceptance without project-specific testing. This approach works particularly well for manufactured products with controlled and consistent production processes, including bridge bearings, expansion joints, pre-qualified proprietary systems, and similar products. The manufacturer's QA provides primary control, with Caltrans oversight focused on proper installation rather than product testing. The recommendation for the programmatic assessment of lower-priority items suggests a tiered approach: the highest-risk items receive intensive project-specific oversight, while lower-priority items receive programmatic evaluation. Rather than testing and inspecting the use of every material, programmatic assessment evaluates overall material or supplier performance across multiple projects, identifying systematic problems warranting corrective action while avoiding redundant testing when performance proves consistently acceptable. This approach requires data

systems that capture results across projects and analytical capability to identify trends and outliers, but it can potentially reduce total testing and inspection while maintaining or improving QA effectiveness by focusing on systematic problems rather than individual, discrete tests.

Caltrans emphasizes the importance of soliciting industry input on materials-related issues through partnering committees. Industry engagement builds an understanding between Caltrans and the industry regarding quality requirements and practical constraints. Engagement also facilitates problem-solving when issues arise, enables joint evaluation of innovations and alternative approaches through pilot projects, and builds buy-in for program changes. Therefore, the industry participates in development rather than simply receiving mandates. The specific reference to pilot projects reflects good practice: testing on a limited scale before full implementation, learning from initial experiences, making adjustments based on lessons learned, and building confidence through demonstrated results.

4.2.5.2 Ohio DOT (ODOT)

4.2.5.2.1 General Information on Field Material Testing and Construction Inspections

ODOT manages material testing and construction inspections under its Construction and Material Specifications (Ohio DOT, 2023) and the Construction Administration Manual of Procedures (Ohio DOT, 2025). These documents define requirements for contractor QC and ODOT QA, including IA testing and conflict resolution when QC and QA results differ. The Central Office Materials Division oversees statewide QA policy, preapproved material sources, and IA programs, while most QA testing occurs in district laboratories. ODOT employs a tiered QA framework that combines centralized oversight with decentralized execution. The materials staff manages critical QA functions at the Central Office, including pre-approved material sources, conflict testing, and IA testing.

ODOT maintains a list of approved suppliers and products to streamline acceptance and ensure compliance with specifications. They also conduct investigations into discrepancies that arise between contractor QC results and ODOT QA results. This process involves side-by-side sampling and testing to resolve inconsistencies and maintain confidence in material compliance. While policy and oversight originate from the Central Office, the majority of QA testing is carried out in district and regional laboratories. These labs handle routine acceptance testing, verification sampling, and day-to-day quality checks for construction projects within their jurisdictions. This decentralized approach allows ODOT to maintain operational efficiency and responsiveness, ensuring testing is performed close to the material production or placement point. Input to ODOT's current material QA practices is provided through specification committees that include representatives from contractors,

suppliers, and industry associations. These committees serve as advisory bodies, offering feedback and recommendations on QA practices for materials. However, their role is limited to providing input, with final decision-making authority remaining with ODOT.

ODOT's material testing program is specification-driven and applies uniformly across projects, regardless of size or risk. Key QC/QA specifications include Item 403 – Asphalt Concrete Quality Assurance; Item 455 – QC Plan, Testing, and Assurance for QC/QA Concrete; Item 511 – Concrete for Structures; and Supplemental Specification 878 – Additional QC/QA requirements. Testing covers asphalt, concrete, aggregates, soils, and structural materials, following AASHTO and ASTM standards. Acceptance is based on contractor QC results (with ODOT verification), ODOT QA and IA testing for compliance, and pre-approved sources and certified products for certain materials.

ODOT has implemented a risk-based construction inspection program since 2017, prioritizing inspection resources based on the potential consequences of failure for each work item. The program uses three inspection levels:

1. Full-time inspection with continuous monitoring for high-risk items (For example, structural components where failure could be catastrophic).
2. Intermittent inspection with daily or periodic checks for items affecting environmental compliance or project delays.
3. End-product inspection with final observation for low-risk items before acceptance.

Currently, ODOT does not implement risk-based material testing, as sampling and testing frequencies remain fixed per specification. Discussions on adopting risk-based testing have occurred, but no formal program exists yet. This approach remains under preliminary review.

4.2.5.2.2 Risk-based Material Testing

As mentioned, ODOT has not implemented risk-based material testing practices for construction projects. The agency acknowledges that risk-based materials testing has been discussed as an approach aligned with the concept of risk-based inspection, but it has not been implemented. ODOT noted that risk-based material testing is under initial consideration, but no implementation timeline has been established. The hesitation about risk-based material testing reflects several factors: material testing protocols may be more tightly constrained by federal requirements or standard specifications than construction inspection practices; material acceptance carries different liability considerations than construction inspection observations; industry standardization of material testing methods may limit flexibility for risk-based modifications; or the agency may prioritize consolidating and refining their construction inspection program before expanding risk-based approaches to material sampling and testing.

ODOT's material testing framework uses QA/QC specifications for major material categories. The agency references key specifications including Item 403 for Asphalt Concrete Quality Assurance, Item 455 for QC Plan, Testing and Assurance for QC/QA Concrete, Item 511 for Concrete for Structures (a performance specification rather than specifically QC/QA), and Item 611 for Pipe Culverts, Sewers, Drains, and Drainage Structures with QC/QA provisions described in sections 611.04 B through 611.04 D (Ohio DOT, 2023). Supplemental Specification 878 provides additional QC/QA requirements. These specifications, available in ODOT's Construction and Material Specifications document, establish standardized testing frequencies, acceptance criteria, and documentation requirements applied uniformly across projects (Ohio DOT, 2023).

The QC/QA specification framework represents a distinct QA approach that differs from traditional agency acceptance testing. In QC/QA specifications, contractors assume responsibility for QC testing to demonstrate that their work meets specifications, while ODOT performs acceptance testing to verify contractor QC and independently assess compliance. This model potentially reduces agency testing requirements compared to traditional specifications, where agencies perform all acceptance testing without contractor QC obligations. However, ODOT maintains standard acceptance testing frequencies in these QC/QA specifications rather than implementing risk-based variations.

The Central Office materials staff at ODOT manages the processes for pre-approved material sources, conflict testing, and IA testing. Pre-approved material sources represent a programmatic approach, establishing approved sources that can supply materials without requiring project-specific approval. This programmatic element indirectly reflects risk-based thinking by reducing oversight of proven reliable sources, though ODOT does not characterize it as risk-based material testing. Conflict testing addresses situations when QA side-by-side testing conflicts with QC sampling results, requiring resolution protocols. IA testing verifies that testing systems function correctly and meet federal QA requirements. Most QA testing occurs in district- or regional-level test labs rather than in centralized facilities. This regional laboratory structure provides flexibility and accessibility but requires coordination to ensure consistency in testing procedures, equipment calibration, and result interpretation across multiple facilities.

ODOT engages contractors, producers, suppliers, and industry groups through specification committees where representatives of associations, contractors, and material suppliers serve. However, the committees are for input only, with ultimate authority residing with the DOT. This engagement model provides industry voice in specification development while maintaining agency control over final decisions. The clarification that committees provide input without decision-making authority reflects a common agency approach that values industry perspective while preserving agency responsibility for setting standards that protect

public interests. This engagement could facilitate the implementation of future risk-based material testing if the agency chooses to pursue it, as industry buy-in and understanding would be essential to the success of any program changes.

ODOT provided assessments reflecting engineering judgment about the impact severity of risks related to non-compliance or failure for major material categories. For project-produced materials, including earthwork, base courses, pavements, and structures, the agency assessed risk as Low to High risk - Premature failure. Earthwork failures typically cause relatively minor localized problems, while structural concrete failures could cause bridge collapse with catastrophic consequences. Premature failure recognizes that even materials that do not cause immediate catastrophic failures can create durability problems requiring expensive premature rehabilitation or replacement. For plant-produced and prefabricated materials, including engineered retaining walls, precast concrete structures and pipe, and structural steel, ODOT assessed risk as High Risk - Premature failure. This elevated assessment compared to project-produced materials may reflect that plant-produced materials often serve critical structural functions where failures carry severe consequences, manufacturing defects may affect multiple units or projects, and detection after installation proves more difficult than during production.

For standard manufactured products, including geotextiles, barriers, pavement markings, and steel poles, ODOT assessed risk as Medium Risk - Premature failure. This intermediate assessment acknowledges that these products perform important functions and failures would cause problems, but typically not catastrophic life-safety consequences. Failed geotextiles might allow soil migration or inadequate filtration; deficient barriers might not adequately contain vehicle impacts; poor pavement markings create visibility and guidance deficiencies; and steel pole failures could drop signs or lights. These risk assessment examples demonstrate that ODOT personnel employ risk-based thinking in material testing, even without formal risk-based material testing protocols.

Despite seven years of risk-based construction inspection experience and active discussion of the concept, the absence of risk-based material testing suggests that ODOT has deliberately chosen implementation priorities and sequencing. The agency may prefer to fully embed and refine risk-based construction inspection before expanding to material testing, avoiding simultaneous changes across multiple program dimensions that could create confusion or implementation challenges. Material testing protocols may be more resistant to change due to industry standardization, long-standing practices, or regulatory constraints. Finally, leadership prioritizes construction inspection changes as providing greater benefit or addressing more pressing needs than risk-based material testing modifications.

4.2.5.2.3 Risk-based Construction Inspection

ODOT operates one of the most explicitly formalized and thoroughly implemented risk-based construction inspection programs across all state DOTs. The program has experienced maturation, refinement based on field experience, and supporting infrastructure development, including training, documentation systems, and organizational knowledge. ODOT's risk-based construction inspection system centers on two fundamental principles:

1. Prioritizing inspection risk for construction activities.
2. Prioritizing documentation frequency for construction activities.

This dual prioritization recognizes that risk-based approaches must address both the intensity of inspections and the comprehensiveness of their documentation. An activity might warrant intensive inspection but streamlined documentation if results are straightforward, while another might need detailed documentation with less frequent inspection. Separating these dimensions enables more nuanced resource allocation than single-factor inspection-intensity ratings.

The agency has established three formal risk tiers, creating a graduated inspection framework that clarifies expectations for different construction activity categories. This three-tier structure balances field understanding and implementation with excessive complexity that could create confusion or implementation difficulties. More risk tiers might allow finer gradations, but they would complicate field decisions and training. Fewer tiers might prove too coarse for meaningful differentiation. Three tier levels corresponding to high (Tier 1), medium (Tier 2), and low (Tier 3) risk provide workable differentiation while remaining manageable, as shown in Figure 12.

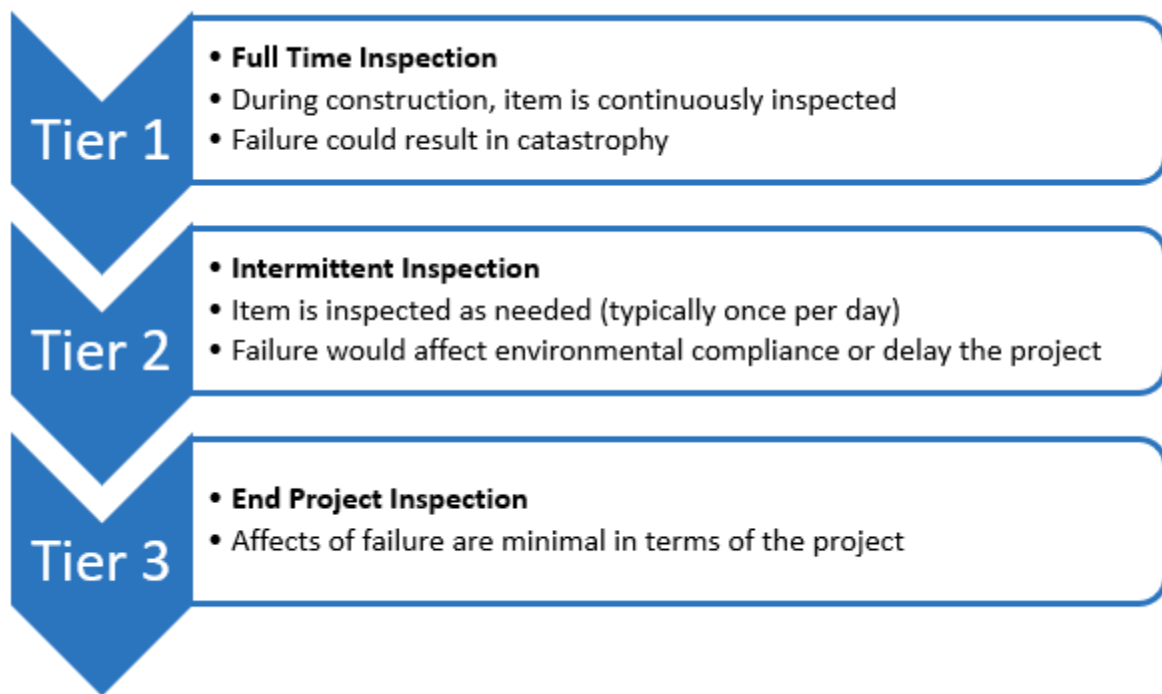


Figure 12: Ohio DOT inspection frequency tier system (Rush, 2021)

A Tier 1 inspection is a continuous, full-time inspection performed while the item is under construction. The policy specifies that this intensive oversight is required for items where the impact of failure could result in catastrophic, life-threatening safety hazards. This highest inspection tier applies risk-based approaches to identifying critical activities, warranting continuous oversight. The catastrophic life-threatening safety hazard threshold provides clear conceptual guidance about what activities receive a Tier 1 designation, where errors could directly cause death or serious injury. Examples include:

- Structural concrete placement for bridge members where concrete deficiencies could cause collapse.
- Welding of non-redundant structural steel, where weld failures could precipitate catastrophic failure.
- Installation of falsework or formwork supporting workers or the public during construction, where collapse would cause immediate casualties.
- Similar activities where the chain from construction deficiency to catastrophic consequence is direct and immediate.

However, continuous inspection also represents the most resource-intensive oversight approach, requiring dedicated inspector assignment to specific activities for their entire duration. This creates significant staffing implications when multiple Tier 1 activities occur simultaneously or when work extends over long periods.

Tier 2 inspection represents Intermittent inspections. Inspection is performed as needed, normally once daily, and focuses on initial setups and critical attributes when the item is actively under construction. This intermediate tier level reflects risk-based recognition that many construction activities warrant regular oversight but not continuous presence. The policy specifies Tier 2 for items that would directly affect environmental compliance or for which repair would delay the project or raise safety concerns. The environmental compliance category reflects that certain construction activities could cause significant environmental violations if performed incorrectly, such as erosion control installations, stormwater management, wetland protection measures, hazardous material handling, and similar work where deficiencies might cause regulatory violations, fines, or environmental damage without necessarily creating immediate life-safety hazards. Project delay consequences recognize that errors requiring rework on critical path activities, work affecting long-lead procurement items, or work that must be removed to access subsequent work create substantial economic impacts and schedule disruptions, warranting prevention through regular inspection, even if safety impacts are indirect.

The Tier 2 framework emphasizes initial setup and critical attributes, reflecting a focus on elements that, if verified correctly, help prevent problems. Initial setup inspection includes paving operations, verifying equipment calibration, mix properties, temperature controls, and procedural compliance before large-scale production begins. Critical attribute inspection focuses on characteristics most important for performance, such as reinforcement placement and concrete consolidation in structural members, even if formwork cosmetics receive less attention; pavement thickness and density, even if surface texture receives less intensive review; and similar prioritization of performance-critical versus aesthetic or less critical characteristics.

Tier 3 represents end-product inspection, which does not require visual observation or construction documentation while the item is actively under construction. However, Tier 3 requires inspection completion before project acceptance. This minimum tier reflects risk-based recognition that some construction activities present minimal consequences if deficient and can be adequately verified through final product inspection rather than process monitoring. The policy specifies Tier 3 for items whose failure consequences are considered minimal for project performance. Intensive process monitoring during construction provides limited value for these activities, since end-product adequacy is easily verifiable and the consequences of deficiencies are relatively minor. By allowing inspection to take place at project completion rather than during construction, more efficient inspector scheduling can be used, reducing the documentation burden during active construction. Contractors benefit from reduced inspector presence during these activities, potentially accelerating work and simplifying coordination.

ODOT emphasizes that the tier of inspection varies based on the specific item of work; the tier of inspection is not dictated by the overall project risk but by individual work activity risk. This distinction proves philosophically important. An alternative approach might assign overall project risk tiers, so that high-risk projects receive intensive inspection across all activities. In contrast, low-risk projects receive reduced oversight, and ODOT assigns risk at the activity level. This activity-specific approach recognizes that even routine projects include some critical, high-risk activities warranting Tier 1 inspection, while major, complex projects include many routine, low-risk activities that are appropriately assigned Tier 3 inspection. The activity-level risk assignment provides better resource allocation than project-level categorization.

ODOT has developed a core group of district champions who represent risk-based inspection SMEs in each district across the state. This distributed expertise model creates regional resources who can provide mentoring, answer questions, address implementation challenges, and maintain programming momentum without requiring constant Central Office involvement. District champions presumably receive enhanced training, participate in program development discussions, provide feedback about field implementation challenges, and serve as organizational change agents promoting risk-based inspections within their districts. This champion model represents sophisticated organizational change management, recognizing that successful program implementation requires sustained local leadership beyond Central Office policy issuance.

However, ODOT candidly acknowledges practical constraints, including staffing levels and availability, which vary district to district, as inspection levels are often adjusted based on availability. Therefore, ideal risk-based inspection principles sometimes yield to practical realities of inspector resource availability. While the three-level framework provides conceptual guidance about appropriate inspection intensity, actual implementation must accommodate workforce constraints. Districts with abundant qualified inspectors can more closely follow ideal risk-based protocols, while districts facing shortages must make pragmatic adjustments. This flexibility prevents the risk-based framework from becoming a rigid doctrine disconnected from operational reality. However, it also means theoretical risk-based principles may not fully manifest in practice when resource constraints are present.

4.2.5.2.4 Staffing for Material Testing and Construction Inspection

ODOT's most distinctive staffing characteristic is that inspection staff share resources with maintenance forces. The shared approach creates a unified workforce that can be flexibly deployed between construction and maintenance, depending on seasonal demands and workload fluctuations. During peak construction season, personnel shift toward inspection to meet intensive summer and fall demands. When construction activity diminishes in winter, these personnel shift to maintenance operations supporting snow removal, equipment

maintenance, facility operations, and winter maintenance. This flexible deployment offers significant advantages: it provides workforce continuity and stable employment year-round rather than laying off workers during the winter. It maximizes workforce utilization by keeping personnel productive year-round rather than experiencing winter underutilization. It provides maintenance operations with personnel experienced in construction quality and procedures who understand how facilities were originally built, potentially improving maintenance quality. It allows adjustment to changing workload patterns between construction and maintenance. From a fiscal perspective, the model spreads personnel costs across construction and maintenance budgets rather than one program bearing the full costs of seasonal workers.

However, the shared workforce model also creates significant challenges that ODOT explicitly acknowledges. ODOT noted that sharing resources between maintenance and construction, while feasible and effective, does cause an erosion of inspection skill sets, as they are not a dedicated group and are often not hired for their technical construction knowledge. This candid assessment identifies fundamental tension as personnel split time between construction and maintenance, and do not develop or maintain construction inspection skills as effectively as dedicated inspectors working full-time in construction. Construction inspection requires detailed knowledge of specifications, construction procedures, material properties, testing methods, quality standards, and documentation requirements. These knowledge domains and skills atrophy during months focused on maintenance operations, requiring refresher training and re-orientation when personnel return to construction duties. The observation that shared personnel are often not hired for their technical construction knowledge suggests that recruitment criteria for combined construction-maintenance positions may emphasize general transportation operations capabilities, equipment operation skills, and maintenance knowledge rather than construction inspection expertise. Personnel hired primarily for maintenance capabilities may lack construction inspection aptitude or interest, viewing construction assignments as temporary diversions from their primary maintenance focus rather than professional specializations. This creates baseline knowledge and engagement gaps that training must address.

Staffing determination depends on the number of construction activities and their related inspection and documentation frequency. This activity-based staffing approach aligns logically with ODOT's activity-based risk assignment. Projects with many concurrent activities requiring intensive Level 1 inspection need more inspectors than projects with sequential Level 3 activities. The documentation frequency consideration recognizes that some inspection documentation proves time-consuming, even if inspection observation proceeds quickly, affecting how many activities one inspector can adequately cover. The agency uses in-house staff, supplemented by consultants, to ensure testing and inspections are performed. This mixed workforce provides core in-house staff, presumably at higher levels of

the organizational structure or in supervisory roles, supplemented by consultants during peak demand periods or for specialized expertise.

The Central Office staff have spent years traveling the state and conducting training on risk-based inspection, reflecting recognition that successful implementation requires comprehensive training to ensure field personnel understand the system and apply it consistently. The traveling training approach brings instruction directly to field locations rather than requiring all personnel to travel to centralized training, potentially improving participation and allowing training tailored to regional needs. Years of training effort underscore that one-time training shows new personnel need training, experienced personnel benefit from refresher training, and ongoing communication maintains focus and consistency.

4.2.5.2.5 Emerging Technologies for Risk-Based Testing and Inspection

ODOT uses a focused technology deployment approach, centered on electronic documentation systems that directly support the risk-based construction inspection program. Rather than pursuing diverse advanced technologies across multiple fronts, ODOT has concentrated on fundamentally transforming inspection documentation from paper-based to electronic systems, then building on this foundation to improve data management, analysis, and reporting capabilities. The agency reports advancing digital reporting for field material testing, though the response provides limited detail about specific systems or capabilities. This process encompasses electronic capture and transmission of test results from field and laboratory testing, replacing paper test reports with digital data entry, potentially through laboratory information management systems, mobile data collection, or electronic ticketing integrated with plant control systems for plant-produced materials, such as asphalt and concrete.

For construction inspection, ODOT has made substantial and explicit technology investments. The transition from paper to electronic inspection documentation represents a fundamental transformation in documentation practices. Electronic forms eliminate the need for physical handling while providing additional capabilities, such as cloud storage for easy access. ODOT's field staff are equipped with tablet computers and handheld devices to record quality and quantity aspects for every construction activity. This hardware investment indicates substantial organizational commitment, as providing handheld devices to field staff requires significant capital expenditure, ongoing technology support, device replacement cycles, cellular or wireless connectivity to transmit data from field locations, and training personnel in device use.

The electronic forms provide several important capabilities supporting risk-based inspection. They include form selection functionality ensuring inspectors use appropriate forms for

specific activities, with forms potentially automatically selected based on pay item or activity codes rather than relying on inspector memory and judgment. This automated form selection helps ensure everyone knows what forms to use for construction documentation. Forms can include embedded guidance about inspection frequencies, critical attributes requiring attention, and documentation requirements specific to inspection levels, providing decision support and consistency. Electronic forms enable structured data entry with validation checks that help prevent common errors, including missing required fields, values outside reasonable ranges, and internal inconsistencies. Required fields can prevent form submission until completed, ensuring documentation completeness. Dropdown menus or checkboxes can standardize terminology and responses, improve data quality, and enable analysis. Photographic and video documentation can be captured directly through cameras and automatically associated with specific inspection forms and locations, providing visual records that support written documentation.

Real-time data transmission from field devices to central databases provides immediate data availability for project management. Project managers can monitor inspection progress, identify activities lacking required documentation, and intervene when problems arise rather than discovering documentation gaps weeks or months later during project closeout. Contractors can receive immediate feedback about acceptance or deficiency identification rather than waiting for inspection reports. Documentation for specific activities, materials, contractors, or time periods can be retrieved through database queries. The “report out” capabilities enable automated generation of inspection summaries, compliance reports, payment documentation, and project records. This reporting automation reduces administrative burden while improving accuracy and consistency.

The analysis capabilities represent perhaps the most significant benefit. Targeted inspection requirement reports are identified on demand, suggesting the system can generate reports showing which activities require inspection, when inspections are due, which have been completed, and which remain outstanding. This demand-driven reporting allows project managers to monitor compliance with risk-based inspection requirements, ensuring Level 1 activities receive continuous inspection, Level 2 activities receive appropriate intermittent inspection, and Level 3 activities receive end-product inspection before acceptance. ODOT can analyze inspection results across multiple projects using electronic data to identify systematic problems with specific contractors, materials, or activity types. Trends over time can reveal whether quality improves or degrades. Correlation analysis can examine the relationship between inspection frequency and detected deficiencies, testing the fundamental hypothesis that risk-based inspection maintains quality while improving efficiency. Contractor performance profiles can be developed to show which contractors consistently meet quality standards and which require intensive oversight, potentially informing future risk-based inspection-level assignments or pre-qualification decisions.

On the other hand, ODOT identified a significant gap between current capabilities and the desired future state, which involves gathering inspection data into a single database for analysis and reporting. The database goal suggests that current systems may remain partially siloed; different districts use separate databases, different inspection types (quality versus quantity) reside in separate systems, or material testing data remains separate from construction inspection documentation. Data scattered across multiple systems prevents comprehensive analysis and creates challenges for enterprise reporting, trend analysis across the entire organization, and integration with other business systems, such as project management, financial accounting, or asset management. Achieving the integrated single database vision requires substantial information technology infrastructure work including database design accommodating diverse data types from quality inspection, quantity documentation, and materials testing; data migration from legacy systems; interface development allowing various field data collection tools to write to the common database; query and reporting tool development enabling users to extract needed information; and system integration connecting the inspection database with other enterprise systems.

4.2.5.2.6 Lessons Learned

ODOT's recommendations emphasize simplicity and stakeholder engagement in developing a risk-based construction inspection system that is easy to understand and explain to field staff. This ensures field staff buy-in, as risk-based programs typically fail without field-level understanding and acceptance. Construction inspection personnel working in field conditions daily ultimately implement any QA program regardless of how well-designed central office policies appear on paper. If field staff does not understand what they should do differently under risk-based approaches, why these changes make sense, and how to implement them in varied real-world situations, the program will not succeed.

A risk-based framework comprehensible to engineers with advanced degrees in civil engineering may prove incomprehensible to inspectors with less education and experience. Systems using complex statistical concepts, multiple interacting variables, or extensive conditional logic may appear logical to program designers but can create confusion and inconsistent applications in the field. ODOT's three-level inspection framework exemplifies this simplicity principle. The levels are conceptually distinct, described in plain language, and linked to clear consequence thresholds (catastrophic, life-threatening; environmental/delay; minimal performance impact). Field personnel can readily understand these distinctions and apply them consistently. Inspectors who understand that risk-based approaches concentrate their efforts on truly critical activities while eliminating busy-work on low-consequence items, and who participated in program development, become program champions, accelerating implementation and increasing use.

Including field staff in the development of the risk-based inspection program provides multiple benefits beyond buy-in. Field personnel possess practical knowledge of construction conditions, contractor practices, common quality problems, and the realities of inspection workflows that central office staff may lack. This knowledge proves essential for developing realistic risk-based protocols that function in actual field conditions rather than idealized scenarios. Field staff can identify unintended consequences or implementation barriers that designers might miss. They can suggest practical solutions leveraging their experience. Their participation in development creates ownership and commitment that passive recipients of directives never develop.

ODOT recommends meeting frequently with field staff to discuss risk-based inspection, documentation, and technologies to ensure inspection quality. Risk-based inspection changes long-established practices and challenges traditional assumptions. Personnel naturally have questions, encounter situations not addressed in training, observe implementation inconsistencies across projects or districts, and develop workarounds when systems prove cumbersome. Without regular venues for discussing these issues, problems accumulate, inconsistencies proliferate, and the program degrades. Frequent meetings provide opportunities to address concerns, reinforce training, share effective practices, identify program refinements, and maintain organizational focus on quality inspection records.

The broader lessons from ODOT's experience emphasize that successful risk-based inspection requires far more than developing sound risk-based frameworks. The technical risk assessment, determining appropriate inspection levels for various activities, represents only one element. Equally important are organizational change management, comprehensive training, distributed leadership, ongoing communication, supporting technology infrastructure, field staff engagement, workforce capability, and sustained leadership commitment. These organizational dimensions often prove more challenging than technical risk assessment. ODOT's experience also demonstrates that risk-based approaches can be implemented successfully despite organizational constraints, including shared construction-maintenance workforce models, resource limitations requiring consultant supplementation, and geographic distribution creating coordination challenges.

4.2.5.3 South Carolina DOT (SCDOT)

4.2.5.3.1 General Information on Field Material Testing and Construction Inspections

SCDOT operates a centralized QA structure supported by strategically located regional laboratories. The Central Office provides overall governance and policy direction for materials QA, while three AASHTO-accredited laboratories deliver operational support to their respective regions. These laboratories perform a wide range of critical functions. The

labs conduct acceptance and verification tests to ensure compliance with specifications for asphalt, concrete, aggregates, and other construction materials and provide hands-on instruction and certification programs to maintain a skilled inspection workforce capable of applying standardized QA/QC procedures. Additionally, the labs evaluate sampling and testing processes to confirm that the DOT and contractor personnel meet required standards, investigate material performance issues, and provide technical solutions to prevent delays and quality failures. The labs also oversee the approval of materials and suppliers, including maintaining qualified products lists (QPL) and ensuring compliance with state and federal requirements. The labs support specialized testing and research initiatives to improve material performance and durability. This integrated system ensures that SCDOT maintains consistent quality standards statewide, while leveraging regional resources for efficiency and responsiveness. Dedicated committees of agency representatives and industry partners meet to address material-related issues.

SCDOT's Materials and Research Office maintains the QPL and publishes a Sampling and Testing Guide that specifies required frequencies for various materials (South Carolina DOT, 2023). Testing covers aggregates, asphalt, concrete, soils, and structural components, following SC-T test methods and AASHTO/ASTM standards. These lists help ensure that only pre-approved materials meeting established standards are incorporated into highway and bridge work. Further, the SCDOT Construction Manual (2004) outlines the required practices and frequencies for sampling, testing, and inspection activities.

Acceptance is based on contractor QC results, SCDOT verification and IA testing (typically 10% of contractor tests), certified sources, and qualified products for certain materials. Sampling and testing frequencies are consistent across projects and are not formally risk-based. For example, SCDOT uses random sampling for density verification (SC-T-87) and monitors contractor gauge readings for asphalt. Nuclear or electronic gauges are used for base and surface courses, and random core sampling ensures compliance with compaction requirements. The SCDOT Construction Manual provides detailed procedures for inspection of all construction activities, including earthwork, paving, structures, and drainage. Inspections ensure compliance with specifications and safety standards. While SCDOT does not implement a formal risk-based inspection program, inspection intensity varies by activity complexity and safety implications. Structural components typically require continuous inspection, while less critical operations may be monitored intermittently. [Figure 13](#) shows the current inspection practice at SCDOT. The flowchart is used to ensure construction results comply with requirements described in specifications and manuals regarding timing (when), responsibility (who), procedure, level of inspection (how often), and inspection details (what is being checked and how).

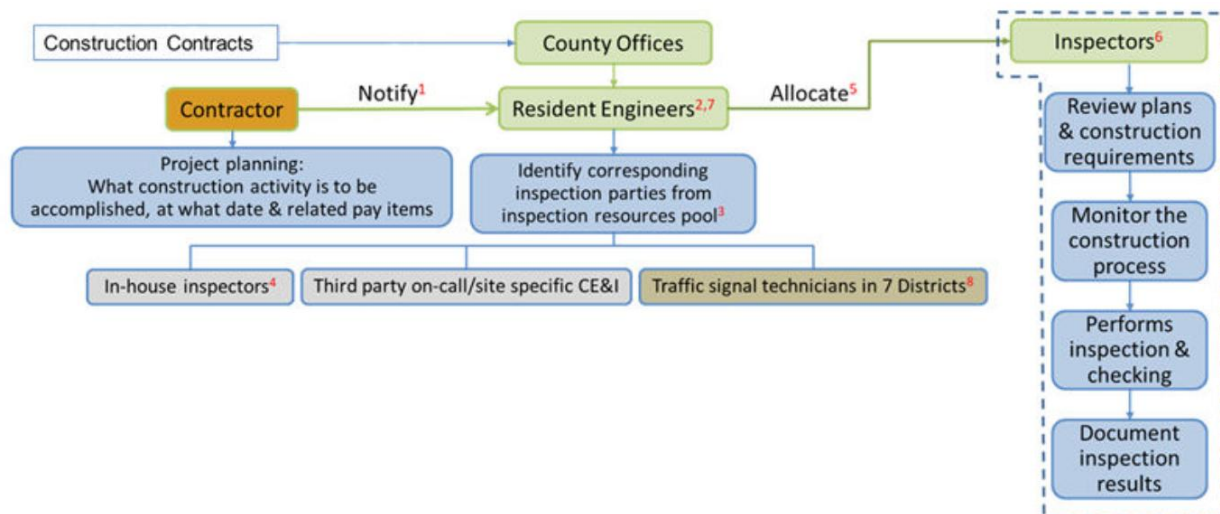


Figure 13: Current inspection practice flowchart at SCDOT (Cai et al., 2022)

4.2.5.3.2 Risk-based Material Testing and Construction Inspection

SCDOT employs a standardized approach to materials testing and construction inspection, with consistent sampling and testing frequencies applied across all projects. The recently completed risk-based inspection research project at SCDOT in 2022 (Cai et al., 2022) found practical implementation difficult, so SCDOT does not implement risk-based adjustments to inspection or testing frequencies. The SCDOT research study originally aimed to create a manual on risk-based inspection practices, but the researcher shifted the focus to building a tool/database. This situation raised major IT concerns due to complex formulas, macros, and maintenance demands, leading to the program being sidelined. Meanwhile, SCDOT was updating its specifications, causing delays since the database was tied to the old specifications. With the updates taking longer than expected (effective January 2025), the committee chose to close the project even though many felt it was incomplete. The COVID-19 pandemic further disrupted progress.

SCDOT maintains consistent sampling and testing frequencies across all projects, as documented in their Construction Manual, with the recent revision to the QC/QA Program Documentation Requirements published in September 2022, and the Sampling Inspection Guide available on their Materials and Research website. The agency's materials office maintains an approved products list for construction materials. This traditional structure effectively delivers QA services without the efficiency gains or resource optimization that risk-based approaches might provide. The SCDOT does utilize some risk-based thinking elements that could support future risk-based implementation. Industry groups and committees from the agency and industry partners meet specifically about materials issues, providing forums for discussing quality concerns and potential program improvements. Contractors, producers, suppliers, and industry groups provide input to current materials QA practices through these channels. This industry engagement could facilitate the future

development of risk-based approaches if the agency chooses to pursue them, as industry cooperation and buy-in are essential to the successful implementation of any QA program changes.

4.2.5.3.3 Staffing for Material Testing and Construction Inspection

Inspection practices at SCDOT are uniform across all project types and sizes, with no differentiation based on risk. Staffing decisions are made by the resident construction engineer, who considers project complexity, size, concurrent activities, and shift requirements. SCDOT relies on consultant inspectors to address staffing shortages, particularly for large-scale or long-term projects. Training for inspectors varies across the state and is largely experienced-based until individuals qualify for formal certification courses.

SCDOT addresses inspector shortages using consultants and maintains a statewide on-call to outsource inspectors for general needs. For larger-scale, long-term projects, the agency procures specific contracts for engineering and inspection, allowing project-specific consultant teams rather than drawing from the statewide on-call pool. This two-tier consultant model provides flexibility for routine supplementation and major project staffing. However, SCDOT does not have internal training and advancement programs for inspection and testing staff. Instead, training will vary until SCDOT personnel have sufficient experience to attend an inspector certification course. This relatively unstructured approach leaves training primarily to on-the-job experience and individual initiative, with formal certification courses available once experience thresholds are met. This model requires minimal institutional investment in training infrastructure but may result in inconsistent inspector capabilities, slower skill development, and recruitment and retention challenges compared to other DOTs offering formal training programs.

4.2.5.3.4 Emerging Technologies for Risk-Based Testing and Inspection

SCDOT's responses did not identify emerging technologies for field materials testing or construction inspection. This suggests an opportunity for modernization, particularly in adopting digital documentation tools and non-destructive testing methods to improve efficiency and data quality.

4.2.5.3.5 Lessons Learned

SCDOT's approach emphasizes standardization and consistency, which benefits statewide uniformity and simplifies contractor compliance. However, the absence of a risk-based framework means that resources cannot be dynamically allocated to high-risk operations, potentially limiting the agency's ability to optimize QA efforts. The agency's reliance on consultants highlights the need for scalable staffing solutions, especially as project complexity and workload increase. SCDOT's traditional approach shows that risk-based

inspection has not been implemented in practice despite promotion through research programs and industry discussions.

The absence of formal training and advancement programs at SCDOT suggests an area where many DOTs could improve, regardless of whether they pursue risk-based program development. Systematic training programs accelerate skill development, improve workforce consistency, support recruitment and retention, and build organizational capability. Even agencies not pursuing risk-based approaches could benefit from enhanced training infrastructure.

4.2.5.4 Virginia DOT (VDOT)

4.2.5.4.1 General Information on Field Material Testing and Construction Inspections

VDOT operates a Materials Division encompassing multiple specialized programs, including aggregates and soils, asphalt, concrete, steel, chemistry, geotechnical, and roadway materials. Within this structure, the QA Section ensures compliance with state and federal standards. The Materials Division staff is responsible for a wide range of critical functions that support the integrity of construction materials across the Commonwealth. Specifically, the staff establishes statewide QA/QC policies and procedures to maintain consistency and compliance with specifications. They also manage and operate VDOT's testing laboratories, which conduct verification and acceptance testing for various materials. The Materials Division staff is also responsible for reviewing and approving new materials and products for inclusion on VDOT's APL, ensuring that only qualified materials are used in construction projects. Additionally, the staff monitors and certifies internal and external laboratories to ensure they meet required standards for accuracy and reliability. Another responsibility is to oversee IA activities to verify that sampling and testing procedures, equipment, and personnel qualifications meet established requirements.

VDOT maintains three dedicated VDOT–industry cooperative groups, each focused on a specific material category: aggregates, asphalt, and soils, which convene at least twice annually. In addition, the department engages with broader industry stakeholders, including the Virginia Transportation Construction Alliance, American Council of Engineering Companies (ACEC), and other associations, through a cooperative forum. These meetings provide a platform to discuss material-related issues, contracting practices, and other topics of mutual interest between VDOT and its industry partners.

VDOT operates under a unified QA program that applies to all project and contract types, ensuring consistency across the state (Virginia DOT, 2018a). However, there are procedural differences between design-bid-build (DBB) and DB projects. A dedicated quality assurance manager is assigned to DB projects, and VDOT accepts the contractor's QC test results as part

of the QA process (Virginia DOT, 2018b). Additionally, VDOT employs a system-based IA program for key material categories, including soils and aggregates, asphalt, and field concrete. This IA program verifies that sampling and testing procedures, equipment, and personnel qualifications meet established standards, providing an extra layer of quality oversight.

VDOT's Materials Manual of Instructions provides detailed guidance on field sampling, testing, and controlling materials used in highways, bridges, and related structures (Virginia DOT, 2024). It includes chapters on sampling frequencies, geotechnical engineering, asphalt and concrete control, and statistical QC. Testing is performed by certified technicians following Virginia Test Methods and ASTM/AASHTO standards.

The Construction Inspection Manual outlines inspection practices to ensure work conforms to plans, specifications, and standards (Virginia DOT, 2018a). Inspections are categorized as continuous inspection for high-risk operations (For example, structural concrete placement and steel erection), intermittent inspection for operations including excavation and grading, and end-product inspection for low-risk activities such as fencing, as shown in [Figure 14](#).

MOBILIZATION

SPEC.	INSPECTION LEVEL	INSPECTION OBJECTIVE	INSPECTOR ACTIVITY
513	End Product	Ensure sufficient labor and equipment is on site to begin work.	Obtain listing of contractor's personnel (including emergency contact personnel, work zone responsible party), and equipment for possible use in contract administration activities such as work orders and force accounts.

CLEARING & GRUBBING

SPEC.	INSPECTION LEVEL	INSPECTION OBJECTIVE	INSPECTOR ACTIVITY
301	Intermittent	Ensure environmental controls are in place prior to land-disturbing activity. Ensure clearing and grubbing operation is confined to proposed construction limits and the excavation is planned to be performed in the next 15 days. Ensure denuding of vegetation confined to areas required for excavation.	BEFORE work begins: Measure any additional area requiring clearing & grubbing and prepare documentation. Measure environmental controls and prepare documentation. Review contractor-employee certification. The contractor must have a person certified through VDOT's Erosion and Sediment Control Contractor Certification (ESCCC) program within the limits of the project during all land disturbing activities. (See Excavation & Embankment)

Figure 14: Example level of inspection required for specified type of work (Virginia DOT, 2018a)

4.2.5.4.2 Risk-based Material Testing

While VDOT does not have a formal, codified risk-based protocol, it applies risk considerations informally across projects, particularly for large or complex undertakings. The Materials Division oversees multiple specialized programs and is responsible for setting statewide QA policy, approving new products, managing laboratory qualifications, and administering the IA program. VDOT incorporates risk-based sampling and testing protocols

for materials such as asphalt, concrete, and aggregates. When determining testing frequency, these protocols consider multiple factors, including historical performance data, supplier quality records, the complexity of construction processes, and past contractor compliance.

VDOT's approach to risk is most evident in its handling of DB projects, where QA/QC roles are clearly delineated. VDOT typically verifies 10% of the design-builder's QC tests and performs additional owner checks at 10% of that QA rate. This layered verification strategy ensures oversight without duplicating the contractor's QC efforts. For DBB projects, sampling and testing frequencies are prescribed in the Materials Manual of Instructions (Virginia DOT, 2024), while DB projects follow the DB QA/QC Guide (Virginia DOT, 2018a). Rather than duplicating contractor testing, VDOT evaluates the reliability of contractor quality management systems and validates results through IA checks. This approach reduces unnecessary repetition while still safeguarding against poor-quality work.

When a particular material, supplier, or project experiences quality problems, VDOT can respond by increasing oversight. This reactive capability provides important safety nets against systematic quality failures. However, without documented criteria for triggering increased oversight or formal processes for evaluating when to reduce oversight based on positive performance history, decisions become dependent on individual judgment and are potentially inconsistent across projects and districts. District materials engineers and Central Office program managers make these determinations informally, which works when these professionals possess strong expertise and good judgment, but creates vulnerability to personnel changes and lacks transparency for contractors and suppliers about what triggers changes in oversight intensity.

VDOT has implemented a system-based IA program for soils, aggregate, asphalt, and concrete. IA programs, required by federal regulations, provide objective verification that QA and QC testing are performed correctly. System-based approaches evaluate the overall testing system rather than retesting individual test results, thereby achieving efficiency gains that indirectly reflect risk-based thinking by focusing on system reliability rather than universal verification. This programmatic approach demonstrates VDOT's willingness to implement alternative QA strategies without a comprehensive risk-based framework.

VDOT indicated that risks related to non-compliance or failure for major material categories, project-produced materials, plant-produced and prefabricated materials, and standard manufactured products would run the gamut from minor to major problems and noted that VDOT has redundancy built into many processes, materials, and structures. This response reflects an important engineering reality: highway infrastructure typically incorporates substantial safety factors, redundant load paths, and conservative design practices that provide tolerance for some material variability or deficiency. Not every material deficiency leads to structural failure or safety hazards.

4.2.5.4.3 Risk-based Construction Inspection

Inspection practices at VDOT prioritize structural components, which are considered higher risk. Although the agency does not employ a formal risk matrix, risk assessments are conducted on larger-tier projects to identify areas requiring increased oversight. This pragmatic approach allows VDOT to allocate resources where they are most needed.

VDOT noted that various components require higher inspection frequencies, particularly structural items. Structural bridge components, foundation elements, and other critical work receive more intensive inspection than less critical work, representing an implicit risk-based allocation of inspection resources. However, VDOT applies differentiated inspection based on engineering judgment about component importance; they do not utilize formal risk levels, documented risk assessment methodologies, or explicit risk-based inspection frequency protocols.

4.2.5.4.4 Staffing for Material Testing and Construction Inspection

Staffing decisions are based on federal minimum requirements and project characteristics such as size and complexity. VDOT has established a formal inspector trainee apprenticeship program, certified through the Department of Labor and Industry, to develop a pipeline of qualified inspectors. Despite this, the agency relies heavily on consultant inspectors, particularly during peak construction seasons, when consultants account for approximately 70% of the inspection workforce compared to 30% of VDOT staff. This high consultant ratio raises important questions about organizational strategy, workforce planning, and cost-effectiveness. VDOT noted that this reflects efforts to meet inspection and testing requirements, given in-house inspector shortages. VDOT experiences pronounced seasonal patterns with an annual ramp-up of inspector onboarding in spring and a wind-down in late fall, reflecting Virginia's climate-driven construction season, where winter weather curtails many highway construction activities. This seasonal workforce model hires large numbers of consultants in spring, maintains them through the construction season, and releases them in fall, providing maximum flexibility and avoiding personnel costs during low-activity winter months.

However, using consultant inspectors also creates significant challenges. Training new consultant personnel each spring consumes time and resources. Institutional knowledge departs each fall when consultants leave. Quality and consistency may vary among rotating consultants. Documentation continuity may be disrupted during seasonal workforce transitions. The annual ramp-up creates intense recruitment and onboarding demands each spring. Competition with other agencies and private sector firms seeking seasonal construction personnel may create shortages and wage inflation.

The seventy-thirty ratio also raises questions about organizational identity and capability. When consultant personnel outnumber permanent staff by more than two-to-one, the consultant workforce becomes the primary delivery mechanism with permanent staff serving in supervisory and management functions. This structure can work but requires robust management systems, clear delegation and oversight protocols, strong contract management, and acceptance that the agency's construction inspection capacity fundamentally depends on external resources. It represents a strategic choice about organizational core competencies, maintaining in-house expertise in inspection management and QA program design while outsourcing inspection delivery.

VDOT determines staffing by federal minimum requirements and the type and size of the project. Federal regulations under 23 CFR require that DOTs maintain adequate QA programs for federal-aid projects, including independent acceptance of materials and workmanship. These regulations establish minimum oversight requirements that agencies cannot reduce regardless of risk-based approaches or other efficiency measures. Federal minimum requirements thus create a floor below which staffing cannot fall, constraining potential staffing reductions from risk-based approaches. In addition, project type and size are considered when determining appropriate staffing ratios for different project categories.

VDOT operates a formal inspector trainee program. The certified apprenticeship program follows federal and state standards for work-based learning, combining on-the-job training with related technical instruction, progressive wage increases as competency develops, and issuance of nationally recognized credentials upon completion. This formalized approach provides structure and credibility to inspector development while potentially accessing workforce development funding and recruiting benefits associated with registered apprenticeships. Upon completion, trainees typically advance to the inspector role, creating a defined career progression path. This formalized training infrastructure represents a significant organizational investment but improves workforce quality, retention, and recruitment compared to informal on-the-job training.

4.2.5.4.5 Emerging Technologies for Risk-Based Testing and Inspection

VDOT implements technology applications for documentation efficiency rather than a comprehensive technology-enabled transformation of QA approaches. For both material testing and construction inspection, VDOT uses eTicketing and PlanGrid. E-ticketing improves accuracy, real-time data availability, automated compilation, and paper elimination. PlanGrid provides cloud-based access to project drawings, manuals, specifications, and documents from mobile devices in the field; markup and annotation capabilities for field notes and documentation; photograph capture and association with specific drawing locations; automated distribution of markups and issues to relevant personnel; and version control, ensuring field personnel have access to current drawings. These technologies improve field

documentation efficiency and communication. VDOT indicated that these technologies are not specifically applied to support risk-based approaches to field material testing and construction inspection, suggesting that deployment focuses on documentation and efficiency, independent of risk-based decision-making.

4.2.5.4.6 Lessons Learned

VDOT operates primarily through professional judgment and informal risk practices rather than formalized risk-based protocols. Such testing and inspection systems can function adequately when used by experienced, knowledgeable field personnel exercising sound engineering judgment. District materials engineers and Central Office program managers with decades of experience understand material behavior, recognize quality problems, and make reasonable decisions about oversight intensity even without documented risk assessment methodologies. This experiential expertise represents a valuable organizational capability that formal systems should leverage rather than replace. However, judgment-based approaches depend on individual knowledge and judgment, making them vulnerable to personnel turnover and retirements.

VDOT's apprentice inspector training program represents the best practice that other DOTs might emulate. Registered apprenticeships provide structured progression from entry-level through journeyman status, combining on-the-job training with related technical instruction, progressive wage increases, and recognized credentials upon completion. Other DOTs struggling with inspector recruitment and retention might consider whether registered apprenticeship programs could strengthen workforce development. VDOT's unified QA program across all project and contract types provides consistency, and using approaches for DB versus DBB recognizes that alternative delivery methods require adapted QA strategies. The challenge lies in ensuring equivalent quality outcomes across different delivery methods with different QA approaches, intensive owner inspection for DBB, and owner verification of design-builder QC for DB.

4.2.5.5 Washington State DOT (WSDOT)

4.2.5.5.1 General Information on Field Material Testing and Construction Inspections

WSDOT manages material testing and construction inspections through a structured framework outlined in its Construction Manual (M 41-01) (Washington State DOT, 2025a), Materials Manual (M 46-01) (Washington State DOT, 2025b), and Standard Specifications (M 41-10) (Washington State DOT, 2026). WSDOT maintains a centralized materials laboratory within its Construction Division, which serves as the primary authority for materials QA across the state. This central office staff is critical in ensuring all highway and bridge construction materials meet state and federal standards. Their responsibilities include

developing and updating QA policies and procedures, managing the WSDOT Construction and Materials Manuals, and ensuring that all acceptance and verification processes align with federal and state requirements. The central office also operates an AASHTO-accredited materials laboratory that performs specialized testing of asphalt, concrete, aggregates, soils, and other materials that require advanced analysis. In addition, they oversee the IA program, which verifies that sampling and testing procedures, equipment calibration, and personnel qualifications meet established standards. Other key functions include approving new materials and suppliers, maintaining the QPL, providing technical support and troubleshooting for regional offices, and delivering training and certification programs for field inspectors and laboratory technicians. This centralized structure ensures uniform quality standards, supports risk-based decision-making, and provides the technical expertise necessary to address complex material performance issues across the state.

The Materials Manual governs field material testing at WSDOT, which includes over 95 field operating procedures and 11 standard operating procedures for laboratory and field testing (Washington State DOT, 2025b). These procedures align with AASHTO, ASTM, and Western Alliance for Quality Transportation Construction (WAQTC) standards, ensuring consistency and national compliance. Testing covers aggregates, asphalt, concrete, soils, and structural materials, with specific methods for sampling, compaction, and strength verification.

WSDOT's QAP, required under 23 CFR 637, includes IA testing, qualified tester programs, and equipment calibration protocols. Chapter 9 of the Construction Manual allows project engineers limited authority to adjust testing frequencies under specific conditions, but any deviation from standard QA procedures requires approval from the state materials engineer.

Construction inspections at WSDOT are guided by the Construction Manual, which prescribes methods for monitoring contractor compliance with specifications (Washington State DOT 2025a). Inspections focus on structural integrity, safety, and adherence to design requirements. WSDOT mandates that all inspectors, whether state employees or consultants, hold a general inspector certification under the WSDOT Construction Inspector Certification Program. This program requires passing ten open-book exams covering technical math, plan reading, materials documentation, and environmental compliance. Subdivision certifications for specialized areas, such as earthwork and structures, are available.

4.2.5.5.2 Risk-based Material Testing

In the 2000s, WSDOT conducted a comprehensive risk assessment using the Delphi process, a structured communication technique for forecasting and building expert consensus. This methodology involved multiple rounds of questionnaires sent to panels of experts, with anonymous responses aggregated and shared between rounds to build toward consensus. The resulting Materials Risk Analysis Report documented this extensive effort, showing the first Delphi iteration materials risk consensus (Baker et al., 2010). This consensus table

categorized major material groups: project-produced materials, including earthwork, base courses, pavements, and structures; plant-produced and prefabricated materials, including engineered retaining walls, precast concrete structures and pipe, and structural steel; and standard manufactured products such as geotextiles, barriers, pavement markings, and steel poles according to risk levels based on expert consensus. The Delphi process represented a substantial investment of time and expertise, bringing together materials engineers, construction managers, QA professionals, and other stakeholders with deep knowledge of highway materials and their failure modes. Through successive rounds of questionnaires and feedback, the panel members converged on risk classifications that reflected collective professional judgment about the probability and impact of material failures. The resulting report provided WSDOT with a rational, defensible foundation for risk-based material testing, drawing on the best available expertise within WSDOT and the broader transportation community.

In its 2010 Material Risk Analysis report, WSDOT identified two key risk factors in the acceptance of construction materials:

1. the likelihood that a material will fail to meet specifications and
2. the consequences of such a failure (Baker et al., 2010).

To systematically assess these risks, WSDOT implemented a two-step approach. The first step involved establishing a conceptual ranking system for QA acceptance, categorizing materials into four levels based on the extent of examination required, which are listed here from lowest to highest:

1. Visual Inspection
2. Certification/Catalog Cut or Visual Inspection
3. Certification with Quality System Plan and/or Visual Inspection
4. State Acceptance Testing and/or Manufacturing Quality System Plan

These levels help evaluate material quality by integrating QA acceptance methods with a risk assessment framework that considers both the probability and impact of failure. Figure 15 illustrates the ranking of these acceptance methods, ranging from the most rigorous and high-assurance approach to the least intensive level of evaluation. The second step in WSDOT's approach involves assigning risk ratings to all materials included in its program using the Delphi technique.

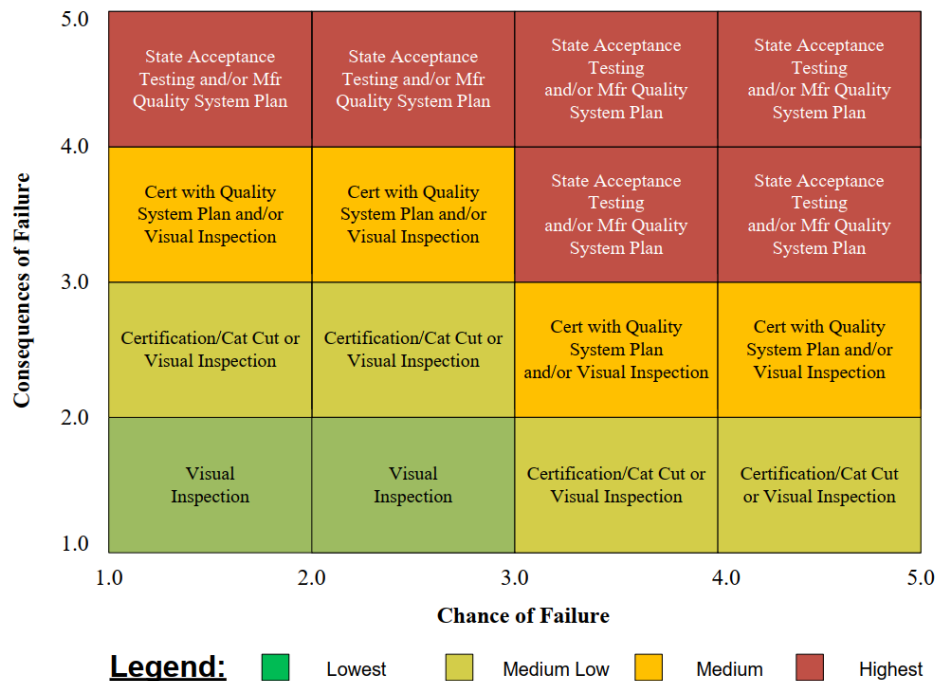


Figure 15: WSDOT material acceptance rating matrix (NASEM, 2017)

Chapter 9-1.1 of the WSDOT Construction Manual indicates that for some materials, WSDOT uses different sampling, material testing, and inspection approaches based on project attributes, suggesting a limited selective application of risk-based thinking. However, the overall pattern suggests that the 2010 Material Risk Analysis report, while valuable as a knowledge-building exercise, did not translate into systematic operational changes in how materials are sampled and tested in the field. The agency noted that project engineers have authority over material approvals and acceptance, which might allow individual discretion in applying risk-based thinking, but without standardized protocols or mandatory implementation, risk analysis has not fundamentally transformed the QA program.

WSDOT reports they have not seen measurable increases in material quality issues despite the lack of implementation of risk-based testing reductions, and they have not considered abandoning risk-based approaches. Instead, the agency has considered additional materials that could warrant reduced levels of QA material testing. Conducting a risk analysis is only the first step; substantial organizational change management, policy development, training, and sustained leadership commitment are required to translate the analysis into operational practice. WSDOT's experience also highlights resource constraints as implementation barriers. WSDOT emphasized that finding expertise and funding to perform risk-based assessments of materials with available testing data is a significant challenge. Combining statistical expertise, materials engineering knowledge, and an understanding of highway construction is difficult to acquire and retain. This expertise gap contributes to the limited operationalization of risk analysis, as the agency lacks sufficient capacity to consistently apply risk-based decision-making across its program.

4.2.5.5.3 Risk-based Construction Inspection

WSDOT explicitly states that they do not use risk-based analysis for construction inspections. The agency expects project engineers to fulfill all inspection duties defined by policy without risk-based prioritization or differentiation. Inspection frequencies do not change based on risk. However, reality proves more complex than policy suggests. WSDOT acknowledges that staff limitations and workload may compromise its ability to complete all inspections on time. This assessment recognizes a common situation across transportation agencies, where inspection demands sometimes exceed available resources. When this occurs, decisions must be made about priorities. Additionally, some locations and conditions may pose significant safety risks for employees that cannot be easily mitigated, creating situations where required inspections might be unsafe. The agency has not abandoned inspection in these circumstances but has established procedures to address them.

When staff limitations, workload constraints, or safety issues prevent inspections from being completed as specified, project engineers consult with region construction managers and the WSDOT Construction Office. These consultations lead to infrequent risk-based inspection decisions, in which managers determine which activities present the least risk based on assessments of cost, complexity, and public safety. This exception-based, escalation-driven risk-based decision-making occurs on a project-by-project basis rather than through standardized protocols. When required inspections are not performed or unreasonably delayed, these deviations are recorded in project records, creating documentation and accountability. The specific risk criteria applied when such decisions become necessary focus on elements that do not carry traffic or pose safety risks to the traveling public, which may be inspected after the fact or through documentation review. This approach identifies a category of construction activities in which inspection timing is less critical than verifying that work meets specifications, even if that verification occurs after completion rather than during execution. Examples might include aesthetic elements, landscape work, or non-structural components where deficiencies would be visually apparent and could be corrected without major reconstruction.

WSDOT's approach also considers inspector qualifications when assigning personnel to various construction activities. Project engineers typically assess inspectors' experience and skills when assigning staff to various construction activities, representing a form of risk-based resource allocation. More complex, critical, or technically demanding work receives assignment to more experienced or qualified inspectors, while routine activities may be assigned to less experienced personnel. This personnel management practice implicitly acknowledges that inspection quality depends on inspector capability and that matching capability to task criticality improves overall QA effectiveness.

The WSDOT's approach reveals important tensions about risk-based construction inspection. On the one hand, the agency maintains a policy position that risk-based inspection does not align with its QA philosophy or regulatory responsibilities. Inspection requirements are specified in policies and standards to ensure quality, protect public safety, meet federal requirements, and systematically reduce inspections based on risk assessment, but this practice has not been adopted as official policy. On the other hand, practical realities such as limited staffing, competing priorities, and safety constraints force occasional risk-based decisions. By handling these as exceptions requiring management approval and project-specific documentation rather than as routine programmatic practice, WSDOT maintains its policy position while acknowledging practical necessities. The infrequency of these exceptions and the escalation to management levels provides checks against systematic under-inspection while allowing flexibility for legitimate constraints.

4.2.5.5.4 Staffing for Material Testing and Construction Inspection

WSDOT's staffing model distributes decision-making to the six state regions, each of which determines project staffing needs for field testing and construction inspection. This regional autonomy allows adaptation to local conditions, construction markets, contractor capabilities, project types, and workload characteristics. Regional decision-making potentially allows more responsive and appropriate staffing than centralized statewide determinations. However, it may also create inconsistency across regions in staffing ratios, qualification requirements, and inspection intensity unless state-level policies establish boundaries and standards. For materials testing, WSDOT's six regions utilize consultants and WSDOT staff to train materials testers. This indicates that both state employees and consultant personnel participate in the testing workforce, with training provided for both groups. For construction inspection, WSDOT uses its own employees and supplements them with consultants when the workload exceeds WSDOT's internal staffing capacity. This seasonal and workload-driven consultant supplementation aligns with patterns observed by other agencies, maintaining a core permanent workforce supplemented by consultant personnel during high-activity periods.

WSDOT maintains a construction inspection certification program detailed in the Construction Manual (Washington DOT, 2025a). WSDOT requires general inspector certification that establishes a broad foundation for building expertise through experience and training, as shown in [Figure 16](#). This approach prioritizes foundational knowledge, understanding of construction processes, specifications, inspection procedures, documentation requirements, and safety practices over specialized technical certifications. Inspectors build expertise through on-the-job experience and targeted training rather than requiring extensive pre-qualification. WSDOT uses a certification table that outlines the general certification structure, though the specific details were not fully captured in the

document. The emphasis on general certification that builds toward expertise through experience suggests a developmental model in which entry-level inspectors receive general training, gain experience under the supervision of experienced personnel, and gradually develop specialized capabilities.

<i>Inspector Certification Program</i>					
General Certification Exam Subjects:			Study Material:		
		On Line Course	Instructor Led Course	Self Study	Manuals
1	Change Order	WSDOT CN: Inspector's Role for Change Order Work	WSDOT CN: Construction Inspection Documentation		Construction Manual, Standard Specifications
2	Environmental		WSDOT CN: Excavation & Embankment Inspection, WSDOT CN: Drainage Inspection, WSDOT ENV: Environmental Compliance for Construction		Construction Manual, Standard Specifications, Environmental
3	Force Account	WSDOT CN: Force Account Documentation and Payment	WSDOT CN: Construction Inspection Documentation		Construction Manual, Standard Specifications
4	Inspector's Daily Report	WSDOT CN: Composing An Inspector's Daily Report	WSDOT CN: Construction Inspection Documentation		Construction Manual
5	Materials	WSDOT CN: Acceptance and Approval of Material	WSDOT CN: Construction Materials Approval + Acceptance		Construction Manual, Standard Specifications
6	Math			Tech Math I	Highway Engineering Field Formulas
7	Plans Reading			Plans Reading	
8	Safety				Safety Procedures and Guidelines, Standard Specifications
9	Surveying			Basic Surveying	Highway Surveying Manual
10	Utilizing Resources	WSDOT CN: Inspector's Use of Contract Resources	WSDOT CN: Construction Inspection Documentation		Standard Specifications, Standard Plans
11	Work Zone Traffic Control	WSDOT CN: Work Zone Traffic Control Review			WZTC Documents can be supplied by Region Trainer

Figure 16: WSDOT inspector training program (Washington State DOT, 2025a)

WSDOT addresses inspector shortages through alternative delivery programs. WSDOT noted that they are using DB to help deliver construction projects. The use of alternative delivery transfers some QA and inspection responsibilities from the WSDOT to design-builders or other private partners. In DB, the design-builder typically maintains a QC program with owner QA oversight rather than owner inspection of all work. This reduces owner inspection resource requirements but requires confidence in design-builder QC and effective owner QA verification systems. Without systematic risk-based approaches, the agency has not developed models for how risk-based inspection would affect staffing requirements. This represents a barrier to implementing risk-based approaches.

4.2.5.5.5 Emerging Technologies for Risk-Based Testing and Inspection

WSDOT pursues more focused technology applications, evaluating specific innovations rather than comprehensive technology transformation. For materials testing, WSDOT is evaluating

and considering a transition to the Indirect tensile asphalt cracking test to assess and improve the cracking resistance of HMA pavements. The indirect tensile asphalt cracking test represents an emerging asphalt mixture performance test developed by the Texas DOT that directly measures cracking resistance through indirect tensile testing of compacted specimens, with crack initiation and propagation quantified through load-displacement relationships. Traditional asphalt mixture acceptance relies on volumetric properties, such as asphalt content, aggregate gradation, and air voids, that correlate imperfectly with field cracking performance. The test provides performance-based acceptance criteria more directly related to pavement durability than volumetric specifications. It can identify mixtures susceptible to cracking before field placement, allowing mix design adjustments. It enables comparison of mixture-cracking resistance across different designs, aggregates, and asphalt binders. However, implementing the indirect test requires equipment acquisition, technician training, specification development relating test results to acceptance criteria, and potentially mix design adjustments to achieve target performance.

For construction inspection, WSDOT has recently adopted Oracle's Unifier to manage construction projects, providing a centralized system that ensures consistency across the agency and improves efficiency through predefined business processes. Enterprise project management systems such as Unifier provide comprehensive platforms for project controls, document management, workflow automation, cost tracking, schedule management, and reporting. For construction inspection, such systems can standardize inspection documentation, automate routing of inspection reports and material certifications, track testing frequencies and results, manage punch lists and deficiency corrections, and generate compliance reports.

WSDOT has also recently implemented Haul Hub to manage its eTickets for various material types. E-ticketing systems replace paper tickets for materials deliveries with electronic data capture, transmission, and storage. Benefits include improved accuracy by eliminating manual transcription errors, real-time data availability for project management and payment calculations, automated compilation of quantities for payment and compliance documentation, integration with plant control systems capturing mixed properties, and elimination of paper handling and storage.

WSDOT also plans to explore new technologies to evaluate data in real time to assess material quality and investigate the potential use of artificial intelligence (AI), as well as to equip construction equipment with intelligent compaction to assess asphalt compaction in real time. Intelligent compaction systems in rollers measure pavement stiffness through machine response during compaction, providing 100% spatial coverage of compaction quality rather than scattered spot tests. AI algorithms could analyze these continuous data streams, comparing actual compaction patterns against specifications, detecting areas

requiring additional rolling, identifying systematic problems suggesting mix or temperature issues, and generating real-time feedback to operators and inspectors. However, AI and intelligent compaction are not currently used by WSDOT, but they could offer viable alternatives that may reduce current testing frequencies.

4.2.5.5.6 Lessons Learned

WSDOT's primary recommendation emphasizes expertise as the critical success factor. In other words, it is important to find statistical expertise that can work with DOT experts to help assess and develop specifications and materials testing requirements based on risk probability and the impact of failure. This recommendation clearly identifies a lack of analytical capability to translate risk analysis into operational specifications and testing requirements. WSDOT further elaborated that the need to understand statistical applications, data, and highway materials is specialized and not readily available. Statistical expertise alone proves insufficient without materials engineering knowledge. Not understanding concrete behavior, asphalt performance, steel properties, or construction processes means that statisticians cannot develop meaningful specifications or acceptance criteria, regardless of statistical sophistication. Conversely, materials engineers without statistical training cannot design appropriate risk-based sampling plans, calculate confidence levels, assess specification-compliance probabilities, or develop risk-based acceptance criteria, regardless of their materials expertise. The combination of statistical capability and materials engineering knowledge represents rare, specialized expertise that most agencies lack internally.

WSDOT's additional observation about finding the expertise and funding to perform risk-based assessments of materials with the available testing data highlights that expertise and resources represent barriers. Even when expertise is available, WSDOT faces competing demands due to limited budgets. Risk-based program development competes with immediate construction delivery pressures, emergency response needs, maintenance backlogs, and other priorities that may appear more urgent than QA program refinement. Building the business case for risk-based program investment requires quantifying potential benefits, including cost savings, reduced construction delays, and improved quality outcomes, to justify development costs. Without a clear quantification of benefits, securing funding to implement a risk-based approach proves challenging.

WSDOT's positive experience is that when material testing frequencies have been reduced, they have not seen a marked increase in material quality issues. This observation, while not from a systematic implementation of risk analysis, suggests that appropriately designed risk-based reductions in testing can maintain quality while improving efficiency. WSDOT noted that they have not considered abandoning risk-based approaches but have considered

additional materials that could warrant reduced QA material testing. This suggests that WSDOT may pursue risk-based expansion if it can address expertise and resource barriers.

However, WSDOT recognizes that reducing QA frequency may increase the risk of failure, potentially resulting in catastrophic consequences. Risk-based approaches are not simply about reducing oversight to save money; they require a sophisticated understanding of which reductions maintain acceptable risk levels versus which create unacceptable hazards. Materials with catastrophic failure consequences demand sustained intensive oversight even when such oversight proves expensive and time-consuming. The risk-based framework is to allocate resources to these critical items while identifying lower-consequence materials for which reduced oversight is acceptable.

4.3 Research Objective #3: Prioritize and Recommend Potential Modifications to SDDOT Construction Material Testing and Inspection

To determine recommended modifications for the SDDOT construction material testing and inspection program, an analysis of quantitative project data was conducted to confirm the Task 3 risk assessment. Project information from the SDDOT Material Sampling and Testing (MS&T) system was collected and analyzed for material testing activities. SDDOT provided electronic copies of daily diaries for review of construction inspection activities.

4.3.1 Material Testing Activities

A comprehensive review and analysis were performed on SDDOT construction project information provided as PDF files and accessed through the MS&T system. SDDOT personnel provided project information for 22 projects across the state's four regions. In addition, the research team searched the MS&T system for additional projects in each SDDOT region. A list of the 189 projects reviewed is provided in [Appendix K](#). All projects were randomly selected and constructed between 2004 and 2025, with the majority selected from 2020 to 2025. All testing information, including total tests performed, total passed, total failed, and total corrected, was collected across projects for each specification section outlined below. From the 189 projects, the research team analyzed relevant MS&T documents to determine when and where failures occurred and what actions were taken to address the failures. The documents reviewed are listed in [Table 28](#).

Table 28: List of documents reviewed for SDDOT projects in the MS&T system

Document Name	Description
Contract Information	Contains pertinent project information: contract number, PCN number, letting date, projects, location, type of work, engineers, length of project, Area Office, Region, and contractor.
Material Testing	Contains line items of construction activities and associated material testing results, including total complete, total tests, total passed, total failed, and total corrected testing information.

Document Name	Description
DOT-1A Summary	A list of project bid items and associated material groups and requirements for material testing.
DOT-18 Summary	A summary of contract issues that includes the issue number, date, person performing the test, closure status, description of the issue, and the resolution that was performed.
Specifications Deviation Summary	A summary report that includes issue number and status, material type, bid items, price adjustment amount, action taken, determination, and failing results.
Test Results Detail	A comprehensive report that lists all material tests performed on a project and includes the group, test, field number, person performing the test, date, sample ID, purpose, and passing status.
Failed Tests with Specifications and Results	A report that includes the details of all failed tests on a project and includes the sample ID, field number, purpose, testing group name, date tested, and whether the failed test is found in the DOT-18 report or not.

For each of the 189 projects reviewed, the research team used the MS&T to collect material testing information (Number of tests, passing tests, failed tests, and corrected tests). This information was then aligned with the risk assessment performed rankings in Task 3 (See [Appendix I](#)). The results of the analysis are described in the sections below. Each section is aligned with the 2025 SDDOT Standard Specifications for Roads and Bridges (Spec Book), and the test activities are aligned with the MSTR and the risk assessment conducted in Task 3. The test activities reviewed are listed under each section to help SDDOT understand the information collected from the MS&T.

4.3.1.1 Specification 120 Unclassified Excavation

Part A Earthwork of the SDDOT Standard Specifications for Roads and Bridges (Spec Book) includes Specification 120 for Embankment Construction. [Table 29](#) presents the results from projects found in the MS&T by investigating Unclassified Excavation; Borrow Unclassified Excavation; Unclassified/Rock Excavation; Contractor Furnished Select Subgrade Topping; Select Subgrade Topping; Option Borrow Excavation; and Contractor Furnished Borrow Excavation.

Table 29: Unclassified excavation testing analysis results

MSTR Testing Activity	Task 3 Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
Specified Density (In-Place) for Berms	8 th	13	246	217	16	16	6.5%	6.5%
Specified Density (In-Place) for Embankments	17 th	30	2,147	2,041	62	50	2.9%	2.3%
Specified Density (In-Place) for Pipe & Box Culvert Backfill	19 th	26	2,646	2,522	76	59	2.9%	2.2%

MSTR Testing Activity	Task 3 Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
Specified Density (In-Place) for Pipe Undercut Backfill (Soil)	23 rd	14	87	83	3	1	3.4%	1.1%
Moisture Content for Embankments	24 th	30	5,101	4,912	62	57	1.2%	1.1%
Moisture Content for Box Culvert, Pipe Backfill	25 th	26	1,760	1,730	17	13	1.0%	0.7%
Specified Density (In-Place) for Cross Pipe Pre-Installation Density/Undercut	26 th	13	234	208	12	10	5.1%	4.3%

4.3.1.2 Specification 260 Subbase, Base Course, and Cushion Material

Specification 260 includes Subbase, Base Course, Cushion, and Gravel Surfacing. [Table 30](#) presents the results from projects found in the MS&T by investigating Base Course; Base Course, Salvaged; Base Course, Modified; Base Course, Salvaged Asphalt Mix; Granular Material; and Granular Material, Furnish.

Table 30: Subbase, base course, cushion material testing analysis results

MSTR Testing Activity	Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
Subbase/Base Course Composite Aggregate Sieve Analysis	16 th	68	766	641	93	34	12.1%	4.4%
In-Place Density for Subbase/Base Course	18 th	53	873	807	30	28	3.4%	3.2%
Gravel Surfacing Aggregate Composite Sieve Analysis	22 nd	7	13	12	1	0	7.7%	0.0%
Gravel Cushion Aggregate Composite Sieve Analysis	31 st	24	163	126	31	6	19.0%	3.7%
Standard Density (4-Point) for Subbase/Base Course	35 th	51	119	119	0	0	0.0%	0.0%

4.3.1.3 Specification 280 Full Depth Reclamation (FDR)

For Specification 280, Full Depth Reclamation (FDR) includes processing and blending asphalt mix and granular materials. With assistance from SDDOT field personnel, 16 projects in the MS&T were identified that performed In-Place Density and Standard Density tests for FDR materials. From the 16 projects, In-Place Density for FDR shows only a 0.8% failure rate (See [Table 31](#)). In-Place Density for FDR ranks in the top 30 of the Task 3 risk assessment, indicating a moderate risk with a very low failure rate.

Table 31: FDR testing analysis results

MSTR Testing Activity	Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
In-Place Density for FDR	10 th	16	607	597	5	5	0.8%	0.8%
Standard Density for FDR	36 th	16	32	32	0	0	0.0%	0.0%

4.3.1.4 Specification 320 Asphalt Concrete

Part C Asphalt Construction includes Specification 320 Asphalt Concrete, General. From the MS&T, testing information for this specification focused on the different asphalt concrete types (Q, E, HR) and variations in Q-type asphalt concrete (Q2R, Q3R, Q3). Asphalt Concrete Blade Laid and Modified asphalt line items were also reviewed in the MS&T. The material testing activities reviewed and collected for this specification include the following:

- Aggregate Composite Sieve Analysis
- In-Place Density
- Asphalt Binder
- Asphalt Binder Content
- Standard Density
- Lime Content
- Theoretical Maximum Specific Gravity (Rice)
- Bulk Specific Gravity
- Moisture Content of Class Q and HR Mix
- Mineral Aggregate for Microsurfacing

Table 32 provides a quantitative analysis of these testing categories, based on data collected and analyzed from the MS&T. All tests shown have a low failure rate (less than 5%). For In-Place Density for HMA Aggregate, the Task 3 risk ranking is 3rd with a failure rate of 1.3%, making this testing activity high risk with a low failure rate.

Table 32: Asphalt concrete testing analysis results

MSTR Testing Activity	Task 3 Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
In-Place Density for Hot Mix Asphalt (HMA) Aggregate	3 rd	49	1,842	1,818	24	0	1.3%	0.0%
Asphalt Binder Content	28 th	49	1,107	1,092	15	0	1.4%	0.0%

MSTR Testing Activity	Task 3 Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
Aggregate Composite Sieve Analysis	30 th	49	3,200	3,035	119	2	3.7%	0.1%
Theoretical Maximum Specific Gravity (Rice)	40 th	12	306	306	0	0	0.0%	0.0%
Asphalt Binder	47 th	49	705	696	9	0	1.3%	0.0%
Lime Content	48 th	38	801	792	9	0	1.1%	0.0%
Moisture Content of Mix (Class Q and HR)	52 nd	41	264	264	0	0	0.0%	0.0%
Bulk Specific Gravity	67 th	12	33	33	0	0	0.0%	0.0%

4.3.1.5 Specification 330 Prime, Tack, Fog Seal, and Flush Seal

For Specification 330, the material testing relates to treating prepared pavement surfaces with asphalt liquid materials and sand. The tests analyzed for asphalt liquid materials include:

- MC-70 Asphalt for Prime
- SS-1h or CSS-1h Asphalt for Tack
- SS-1h or CSS-1h Asphalt for Flush Seal
- SS-1h or CSS-h1 Asphalt for Fog Seal

Table 33 presents the data collected for each test listed. In the Task 3 risk assessment, asphalt liquid was ranked 34th, outside the top 20. The failure rate for MC-70 Asphalt for Prime and SS-1h or CSS-1h Asphalt for Flush Seal is less than 5%, making these two testing activities low-risk with a low failure rate. SS-1h or CSS-1h Asphalt for Tack is a low-risk, moderate failure rate test activity, while SS-1h or CSS-1h Asphalt for Fog Seal is a low-risk but high failure rate test activity.

Table 33. Asphalt liquid testing analysis results

MSTR Testing Activity	Task 3 Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
MC-70 Asphalt for Prime	34 th	19	41	41	0	0	0.0%	0.0%
SS-1h or CSS-1h Asphalt for Tack	34 th	52	130	123	7	0	5.4%	0.0%
SS-1h or CSS-1h Asphalt for Flush Seal	34 th	43	59	57	2	0	3.4%	0.0%

MSTR Testing Activity	Task 3 Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
SS-1h or CSS-1h Asphalt for Fog Seal	34 th	6	44	33	11	0	25.0%	0.0%

4.3.1.6 Specification 360 Asphalt Surface Treatment

Specification 360 for Asphalt Surface Treatment was found in the MS&T for projects that performed chip sealing activities. For asphalt surface treatment, the tests analyzed included the following:

- Sieve Analysis for Types 1 and 2 Cover Aggregate
- Sieve analysis for Type 3 Cover Aggregate
- Mineral Aggregate for Microsurfacing

Based on information from SDDOT personnel, 47 projects were found for the Types 1 and 2 Cover Aggregate Sieve Analysis, and 23 projects were found for the Mineral Aggregate for Microsurfacing. However, only three projects with a total of three tests were found for the Type 3 Cover Aggregate Sieve Analysis, as the majority of the projects reviewed in the MS&T used Types 1 and 2 Cover Aggregates and not Type 3. As shown in [Table 34](#), the Mineral Aggregate for Microsurfacing shows a high failure rate of 19.5%, but with a Task 3 risk ranking of 59th, this testing activity has a high failure rate but low risk.

Table 34: Asphalt surface treatment testing analysis results

MSTR Testing Activity	Task 3 Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
Cover Aggregate, Types 1 & 2 Gradation Sieve Analysis	32 nd	47	1,181	1,092	89	0	7.5%	0.0%
Cover Aggregate, Type 3 Gradation Sieve Analysis	45 th	3	4	4	0	0	0.0%	0.0%
Mineral Aggregate for Microsurfacing	59 th	23	277	223	54	0	19.5%	0.0%

4.3.1.7 Specification 380 Portland Cement Concrete Pavement

Portland Cement Concrete (PCC) pavement testing is critical to ensure the materials in the concrete mix meet specifications. The testing information reviewed in the MS&T looked at all line items associated with Non-Reinforced PCCP, Fast Track Concrete for PCCP Repair, Miscellaneous PCCP, and Continuously Reinforced PCCP. The testing activities focused on in the MS&T for this specification include:

- Fresh Concrete Test
- Concrete Compressive Strength Test
- Fine and Coarse Aggregate Sieve Analysis
- Measurement Thickness
- Fly Ash Content
- Cement Content

Table 35 shows the results of these tests taken from the MS&T. The PCCP Fresh Concrete Test has a failure rate of 8.0% and is ranked 4th in the Task 3 risk assessment, making this testing activity high risk with a moderate failure rate. Compressive Strength tests have a 2.1% failure rate and rank 12th, making this testing activity a moderate risk with a low failure rate. Fly Ash and Cement had no failed tests (failure rate = 0%) across the projects reviewed in the MS&T.

Table 35: PCC pavement testing analysis results

MSTR Testing Activity	Task 3 Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
Fresh Concrete Test: Air Content, Unit Weight, Slump, Temperature	4 th	30	2,156	1,981	172	3	8.0%	0.1%
Compressive Strength Test	12 th	30	1,154	1,127	24	3	2.1%	0.3%
Fine and Coarse Aggregate Sieve Analysis	29 th	30	576	560	17	0	3.0%	0.0%
Measurement Thickness	56 th	24	230	227	3	0	1.3%	0.0%
Fly Ash	62 nd	26	40	40	0	0	0.0%	0.0%
Cement	63 rd	28	43	43	0	0	0.0%	0.0%

4.3.1.8 Specification 421 Pipe and Box Culvert Undercut Backfill

Specification 421 includes work to remove unstable material or rock below the bedding grade of box, pipe, and plate pipe culverts, as well as the backfill of undercut areas. The material testing activity for this specification is the In-Place Density for Pipe and Box Culvert Undercut Backfill materials listed in Table 36. This testing activity is ranked 15th from the Task 3 risk assessment and has a failure rate of 11.0%, making this testing activity a moderate risk with a high failure rate.

Table 36: Pipe and box culvert undercut backfill testing analysis results

MSTR Testing Activity	Task 3 Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
In-Place Density for Pipe and Box Culvert Undercut Backfill	15 th	22	127	109	14	4	11.0%	3.2%

4.3.1.9 Specification 430 Granular Bridge End Backfill and Bridge End Embankment

Under specification 430, material testing activities focus on work involving backfilling bridge components. The tests reviewed in the MS&T for this specification are:

- Granular Bridge End Backfill Aggregate Sieve Analysis
- In-Place Density for Granular Bridge End Backfill
- In-Place Density for Bridge End Embankment

Table 37 illustrates the testing activities reviewed in the MS&T. Each testing activity for Specification 430 is ranked in the top 10 from the Task 3 risk assessment. The Granular Bridge-End Backfill Aggregate Sieve Analysis has a failure rate above 10%, making this testing activity high risk. The two in-place density testing activities have moderate failure rates, less than 10%, but greater than 5%.

Table 37: Granular bridge end backfill & bridge end embankment testing analysis results

MSTR Testing Activity	Task 3 Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
Granular Bridge End Backfill Aggregate Sieve Analysis	5 th	35	44	38	5	2	11.4%	4.5%
In-Place Density for Granular Bridge End Backfill	6 th	5	30	27	2	1	6.7%	3.3%
In-Place Density for Bridge End Embankment	7 th	20	217	184	20	12	9.2%	5.5%

4.3.1.10 Specification 460 Portland Cement Concrete Structures

PCC structures construction includes some of the highest risk material testing activities compared to other specifications at SDDOT. In reviewing projects, Class A45 concrete was the focus material, and testing information was collected from Bridge, Bridge Deck, Box Culvert, Concrete Approach Slab for Bridge, Concrete Approach Sleeper Slab for Bridge, Self-

Consolidating, Bridge Repair, and Bridge Barrier categories listed in the MS&T. The focus of the testing analysis was on the following testing activities:

- Fresh Concrete Test
- Concrete Compressive Strength Test
- Fine and Coarse Aggregate Sieve Analysis
- Fine and Coarse Aggregate Moisture Content
- Cement Content
- Fly Ash Content

The Fresh Concrete Test (1st) and the Concrete Compressive Strength Test (2nd) are the top two Task 3 risk assessment material testing activities (See [Table 38](#)). Fresh concrete tests have a failure rate of 4.8%, and compressive strength tests have a failure rate of 5.5%. Sieve analysis for fine and coarse aggregate is also ranked in the top 10 from the Task 3 risk assessment, with a failure rate of 5.7%, making this activity high risk with a moderate failure rate. Fly Ash and the Moisture Content of Fine and Coarse Aggregate have a 0.0% failure rate, as no failed tests were found.

Table 38: PCC structures testing analysis results

MSTR Testing Activity	Task 3 Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
Fresh Concrete Tests: Air Content, Unit Weight, Slump, Temperature	1 st	35	1,089	1,046	52	0	4.8%	0.0%
Compressive Strength Test	2 nd	35	770	728	42	0	5.5%	0.0%
Fine and Coarse Aggregate Sieve Analysis	9 th	34	350	324	21	5	6.0%	1.4%
Fly Ash	46 th	29	35	35	0	0	0.0%	0.0%
Cement	49 th	32	37	36	1	0	2.7%	0.0%
Moisture Content of Fine and Coarse Aggregate	NA	31	291	291	0	0	0.0%	0.0%

4.3.1.11 Specification 560 Pre-cast and Pre-tensioned Pre-stressed Concrete

Specification 560 covers precast and prestressed concrete materials. All line items in the MS&T associated with specification 560 were reviewed, and information was collected. The analysis of these material testing activities focused on:

- Fresh Concrete Test
- Concrete Compressive Strength Test
- Fine and Coarse Aggregate Sieve Analysis
- Cement Content
- Fly Ash Content

Pre-cast and pre-stressed concrete testing was found from the MS&T list of projects reviewed, as shown in [Table 39](#). The Fresh Concrete Test (11th) and the Compressive Strength Test (12th) are both ranked in the top 20 of the Task 3 risk assessment rankings. Fresh Concrete Tests have a failure rate of only 0.6%, and Compressive Strength Tests have a failure rate of 1.2%, making both high-risk but low failure rate testing activities. Cement, whether it was Type II, III, IV, or V, was found never to fail when tested for pre-cast and pre-stressed concrete. Fine and Coarse Aggregate Sieve Analysis for pre-cast and pre-stressed concrete has the highest failure rate for this specification at 3.2%, but is ranked 27th in the risk ranking, making this material low risk with a medium failure rate. Fly Ash was also found never to fail, and it is rarely tested, as many projects have no tests for fly ash in pre-cast or pre-stressed concrete.

Table 39: Pre-cast and pre-stressed concrete testing analysis results

MSTR Testing Activity	Task 3 Risk Ranking	Number of Projects	Total Test	Passed	Failed	Corrected	Failure Rate	Correction Rate
Fresh Concrete Test	11 th	26	837	832	5	0	0.6%	0.0%
Compressive Strength Test	12 th	26	807	796	10	1	1.2%	0.1%
Fine and Coarse Aggregate Sieve Analysis	27 th	27	160	155	5	0	3.1%	0.0%
Cement	38 th	27	34	34	0	0	0.0%	0.0%
Fly Ash	44 th	7	7	7	0	0	0.0%	0.0%

4.3.1.12 Summary of Construction Material Testing Analysis

[Table 40](#) summarizes the failure and correction rates for the top 30 risk assessment material testing activities. The top 10 are considered high-risk testing activities, while testing activities 11-30 are considered moderate risk. The other 42 activities ranked in the Task 3 risk assessment are then considered low risk due to the lower risk ranking and the lack of testing information found for these testing activities in the MS&T. Overall, the top five material testing activities with the highest failure rates from the top 30 Task 3 material testing activities are:

1. Subbase, Base Course, and Cushion Construction: Untreated Subbase, Base Course, and Cushion Sieve Analysis – Risk Rank 16th; Failure Rate 12.1%.
2. Miscellaneous Granular Materials: Granular Bridge End Backfill Sieve Analysis – Risk Rank 5th; Failure Rate 11.4%.
3. Miscellaneous Granular Materials: In-Place Density for Pipe and Box Culvert Undercut Backfill – Risk Rank 15th; Failure Rate 11.0%.
4. Subgrade Construction: Specified Density (In-Place) for Bridge End Embankment – Risk Rank 7th; Failure Rate 9.2%.
5. PCC Paving Construction: Fresh Concrete Test – Risk Rank 4th; Failure Rate 8.0%.

These five testing activities include sieve analysis, in-place density testing, and fresh concrete tests, all of which are significant and essential for many SDDOT construction projects.

Table 40: Failure and correction rates for the top 30 construction material testing activities

Task 3 Risk Rank	Category	QA Sub-Category	MSTR Testing Activity	Failure Rate	Correction Rate
1 st	6. PCC Structure Construction	6.3 Fresh Concrete Test	Air Content, Unit Weight, Slump, Temperature	4.8%	0.0%
2 nd	6. PCC Structure Construction	6.2 Strength Test	Compressive Strength	5.5%	0.0%
3 rd	1. Asphalt Construction	1.1 Hot Mix Asphalt Concrete	In-Place Density Aggregate, Composite	1.3%	0.0%
4 th	5. PCC Paving Construction	5.3 Fresh Concrete Test	Air Content, Unit Weight, Slump, Temperature	8.0%	0.1%
5 th	3. Miscellaneous Granular Materials	3.4 Granular Bridge End Backfill	Aggregate, Sieve Analysis	11.4%	4.5%
6 th	3. Miscellaneous Granular Materials	3.4 Granular Bridge End Backfill	In-Place Density	6.7%	3.3%
7 th	4. Subgrade Construction	4.1 Specified Density (In-Place)	Bridge End Embankment	9.2%	5.5%
8 th	4. Subgrade Construction	4.1 Specified Density (In-Place)	Berms	6.5%	6.5%
9 th	6. PCC Structures Construction	6.1 Materials	Fine and Coarse Aggregate, Sieve Analysis	6.0%	1.4%
10 th	3. Miscellaneous Granular Materials	3.10 Salvaged and Full Depth Reclamation Materials	In-Place Density	0.8%	0.8%
11 th	11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.21 Pre-Cast and Pre-Stressed Concrete	Fresh Concrete Test	0.6%	0.0%

Task 3 Risk Rank	Category	QA Sub-Category	MSTR Testing Activity	Failure Rate	Correction Rate
12 th	11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.21 Pre-Cast and Pre-Stressed Concrete	Compressive Strength	1.2%	0.1%
13 th	5. PCC Paving Construction	5.2 Strength Test	Compressive Strength	2.1%	0.3%
14 th	1. Asphalt Construction	1.2 Cold In-Place Recycling	In-Place Density	NA	NA
15 th	3. Miscellaneous Granular Materials	3.11 Pipe and Box Culvert Undercut Backfill	In-Place Density	11.0%	3.1%
16 th	2. Subbase, Base Course, And Cushion Construction	2.1 Subbase and Base Course	Aggregate, Composite Sieve Analysis	12.1%	4.4%
17 th	4. Subgrade Construction	4.1 Specified Density (In-Place)	Embankment	2.9%	2.3%
18 th	2. Subbase, Base Course, And Cushion Construction	2.1 Subbase and Base Course	In-Place Density	3.4%	3.2%
19 th	4. Subgrade Construction	4.1 Specified Density (In-Place)	Pipe and Box Culvert Backfill	2.9%	2.2%
20 th	11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.3 Bolt Assemblies	High Strength Bolts	NA	NA
21 st	12. Pavement Restoration	12.2 Joint and Spall Repair	Concrete from Ready-Mix Plants	NA	NA
22 nd	3. Miscellaneous Granular Materials	3.2 Gravel Surfacing	Aggregate Sieve Analysis	7.7%	0.0%
23 rd	4. Subgrade Construction	4.1 Specified Density (In-Place)	Pipe Undercut Backfill (Soil)	3.4%	1.1%
24 th	4. Subgrade Construction	4.3 Moisture Content	Embankment	1.2%	1.1%
25 th	4. Subgrade Construction	4.3 Moisture Content	Box Culvert, Pipe Backfill	1.0%	0.7%
26 th	4. Subgrade Construction	4.1 Specified Density (In-Place)	Cross Pipe Pre-Installation Density/Undercut	5.1%	4.3%
27 th	11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.21 Pre-Cast and Pre-Stressed Concrete	Aggregate, Fine and Coarse, Sieve Analysis	3.1%	0.0%
28 th	1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Asphalt Binder Content	1.4%	0.0%
29 th	5. PCC Paving Construction	5.1 Materials	Aggregate, Fine and Coarse, Sieve Analysis	3.0%	0.0%
30 th	1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Aggregate, Composite Sieve Analysis	3.7%	0.1%

Three of the top 30 testing activities are not included in the analysis. The In-Place Density for Cold In-Place Recycling (Risk rank 14th) was removed from the analysis based on feedback from SDDOT personnel, who noted that cold in-place recycling has not been used for many

years. Testing of Concrete from Ready-Mix Plants for Joint and Spall Repair (Risk rank 21st) was not included because no tests specifically for this activity were found in the MS&T. The same applies to testing High-Strength Bolts for Bolt Assemblies (Risk rank 20th): no testing information was found in the MS&T.

4.3.1.13 Correlations between Risk Assessment and MS&T Project Data

The risk assessment performed in Task 3 (See [Section 4.2.2](#) and [Appendix I](#)) provides an average expected value and ranking of 72 individual material testing activities. Each activity is scored on three expected value (EV) impact components: Cost, Safety, and Service Interruption, and assigned a whole-number rank from 1 (most critical) to 72 (least critical). Task 3 breaks each sub-category down into individual QA activities. For example, under Asphalt Concrete, Hot Mix, there are nine activities ranked separately, ranging from In-Place Density (Rank 3rd) to Bulk Specific Gravity (Rank 67th).

In Task 6, the research team recorded material testing outcomes from the MS&T for 189 projects constructed between 2004 and 2025 (See [Appendix K](#)), reporting total tests conducted, total failure tests, and total corrected tests for each testing activity. The objective is to investigate whether the rankings provided by SDDOT staff in Task 3 are reflected in the failure patterns observed in Task 6. The next three sections outline high, medium, and low failure rates for material testing activities and compare them with the Task 3 risk assessment rankings.

4.3.1.13.1 High-Failure Material Testing Activities (Failure Rate > 10%)

From the analysis performed in Task 6, the testing activities shown in [Table 41](#) had the highest failure rates across the 189 projects reviewed. When comparing the risk assessment ranking results to the failure rates, Granular Bridge-End Backfill Aggregate Sieve Analysis under Miscellaneous Granular Materials ranked as the fifth-highest impact testing activity when a failure occurs, and the failure rate shows that 1 in 9 tests fail. Testing frequencies should not be reduced or revised for Granular Bridge End Backfill Aggregate Sieve Analysis due to a high failure rate and the extreme impact a failure can have on cost, safety, and service. In addition, the In-Place Density for Pipe and Box Culvert Undercut Backfill, and the Aggregate Composite Sieve Analysis for Subbase and Base Course both have similar failure rates: 1 out of every 9 tests fails. While these two testing activities are ranked outside the top ten in the Task 3 risk assessment, they should be considered moderate risk and high failure rate, and require the proper amount of testing for each SDDOT construction project. It is advised not to reduce testing for these three activities.

Table 41: Summary of testing activities with high failure rates and associated risk assessment rank

Category	QA Sub-Category	MSTR Testing Activity	Task 3 Risk Rank	Task 6 Failure Rate
3. Miscellaneous Granular Materials	3.4 Granular Bridge End Backfill	Aggregate, Sieve Analysis	5 th	11.4%
3. Miscellaneous Granular Materials	3.11 Pipe and Box Culvert Undercut Backfill	In-Place Density	15 th	11.0%
2. Subbase, Base Course, And Cushion Construction	2.1 Subbase and Base Course	Aggregate, Composite Sieve Analysis	16 th	12.1%

4.3.1.13.2 Moderate-Failure QA Sub-Categories (5% ≤ Failure Rate ≤ 10%)

Next, the testing activities shown in [Table 42](#) have failure rates of 5% to 10% across 189 projects reviewed in the MS&T. The results show that five testing activities ranked in the top 10 have moderate failure rates ranging from 5.1% to 9.2%. Given the criticality of these materials (PCC, Granular Materials, Subgrade Construction), SDDOT should consider frequent testing to ensure they remain within specifications.

In addition, Gravel Surfacing Sieve Analysis and Specified Density (In-Place) for Cross Pipe Pre-Installation Density/Undercut testing activities are ranked in the top 30 and have moderate failure rates. While these two tests are moderate risk, they also have moderate failure rates, and SDDOT should exercise caution before reducing testing for these two activities.

Table 42: Summary of testing activities with moderate failure rates and associated risk assessment rank

Category	QA Sub-Category	MSTR Testing Activity	Task 3 Risk Rank	Task 6 Failure Rate
5. PCC Structure Construction	5.2 Strength Test	Compressive Strength	2 nd	5.5%
6. PCC Paving Construction	6.3 Fresh Concrete Test	Air Content, Unit Weight, Slump, Temperature	4 th	8.0%
3. Miscellaneous Granular Materials	3.4 Granular Bridge End Backfill	In-Place Density	6 th	6.7%
4. Subgrade Construction	4.1 Specified Density (In-Place)	Bridge End Embankment	7 th	9.2%
4. Subgrade Construction	4.1 Specified Density (In-Place)	Berms	8 th	6.5%
5. PCC Structures Construction	6.1 Materials	Aggregate, Fine and Coarse, Sieve Analysis	9 th	6.0%
3. Miscellaneous Granular Materials	3.2 Gravel Surfacing	Aggregate Sieve Analysis	22 nd	7.7%
4. Subgrade Construction	4.1 Specified Density (In-Place)	Cross Pipe Pre-Installation Density/Undercut	26 th	5.1%

4.3.1.13.3 Low-Failure QA-Categories (Failure Rate < 5%)

The testing activities summarized in [Table 43](#) have failure rates below 10%. In-Place Density for HMA Aggregate was ranked 3rd in the Task 3 risk assessment and had a failure rate of 5.9% in the Task 6 analysis. While failures are rare, when in-place density fails for HMA aggregate, the impact is significant to project costs and service interruptions. Specified Density (In-Place) for Bridge End Embankments ranked 5th highest in the risk assessment and has an associated failure rate of 6.0%. Failures are rare for the Specified Density (In-Place) for Bridge-End Embankments, but the impact is high when they occur. Then, the Specified Density (In-Place) for Berms was ranked 8th with a failure rate of 6.0%. Failed tests are uncommon for the Specified Density (In-Place) for Berms, but when they do occur, they affect cost and service.

Table 43: Summary of testing activities with low failure rates and associated risk assessment rank

Category	QA Sub-Category	MSTR Testing Activity	Task 3 Risk Rank	Task 6 Failure Rate
6. PCC Structure Construction	6.3 Fresh Concrete Test	Air Content, Unit Weight, Slump, Temperature	1 st	4.8%
1. Asphalt Construction	1.1 Hot Mix Asphalt Concrete	In-Place Density Aggregate, Composite	3 rd	1.3%
3. Miscellaneous Granular Materials	3.10 Salvaged and Full Depth Reclamation Materials	In-Place Density	10 th	0.8%
11. Miscellaneous Incidental	11.21 Pre-Cast and Pre-Stressed Concrete	Fresh Concrete Test	11 th	0.6%
11. Miscellaneous Incidental	11.21 Pre-Cast and Pre-Stressed Concrete	Compressive Strength	12 th	1.2%
5. PCC Paving Construction	5.2 Strength Tests	Compressive Strength	13 th	2.1%
4. Subgrade Construction	4.1 Specified Density (In-Place)	Embankment	17 th	2.9%
2. Subbase, Base Course, And Cushion Construction	2.1 Subbase and Base Course	In-Place Density	18 th	3.4%
4. Subgrade Construction	4.1 Specified Density (In-Place)	Pipe and Box Culvert Backfill	19 th	2.9%
4. Subgrade Construction	4.1 Specified Density (In-Place)	Pipe Undercut Backfill (Soil)	23 rd	3.4%
4. Subgrade Construction	4.3 Moisture Content	Embankment	24 th	1.2%
4. Subgrade Construction	4.3 Moisture Content	Box Culvert, Pipe Backfill	25 th	1.0%
11. Miscellaneous Incidental	11.21 Pre-Cast and Pre-Stressed Concrete	Aggregate, Fine and Coarse, Sieve Analysis	27 th	3.1%
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Asphalt Binder Content	28 th	1.4%
5. PCC Paving Construction	5.1 Materials	Aggregate, Fine and Coarse, Sieve Analysis	29 th	3.0%
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Aggregate, Composite Sieve Analysis	30 th	3.7%

To visualize the high, moderate, and low failure rates alongside the Task 3 risk rankings, [Figure 17](#) illustrates the top 30 risk-ranked testing activities and their associated failure rates. Testing activities in the upper-left corner of the figure are high-risk, high failure rate activities, while those in the lower-right corner are lower risk and have lower failure rates.



Figure 17: Risk ranking and failure rate for top 30 material testing activities

4.3.2 Material Testing Priorities

The risk assessment from Task 3 was performed based on rankings from SDDOT personnel familiar with construction material testing. Then, to confirm the rankings and determine potential frequencies and prioritizations for testing materials, 189 projects were selected from the MS&T system, reviewed, and analyzed by examining total and failed test counts to calculate a material testing activity failure rate. From failure rates and risk assessment rankings, materials can be prioritized and testing frequencies determined so that every project focuses on the most critical material testing and limits testing on less critical materials, allowing more time for construction inspections.

4.3.2.1 High Priority Material Testing Activities

High-priority material testing activities are tests that need to be prioritized above other testing and inspection responsibilities, as these materials have a high or moderate failure rate and are ranked in the top 30 of the Task 3 risk assessment. [Table 44](#) outlines the material

testing activities from the top 30 of the Task 3 risk assessment that have a high or moderate failure rate. These high-priority material testing activities should be tested frequently, and testing should not be reduced due to the potential impact of failures and associated issues that may arise.

Table 44: Summary of high-priority material testing activities

Category	QA Sub-Category	MSTR Testing Activity	Task 3 Risk Ranking	Task 6 Failure Rate	Impact
6. PCC Structures Construction	6.3 Fresh Concrete Test	Air Content, Unit Weight, Slump, Temperature	1 st	4.8%	Significant impact on cost, safety, and service.
6. PCC Structures Construction	6.2 PCC Structures Strength	Compressive Strength	2 nd	5.5%	Significant impact on cost, safety, and service.
5. PCC Paving Construction	5.3 PCC Paving Fresh Concrete Test	Air Content, Unit Weight, Slump, Temperature	4 th	8.0%	Significant impact on cost and service, moderate impact on safety.
3. Miscellaneous Granular Materials	3.4 Granular Bridge End Backfill	Aggregate Sieve Analysis	5 th	11.4%	Significant impact on costs. Moderate impact on safety and service.
3. Miscellaneous Granular Materials	3.4 Granular Bridge End Backfill	In-Place Density	6 th	6.7%	Significant impact on costs. Moderate impact on safety and service.
4. Subgrade Construction	4.1 Specified Density (In-Place)	Bridge End Embankment	7 th	9.2%	Significant impact on cost and service. Moderate impact on safety.
4. Subgrade Construction	4.1 Specified Density (In-Place)	Berms	8 th	6.5%	Significant impact on cost and service. Moderate impact on safety.
6. PCC Structures Construction	6.1 PCC Structures Materials	Aggregate, Fine and Coarse Sieve Analysis	9 th	6.0%	Significant impact on service. Moderate impact on cost and safety.
3. Miscellaneous Granular Materials	3.11 Pipe and Box Culvert Undercut Backfill	In-Place Density	15 th	11.0%	Significant impact on cost and service. Moderate impact on safety.
2. Subbase, Base Course, Cushion	2.1 Subbase and Base	Aggregate, Composite Sieve Analysis	16 th	12.1%	Significant impact on cost, moderate impact on service. Minimal impact on safety.
3. Miscellaneous Granular Materials	3.2 Gravel Surfacing	Aggregate Sieve Analysis	22 nd	7.7%	Significant impact on cost. Moderate impact on safety and service.
4. Subgrade Construction	4.1 Specified Density (In-Place)	Cross Pipe Pre-Installation Density/Undercut	26 th	5.1%	Significant impact on cost. Moderate impact on safety and service.

4.3.2.2 Medium Priority Material Testing Activities

Medium-priority material testing activities have a high or moderate failure rate from the Task 6 analysis or are ranked in the top 30 of the Task 3 risk assessment. [Table 45](#) summarizes the material testing activities that had either a high or moderate failure rate or a ranking in the top 30 of the risk assessment. Overall, these materials have less impact on cost, safety, and service than the high-priority material testing activities. The recommendation is for SDDOT to

consider reducing the testing frequency for these materials based on a project's scope of work and characteristics, as well as material testing requirements. Reducing testing frequency for these materials should provide more time to perform essential construction inspection tasks.

Table 45: Summary of medium-priority material testing activities

Category	QA Sub-Category	MSTR Testing Activity	Task 3 Risk Ranking	Tasks 6 Failure Rate	Impact
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	In-Place Density HMA Aggregate	3 rd	1.3%	Significant impact on cost and service. Moderate impact on safety.
3. Miscellaneous Granular Materials	3.10 Salvaged and Full Depth Reclamation Materials	In-Place Density	10 th	0.8%	Significant impact on cost. Moderate impact on service. Minimal impact on safety.
11. Miscellaneous Incidental	11.21 Pre-Cast and Pre-Stressed Concrete	Fresh Concrete Test	11 th	0.6%	Significant impact on cost, safety, and service.
11. Miscellaneous Incidental	11.21 Pre-Cast and Pre-Stressed Concrete	Compressive Strength	12 th	1.2%	Significant impact on cost, safety, and service.
5. PCC Paving Construction	5.2 Strength Tests	Compressive Strength	13 th	2.1%	Significant impact on cost. Moderate impact on service. Minimal impact on safety.
4. Subgrade Construction	4.1 Specified Density (In-Place)	Embankment	17 th	2.9%	Significant impact on cost. Moderate impact on service. Minimal impact on safety.
2. Subbase, Base Course, and Cushion Construction	2.1 Subbase and Base Course	In-Place Density	18 th	3.4%	Significant impact on cost and service. Moderate impact on safety.
4. Subgrade Construction	4.1 Specified Density (In-Place)	Pipe and Box Culvert Backfill	19 th	2.9%	Significant impact on cost. Moderate impact on service. Minimal impact on safety.
4. Subgrade Construction	4.1 Specified Density (In-Place)	Pipe Undercut Backfill (Soil)	23 rd	3.4%	Significant impact on cost. Moderate impact on service. Minimal impact on safety.
4. Subgrade Construction	4.3 Moisture Content	Embankment	24 th	1.2%	Significant impact on cost. Moderate impact on service. Minimal impact on safety.
4. Subgrade Construction	4.3 Moisture Content	Box Culvert, Pipe Backfill	25 th	1.0%	Significant impact on cost. Moderate impact on service. Minimal impact on safety.
11. Miscellaneous Incidental	11.21 Pre-Cast and Pre-Stressed Concrete	Aggregate Fine and Coarse Sieve Analysis	27 th	3.1%	Moderate impact on cost, safety, and service.
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Asphalt Binder Content	28 th	1.4%	Moderate impact on cost and service. Minimal impact on safety.

Category	QA Sub-Category	MSTR Testing Activity	Task 3 Risk Ranking	Tasks 6 Failure Rate	Impact
5. PCC Paving Construction	5.1 Materials	Fine and Coarse Aggregate Sieve Analysis	29 th	3.0%	Moderate impact on cost, safety, and service.
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Aggregate, Composite	30 th	3.7%	Moderate impact on cost and service. Minimal impact on safety.
2. Subbase, Base Course, and Cushion Construction	2.2 Gravel Cushion	Aggregate Composite Sieve Analysis	31 st	19.0%	Moderate impact on cost. Minimal impact on safety and service.
1. Asphalt Construction	1.3 Asphalt Surface Treatment	Cover Aggregate, Types 1 & 2	32 nd	7.5%	Moderate impact on cost, safety, and service.
1. Asphalt Construction	1.4 Asphalt Liquid	SS-1h or CSS-1h Asphalt for Fog Seal	34 th	25.0%	Moderate impact on cost. Minimal impact on safety and service.
1. Asphalt Construction	1.4 Asphalt Liquid	SS-1h or CSS-1h Asphalt for Tack	34 th	5.4%	Moderate impact on cost. Minimal impact on safety and service.
1. Asphalt Construction	1.3 Asphalt Surface Treatment	Mineral Aggregate for Microsurfacing	59 th	19.5%	Minimal impact on cost, safety, and service.

4.3.2.3 Low Priority Material Testing Activities

Low-priority material testing activities are tests with a low failure rate and are ranked outside the top 30 in the Task 3 risk assessment. [Table 46](#) summarizes the material testing activities that had a low failure rate (less than 5%) or a ranking below the top 30. Overall, these materials have a minimal impact on cost, safety, and service compared to the high- and medium-priority material testing activities. The recommendation is for SDDOT to reduce testing frequency for these materials based on a project's scope of work, project characteristics, and material testing requirements. Reducing testing frequency for these materials will provide more time to perform essential construction inspection activities.

Table 46: Summary of low priority material testing activities

Category	QA Sub-Category	MSTR Testing Activity	Task 3 Risk Ranking	Task 6 Failure Rate	Impact
1. Asphalt Construction	1.4 Asphalt Liquid	MC-70 Asphalt for Prime	34 th	0.0%	Moderate impact on cost. Minimal impact on safety and service.
1. Asphalt Construction	1.4 Asphalt Liquid	SS-1h or CSS-1h Asphalt for Flush Seal	34 th	3.4%	Moderate impact on cost. Minimal impact on safety and service.
2. Subbase, Base Course, Cushion Construction	2.1 Subbase and Base Course	Standard Density (4-point)	35 th	0.0%	Moderate impact on cost. Minimal impact on safety and service.

Category	QA Sub-Category	MSTR Testing Activity	Task 3 Risk Ranking	Task 6 Failure Rate	Impact
11. Miscellaneous Incidental	11.21 Pre-Cast and Pre-stressed Concrete	Cement	38 th	0.0%	Moderate impact on cost, safety, and service.
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Theoretical Maximum Specific Gravity (Rice)	40 th	0.0%	Moderate impact on cost. Minimal impact on safety and service.
11. Miscellaneous Incidental	11.21 Pre-Cast and Pre-stressed Concrete	Fly Ash	44 th	0.0%	Moderate impact on cost, safety, and service.
1. Asphalt Construction	1.3 Asphalt Surface Treatment	Cover Aggregate, Type 3 Gradation Sieve Analysis	45 th	0.0%	Moderate impact on cost. Minimal impact on safety and service.
6. PCC Structures Construction	6.1 Materials	Fly Ash	46 th	0.0%	Minimal impact on cost, safety, and service.
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Asphalt Binder	47 th	1.3%	Moderate impact on cost. Minimal impact on safety and service.
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Lime Content	48 th	1.1%	Moderate impact on cost. Minimal impact on safety and service.
6. PCC Structures Construction	6.1 Materials	Cement	49 th	2.7%	Minimal impact on cost, safety, and service.
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Moisture Content of Mix (Class Q and HR)	52 nd	0.0%	Minimal impact on cost, safety, and service.
5. PCC Paving Construction	5.4 Measurement	Thickness	56 th	1.3%	Moderate impact on cost and service. Minimal impact on safety.
5. PCC Paving Construction	5.1 Materials	Fly Ash	62 nd	0.0%	Minimal impact on cost, safety, and service.
5. PCC Paving Construction	5.1 Materials	Cement	63 rd	0.0%	Minimal impact on cost, safety, and service.
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Bulk Specific Gravity	67 th	0.0%	Minimal impact on cost, safety, and service.

4.3.3 Construction Inspection Activities

To provide a quantitative basis for construction inspection activities, the research team compiled and analyzed daily diaries maintained on SDDOT highway construction projects. Daily diaries from 51 SDDOT projects spanning 2020 through 2026 were reviewed, yielding 287 discrete risk/failure construction inspection events. [Appendix L](#) lists the 51 SDDOT projects reviewed. Each event was classified by severity as follows:

- 119 classified as Major Events – Defects resulting in safety harm, structural failure, a failed acceptance test requiring rework, or significant schedule or cost impact.

- 123 classified as Moderate Events – Defects requiring corrective action without major rework.
- 45 classified as Minor Events – Defects related to administrative, weather, or process notes.

Each of these events was then mapped to the corresponding 35 Task 3 risk assessment construction inspection activities listed in [Appendix J](#).

For each construction inspection activity, four metrics were computed from the project daily diary database: total event frequency, Major event frequency, a severity-weight score (using Equation 2), and the number of projects reporting an event.

$$\text{Severity Weight} = (\text{Major} \times 3 + \text{Moderate} \times 2 + \text{Minor} \times 1)$$

Equation (2)

Concordance between the field record and the Task 3 risk assessment was then evaluated using Spearman's rank correlation. Because the diaries are an independent, field-generated record, they provide a direct empirical test of whether the Task 3 risk assessment identifies the construction inspection activities that generate problems during construction operations.

Each section below outlines construction inspection activities for earthwork, asphalt construction, rigid pavement, structure construction, and incidental construction. These sections capture all 287 events found in the daily diaries. For Task 3 construction inspection activities not discussed but listed in [Appendix J](#), no events were found in the daily diaries for those activities across the 51 projects reviewed.

4.3.3.1 Earthwork – Roadway and Drainage Excavation and Embankment Construction

Roadway and Drainage Excavation and Embankment Construction inspections were ranked 19th in the Task 3 risk assessment. A total of 25 daily diary events were identified across 13 projects, of which 17 were classified as major. [Table 47](#) outlines documented events for Roadway and Drainage Excavation and Embankment Construction inspections, including density failures, compaction failures, soft spots/digouts, excavating in the wrong location, and base/subbase instability.

Table 47: Documented events for roadway and drainage excavation and embankment construction inspections

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
036E	4	3	87% density failure; 94% density failure; Berm material unsuitable	Soil reprocessing/blending
01DX	3	2	Density failure 88%; Density failures 89%/90%	Wet/dry borrow extremes

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
04FC	3	2	Density test failures (retesting); Compaction failures (multiple)	Moisture content variability
07YU	2	2	Soft spots/dig outs; Subgrade/base instability	None
06K3	3	1	Density failure (low moisture)	Density retest after rework; Subgrade processing iterations
035F	2	1	Base course excavation wrong location	Density test failure 88%
05GY	2	1	Backfill density issue	Wet ground (repeated)
04PD	1	1	Subgrade density failure	None
04X5	1	1	IA density failure	None
065D	1	1	Density failure embankment	None
08ED	1	1	Failed proof roll	None
08N5	1	1	Wet borrow/density	None
0745	1	0	None	Stabilization work spring 2025
Total	25	17	-	-

4.3.3.2 Asphalt Construction – Asphalt Concrete

For Asphalt Construction inspections, five asphalt subclasses (Class Q, Class S, Class D/E/G, Class HR, and Composite) were grouped with Asphalt Concrete (Class Q) ranked 15th and Asphalt Concrete (Class S) ranked 18th from the Task 3 risk assessment. As shown in [Table 48](#), all field-observed asphalt construction events are credited to one unit. For Asphalt Concrete inspections, 43 daily diary events were identified, of which 19 were major. Documented issues from the 13 projects listed span the full asphalt production chain: gradation failures, density failures, air-void exceedances, plant equipment failures, and non-pay quantities.

Table 48: Documented events for asphalt concrete inspections

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
069F	8	5	Air void exceedance; Gradation failures; Improper sluff/drop-offs; Unrolled asphalt sections; High non-pay quantities	Cold joint repair failures; Binder/RAP frequent adjustments; Equipment-related interruptions
05TX	6	4	Gradation failures (recurring); Density failures (recurring); Air void variability (systemic); High non-pay quantities	Plant breakdown; Spread rate variability
04X5	4	2	Asphalt gradation failures #8; Failing density core	Plant baghouse problems; Plant scale/motion issues
06RN	4	2	Air void failure; Density failure with rework	Paver stoppages (truck delays); Rejected loads (temp/compaction)
05J4	3	2	Plant breakdowns; Low core density (re-core)	Paving quality variability
088V	2	2	Gradation failures; Work shutdowns; re-mixing	None

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
07YU	4	1	Pavement breakouts/blowouts	Density variability; Mix oil adjustments daily; Roughness/ride issues
06QM	3	1	Air voids out of spec	Density fluctuations; Mix oil content adjustments
068V	4	0	None	Plant equipment failures; Paver breakdowns; Weather shutdowns (cold); Theoretical maximum specific gravity (Rice) test recalibration
08XW	2	0	None	Hot mix production QA; Plant production acceptance
04XT	1	0	None	Combine equipment breakdown
06N7	1	0	None	Asphalt lip/edge defect
07Y7	1	0	None	Cross slope challenge
Total	43	19	-	-

4.3.3.3 Rigid Pavement – Portland Cement Concrete Pavement

PCC Pavement Construction inspection activity was ranked 7th in the Task 3 risk assessment. Four events (three major events) were found in the daily diaries from two projects (See [Table 49](#)). Deficiencies documented for PCC Pavement include improper joint spacing, incorrect dowel basket installation, failed pavement sections, and failed pavement testing.

Table 49: Documented events for PCC pavement inspections

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
021G	3	3	Improper joint spacing/alignment; Incorrect dowel basket installation Failed/rejected paving sections	None
04XK	1	0	None	PCC pavement testing
Total	4	3	-	-

4.3.3.4 Structures Construction – Structural Concrete

The Task 3 risk assessment of construction inspection activities ranked Structural Concrete as the highest-risk inspection area. From the daily diaries review, 13 Structural Concrete events were identified across 9 of the 51 projects, as listed in [Table 50](#). Of the 13 events, 9 are classified as major. Documented events resulting in failed inspections include concrete test failures, concrete cracking, rejected trucks, and weather-related damage. Given these major events, Structural Concrete is a high-risk inspection area that should be a focus for any project involving structural concrete construction.

Table 50: Documented events for structural concrete

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
04FC	3	2	Repeated fresh concrete test failures; Truck rejected - batch corrected	Surface defects/cracking
01DX	2	1	Damage to fresh concrete sill	Improper grout pads/curing
08ED	2	1	Post-construction cracking	Rain damage on fresh concrete
035F	1	1	Concrete failure (crossover)	None
04PD	1	1	Concrete air-content failure	None
04XT	1	1	Concrete test failure (air/slump)	None
06CF	1	1	Concrete trucks rejected	None
06N7	1	1	Cracked concrete panel	None
065D	1	0	None	Concrete pour quality
Total	13	9	-	-

4.3.3.5 Structures Construction – Drilled Shaft Construction

Drilled Shaft Construction inspection was ranked 3rd in the Task 3 risk assessment, making this another high-risk inspection area. The daily diaries review revealed 4 total events across 2 of the 51 projects, 2 of which were classified as major. The documented events in [Table 51](#) include staking errors for drilled shaft location, cofferdam wall failure, and issues with the condition of the drilled shaft slurry.

Table 51: Documented events for drilled shaft construction inspections

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
035F	3	1	Drilled shaft staking error	Drilled shaft slurry condition; Drilled shaft acceptance
076A	1	1	Cofferdam wall failure	None
Total	4	2	-	-

4.3.3.6 Structures Construction – Pipe Culverts

Pipe Culverts inspection activity was ranked 9th in the Task 3 risk assessment. From the daily diaries reviewed, 14 events were identified across eight projects, of which five were classified as major for Pipe Culverts inspections. Documented events listed in [Table 52](#) include damaged pipe ends, pipe-size discrepancies (plan vs. actual), wrong-elevation installations, broken barrels, and water-intrusion challenges.

Table 52: Documented events for pipe culvert inspections

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
04X5	2	2	Damaged pipe end rejected; Water intrusion pipe excavations	None
04PD	3	1	Pipe-size discrepancy	RCP defect; Box culvert tie-in defect
06UM	2	1	Broken barrel section	Pipe sloping non-compliance
035F	1	1	Stream-crossing pipe length wrong	None
06QM	2	0	None	Pipe grade removal; Damaged pipe (lid)
06RN	2	0	None	Pipe removal/replacement; Grade problems with pipe placement
04XT	1	0	None	Pipe redesign during construction
0541	1	0	None	Plan inaccuracy – pipes short
Total	14	5	-	-

4.3.3.7 Structures Construction – Bridge Deck Preparation and Resurfacing

Bridge Deck Preparation and Resurfacing, under Structures Construction, was ranked 6th in the Task 3 risk assessment. [Table 53](#) shows 9 events found in the daily diaries across 7 projects, of which 7 are classified as major. Documented defect events include bad bridge deck, delaminated concrete, failed concrete tests, deck deterioration, and deck breakthrough.

Table 53: Documented events for bridge deck preparation and resurfacing inspections

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
06CF	3	3	Bridge deck 30% bad; Bad concrete tests (coring); Deck deterioration exceeded plan	None
01DX	1	1	Incorrect deck slope rework	None
04DK	1	1	Delaminated concrete/unsound deck	None
05F9	1	1	Bad concrete tests	None
065D	1	1	Deck breakthrough	None
065N	1	0	None	Coordination challenges
07ME	1	0	None	Bridge deck repair equipment limitations
Total	9	7	-	-

4.3.3.8 Structures Construction – Reinforcing Steel

Reinforcing Steel construction inspections were ranked 11th in the Task 3 risk assessment. A total of eight events (five major events) were found related to Reinforcing Steel across seven

projects, as shown in [Table 54](#). Documented events include misplacement of rebar, missing rebar, epoxy deficiencies, and spacing and misfit issues.

Table 54: Documented events for reinforcing steel inspections

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
021G	1	1	Rebar misplacement / clear cover	None
04F0	1	1	Sleeper-slab cage misfit	None
04PD	1	1	Tie-bar epoxy deficiency	None
05F9	1	1	Missed transverse rebar	None
0745	1	1	Missing steel	None
06CF	2	0	None	Steel short (sleeper); Splice missing
04XT	1	0	None	Reinforcement spacing issues
Total	8	5	-	-

4.3.3.9 Structures Construction – Box, Pipe, and Plate Pipe Culvert Undercutting

For Box, Pipe, and Plate Pipe Culvert Undercutting inspections, the Task 3 risk assessment ranked this as 20th. From the daily diaries reviewed, five events (one major event) were found related to this inspection area, from four different projects (See [Table 55](#)). Issues documented during inspections include water in the excavation, alignment and adjustment errors, and site flooding.

Table 55: Box, pipe, and plate pipe culvert undercutting

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
08N5	2	1	Water in the excavation	Culvert undercut adjustments
04XT	1	0	None	Box culvert alignment error
05GY	1	0	None	Box culvert installation
0745	1	0	None	Site flooding
Total	5	1	-	-

4.3.3.10 Structures Construction – Bridge End Backfill

Bridge-End Backfill construction inspections are ranked 16th in the Task 3 risk assessment. The daily diaries recorded four events across two projects in this inspection area, as shown in [Table 56](#). One of the events is classified as major. Documented issues include approach slab grade conflicts, problems with subgrade testing, bridge approach work, and the approach slab concrete.

Table 56: Documented events for bridge end backfill inspections

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
06X2	1	1	Approach slab grade conflict	None
08N4	3	0	None	Subgrade testing; Bridge approach work; Concrete approach slab
Total	4	1	-	-

4.3.3.11 Incidental Construction – Temporary Traffic Control

The Temporary Traffic Control inspection ranks 2nd in the Task 3 risk assessment, indicating it is a high-risk inspection area. From the daily diaries review, 14 events were identified across 10 projects, of which 7 were classified as major, as shown in [Table 57](#). Major events include work zone collisions, a flagger fatality, improper signage, and unauthorized flaggers. The daily diaries evidence concurs that Temporary Traffic Control inspections are a high-risk, high-priority inspection area.

Table 57: Documented events for temporary traffic control inspections

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
04XT	4	2	Fence-failure / livestock collision; Work-zone vehicle-truck collision with ambulance response	Damaged traffic control devices; Downed barricades
04PD	2	1	Unauthorized flagging	Missing tabs/arrow boards
021G	1	1	Missing/improper traffic control signs	None
0745	1	1	Flagger fatality	None
07KM	1	1	Motorist incident on tacked road	None
08R0	1	1	Non-certified flaggers	None
04DK	1	0	None	Incorrect detour signage
04F0	1	0	None	High-risk lane closure
04X5	1	0	None	Loose gravel signage needed
07KY	1	0	None	Incorrect flagger/sign placement
Total	14	7	-	-

4.3.3.12 Incidental Construction – Traffic Signals and Roadway Lighting

Traffic Signals and Roadway Lighting inspections ranked 14th in the Task 3 risk assessment. The daily diaries reviewed included six events related to this inspection area from four different SDDOT projects (See [Table 58](#)). One event is classified as major. The documented events include a signal pole in conflict with a utility gas line, signal wiring issues, and signal coordination issues.

Table 58: Documented events for traffic signals and roadway lighting inspections

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
06N7	2	1	Signal pole conflicts with gas line	Remaining signal/sign work at closeout
04XK	2	0	None	Signal wiring and light base coordination; Signal coordination across multi-phase
06CF	1	0	None	Signals/fencing late-phase coordination
08ED	1	0	None	Pedestrian signal work
Total	6	1	-	-

4.3.3.13 Incidental Construction – Steel Beam Guardrails

For Steel Beam Guardrail inspections, no daily diary events were found in the 51 projects reviewed. However, five of the 51 projects have final construction memos and bridge inspection reports that documented steel beam guardrail inspection events, as shown in [Table 59](#). A total of 14 events were identified, of which 5 were categorized as major. The documented events include untacked post backfill, damage to thrie/W-beams, and delineation issues.

Table 59: Documented events for steel beam guardrail inspections

PCN	Number of Events	Number of Major Events	Documented Major Events	Documented Moderate/Minor Events
05F9	2	0	None	Untacked guardrail-post backfill (all structures); Loose thriebeam end-block bolts (51-065-188)
06X2	2	0	None	Untacked post backfill; Guardrail delineation not reset
04F0	4	2	Thriebeam shoulder damage; End-terminal angle-strut void	Post-base material short; Untacked backfill
04DK	2	1	Thrie/W-beam transition damage	Bent cable-hanger bracket
065L	4	2	Two W-beam sections damaged (64-056-268); Delineation spacing exceeds 50 ft	End-terminal asphalt-width deviation; Untacked post backfill
Total	14	5	-	-

4.3.3.14 Correlations between Risk Assessment and Daily Diaries Review

The analysis of daily diary records for construction inspection focused on the top 20 construction inspection activities as ranked in the Task 3 risk assessment, as these activities represent the high-risk activities. From the daily diaries reviewed, each of the top 20 Task 3 construction inspection activities was assigned to one of three categories based on the strength of corroborating diary evidence, as shown in [Table 60](#). The strongly confirmed category includes 14 of the Task 3 top 20 construction inspection activities, for which more than 4 diary events were found. The confirmed category includes five of the Task 3 top 20

construction inspection activities, for which one to three diary events were found. One of the top 20 construction inspection activities was not confirmed, as no diary events were found.

Table 60: Confirmation categories for the top 20 Task 3 construction inspection activities

Category	Definition	Number of Top 20 Activities	% of Top 20 Activities
Strongly Confirmed	Top 20 Task 3 Construction Inspection Activity and greater than 4 diary events	14	70%
Confirmed	Top 20 Task 3 Construction Inspection Activity and 1–3 diary events	5	25%
Not Confirmed	Top 20 Task 3 Construction Inspection Activity and 0 diary events	1	5%

Table 61 categorizes the Task 3 top 20 construction inspection activities. Many of the strongly confirmed activities are related to Structures Construction, which is critical construction work, as found in interviews with SDDOT field personnel. The top 20 construction inspection activities include 156 diary events, of which 86 are classified as major events. Asphalt Concrete (Class Q) inspections have the most major events recorded in the daily diaries (19), and Roadway and Drainage Excavation and Embankment Construction inspections have the second-most (17).

Table 61: Categories for the top 20 construction inspection activities

Division	Construction Inspection Activity	Task 3 Rank	Task 3 Expected Value	Number of Projects	Number of Diary Events	Number of Major Events	Category
Structures Construction	Structural Concrete	1 st	9.81	9	13	9	Strongly Confirmed
Incidental Construction	Temporary Traffic Control	2 nd	9.31	10	14	7	Strongly Confirmed
Structures Construction	Drilled Shaft Construction	3 rd	8.56	3	4	2	Strongly Confirmed
Structures Construction	Timber, Prestressed, and Steel Piles	4 th	7.44	2	2	2	Confirmed
Structures Construction	Steel Structures	5 th	6.88	2	2	2	Confirmed
Structures Construction	Bridge Deck Preparation and Resurfacing	6 th	6.75	7	9	7	Strongly Confirmed
Rigid Pavement	PCC Pavement	7 th	6.25	2	4	3	Strongly Confirmed
Structures Construction	Precast and Pretensioned Prestressed Concrete	8 th	5.94	1	1	1	Confirmed
Structures Construction	Pipe Culverts	9 th	5.44	8	14	5	Strongly Confirmed
Structures Construction	Bridge Deck Polymer Chip Seal	10 th	5.44	1	1	1	Confirmed

Division	Construction Inspection Activity	Task 3 Rank	Task 3 Expected Value	Number of Projects	Number of Diary Events	Number of Major Events	Category
Structures Construction	Reinforcing Steel	11 th	5.31	7	8	5	Strongly Confirmed
Incidental Construction	Steel Beam Guardrail	12 th	5.25	5	14	5	Strongly Confirmed
Structures Construction	Structural Plate Pipe and Structural Plate Pipe Arch Culverts	13 th	5.13	0	0	0	Not Confirmed
Incidental Construction	Traffic Signals and Roadway Lighting	14 th	5.13	4	6	1	Strongly Confirmed
Asphalt Construction	Asphalt Concrete (Class Q)	15 th	4.94	13	43	19	Strongly Confirmed
Structures Construction	Bridge End Backfill	16 th	4.88	2	4	1	Strongly Confirmed
Incidental Construction	Cable Guardrail	17 th	4.75	1	1	1	Confirmed
Asphalt Construction	Asphalt Concrete (Class S)	18 th	4.63	13	43	19	Strongly Confirmed
Earthwork	Roadway and Drainage Excavation and Embankment Construction	19 th	4.19	13	25	17	Strongly Confirmed
Structures Construction	Box, Pipe, and Plate Pipe Culvert Undercutting	20 th	4.19	4	5	1	Strongly Confirmed

The one unconfirmed inspection activity, Structural Plate Pipe and Structural Plate Pipe Arch Culverts (risk rank 13th), is a specialty item, and no daily diary events were found in the 51 projects provided by SDDOT.

4.3.4 Construction Inspection Priorities

The risk assessment from Task 3 was performed based on ratings from SDDOT personnel familiar with construction inspection activities. Nineteen experienced SDDOT staff ranked construction inspection activities by risk, and an Expected Value (EV) score was calculated to capture the impact of failure for each activity on cost, safety, and service interruption. A priority ranking was then assigned to each of the 35 inspection activities based on the EV. The ratings capture SDDOT personnel's perspectives on risky activities but do not reflect how often problems occur in the field or whether the flagged high-risk activities are the same ones that cause real field construction problems.

To confirm the rankings and determine potential frequencies and prioritizations for conducting visual inspections of work, construction daily diaries from 51 SDDOT highway projects spanning 2020-2026 were reviewed and analyzed to identify events related to

defects or issues found during construction inspections. Do note that the five asphalt subclasses (Class Q, Class S, Class D/E/G, Class HR, and Composite) and the general asphalt category were grouped into a single asphalt-paving family to allow field evidence and expert assessment to be compared on a level playing field.

From the events recorded in the daily diaries and the Task 3 risk assessment rankings, inspection activities can be prioritized, and observation frequencies determined so that every project focuses on the most critical construction inspection components. The sections below outline the prioritization of construction inspection activities.

4.3.4.1 Validating the Task 3 Risk Rankings with Field Evidence

Field evidence in daily diaries was used to confirm whether the construction inspection activities ranked highest in the Task 3 risk assessment are the same activities that actually generate field problems. The top 20 highest-ranked Task 3 activities were sorted by the amount of supporting evidence each has in project field records, then grouped into three confirmation classes, as shown previously in [Table 60](#).

As a result, when the full range of risk is in view, expert consequence judgments do track what happens in the field. In fact, the activities experts flagged as highest-priority are, with few exceptions, exactly the ones that cause the majority of field problems. The 14 “Strongly Confirmed” construction inspection activities in [Table 62](#) are the core activities the SDDOT construction inspection program should focus on. The Structural Plate Pipe and Structural Plate Pipe Arch Culverts inspection activity (ranked 13th in Task 3) was not present in the 51 selected projects, so there was no field opportunity to mention events. Absence of events reflects project selection, not low risk. This activity is the only top-20 activity with no diary or supplementary evidence identified.

Table 62: Strongly confirmed construction inspection activities

Division	Construction Inspection Activity	Task 3 Rank	Highest Expected Value (HEV)	Number of Events	Documented Events/Issues
Structures Construction	Structural Concrete	#1	9.81	13	Repeated fresh-concrete test failures (air / slump); rejected truck loads; cracked panels; post-construction cracking
Incidental Construction	Temporary Traffic Control	#2	9.31	14	Flagger fatality and work-zone vehicle collision; uncertified/unauthorized flaggers; missing or improper signage
Structures Construction	Drilled Shaft Construction	#3	8.56	4	Cofferdam wall failure; drilled-shaft staking error; slurry-condition and acceptance monitoring
Structures Construction	Bridge Deck Preparation and Resurfacing	#6	6.75	9	Deck deterioration exceeding plan (“30% bad deck”); failed tests requiring coring; deck breakthrough; delamination
Rigid Pavement	PCC Pavement	#7	6.25	4	Improper joint spacing and alignment; incorrect dowel-basket installation; failed/rejected paving sections

Division	Construction Inspection Activity	Task 3 Rank	Highest Expected Value (HEV)	Number of Events	Documented Events/Issues
Structures Construction	Pipe Culverts	#9	5.44	14	Damaged pipe ends; size and length discrepancies (plan vs. actual); wrong-grade installation; water intrusion.
Structures Construction	Reinforcing Steel	#11	5.31	8	Rebar cage misfit; tie-bar epoxy deficiency; missed transverse bars and splices; clear-cover and spacing errors
Incidental Construction	Steel Beam Guardrail	#12	5.25	17	Untacked guardrail-post backfill; delineation not reset / spacing out of tolerance; end-terminal deficiencies; damaged rail sections; loose end-block bolts
Incidental Construction	Traffic Signals and Roadway Lighting	#14	5.13	6	Signal-pole conflict with gas line; multi-trade wiring and light-base coordination; late-phase closeout coordination
Asphalt Construction	Asphalt Concrete (all classes)	#15	4.94	43	Gradation, density, and air-void test failures; high non-pay quantities; recurring plant and paver breakdowns
Structures Construction	Bridge End Backfill	#16	4.88	4	Approach-slab grade conflict; subgrade testing and approach-slab placement
Earthwork	Roadway and Drainage Excavation and Embankment Construction	#19	4.19	25	87–94% density failures requiring rework; wet/dry borrow extremes; soft-spot digouts; base course in the wrong location
Structures Construction	Box, Pipe & Plate Culvert Undercutting	#20	4.19	5	Water in excavation; box-culvert alignment error; undercut adjustments; site flooding

The construction inspection daily diary evidence also identified two activities that generate far more events/issues than the Task 3 risk assessment rankings alone would predict. Asphalt Concrete inspection activities have the highest expected value (HEV) of 4.94, but 43 daily diary events were identified, the highest frequency in the entire dataset. Roadway and Drainage Excavation and Embankment Construction inspection activities ranked #19 in the Task 3 risk assessment, but 25 events were identified for this inspection activity, many of them severe density testing failures requiring rework. Both are moderate-impact activities that occur on many SDDOT construction projects, making them major drivers of field inspection-related issues, even though an individual event is rarely major/catastrophic. The SDDOT expert rankings from the Task 3 risk assessment indicate a lower impact from these two activities because the risk assessment focused on the severity of a single event (failed test/inspection), rather than on how often events/issues occur in the field. The evidence from the daily diaries highlights the frequency of many events, as shown in [Figure 18](#).

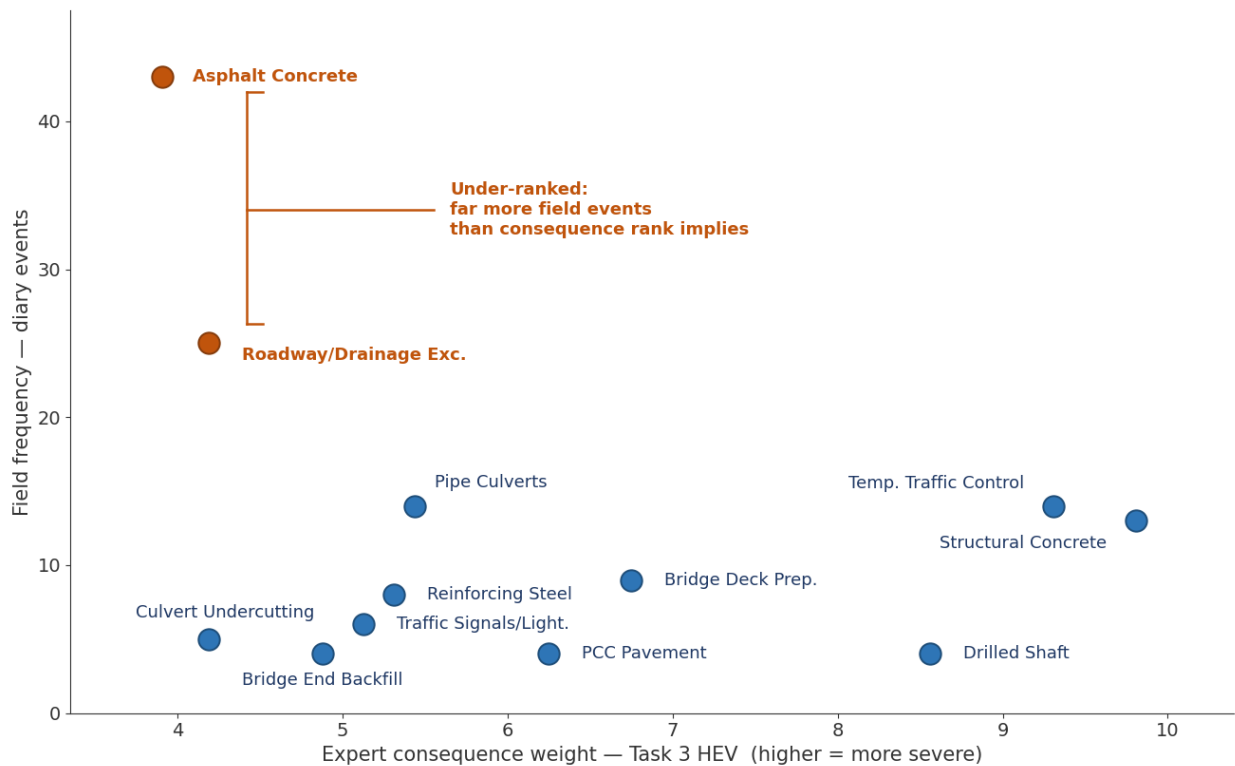


Figure 18: Under-Ranked Activities from the Field Evidence

4.3.4.2 Prioritizing Construction Inspection Activities

Based on the validation results, a three-step framework was developed to assist SDDOT in prioritizing construction inspection activities:

1. Rank activities by relative scores.
2. Assign inspection strategy using an impact–frequency matrix.
3. Apply the results at the project level.

An empirical dataset of 287 events extracted from the construction inspection diaries of 51 SDDOT highway projects was used. Each event was classified by severity and mapped to the Task 3 construction inspection activity to which it belongs ([Appendix J](#)). The “Major” events (n = 119) include safety harm, structural failure, or a failed acceptance test requiring rework. The “Moderate” events (n = 123) include defects requiring corrective action without major rework. The “Minor” events (n = 45) include administrative, weather, or process notes.

Step 1: Rank by relative scores

Relative scores combine two dimensions (risk assessment impact and the frequency of daily diary events) into a single risk-exposure number: relative score = Task 3 risk assessment impact (HEV) multiplied by the frequency of daily diary events. A higher score means the activity carries more overall risk to the project — either because problems with it are serious,

they occur often, or both. An activity rises to the top only if it is both high impact and frequently recorded in daily diaries. With inspectors utilized across many projects, the relative score gives a clear, ranked list of where close attention pays off most, helping SDDOT decide where to concentrate inspectors. Construction inspection activities are sorted into three priority tiers as follows and as shown in [Table 63](#):

- Tier 1 – Critical: Relative score ≥ 100 .
- Tier 2 – High: Relative score = between 99 and 40.
- Tier 3 – Standard: Relative score < 40 .

As a result, the two inspection activities, Asphalt Concrete and Roadway and Drainage Excavation and Embankment Construction, are in the critical tier based on their frequency, along with structural concrete and temporary traffic control inspection activities, which were already ranked as the top 2 in terms of impact from the Task 3 risk assessment.

Table 63: Relative score ranking and priority tiers

Division	Construction Inspection Activity	Task 3 Rank	Highest Expected Value (HEV)	No. of Events	Relative Score	Priority Tier
Structures Construction	Structural concrete	#1	9.81	13	128	Tier 1 – Critical
Incidental Construction	Temporary Traffic Control	#2	9.31	14	130	Tier 1 – Critical
Asphalt Construction	Asphalt Concrete (all classes)	#15	3.91	43	168	Tier 1 – Critical
Earthwork	Roadway and Drainage Excavation and Embankment Construction	#19	4.19	25	105	Tier 1 – Critical
Structures Construction	Pipe Culverts	#9	5.44	14	76	Tier 2 – High
Structures Construction	Bridge Deck Preparation & Resurfacing	#6	6.75	9	61	Tier 2 – High
Structures Construction	Reinforcing Steel	#11	5.31	8	42	Tier 2 – High
Structures Construction	Drilled Shaft Construction	#3	8.56	4	34	Tier 3 – Standard
Rigid Pavement	PCC Pavement	#7	6.25	4	25	Tier 3 – Standard
Incidental Construction	Traffic Signals and Roadway Lighting	#13	5.13	6	31	Tier 3 – Standard
Structures Construction	Box, Pipe & Plate Culvert Undercutting	#20	4.19	5	21	Tier 3 – Standard
Structures Construction	Bridge End Backfill	#16	4.88	4	20	Tier 3 – Standard

Step 2: Assign an inspection strategy (risk assessment impact x number of events matrix)

Plotting each activity by Task 3 risk assessment impact and field event frequency sorts the work into four quadrants, each with its own inspection strategy, as shown in [Figure 19](#). This matrix confirms that high-consequence work stays under intensive or targeted inspection, whether it is common or rare. Each of the four quadrants is described as follows:

- **Intensive (high impact and high frequency of events) Quadrant:** Includes Structural Concrete, Temporary Traffic Control, and Bridge Deck Preparation and Resurfacing inspection activities. The recommended inspection approach is to include full-time, continuous in-process inspection with hold points because these activities are both severe and common and warrant the most inspector hours.
- **Systematic/Process QA (low impact and high frequency of events) Quadrant:** includes Asphalt Concrete, Roadway and Drainage Excavation and Embankment Construction, and Pipe Culverts inspection activities. The recommended inspection approach emphasizes acceptance testing and statistical process control (gradation, density, air voids) rather than continuous visual observation.
- **Targeted / Vigilance (high impact and low frequency of events) Quadrant:** Includes Drilled Shaft Construction, PPC Pavement, Steel Structures, Piles, and Precast Concrete inspection activities. The recommended inspection approach is to perform hold-point inspections at the critical, hard-to-correct stages.
- **Routine / Final-Inspection (low impact and low frequency of events) Quadrant:** Includes Reinforcing Steel, Traffic Signals and Lighting, Box, Pipe, and Plate Culvert Undercutting, Bridge End Backfill, Steel Beam Guardrail, and Cable Guardrail inspection activities. The recommended inspection approach is to establish standardized checklists and to verify final inspection or punch-list items for these inspection activities.

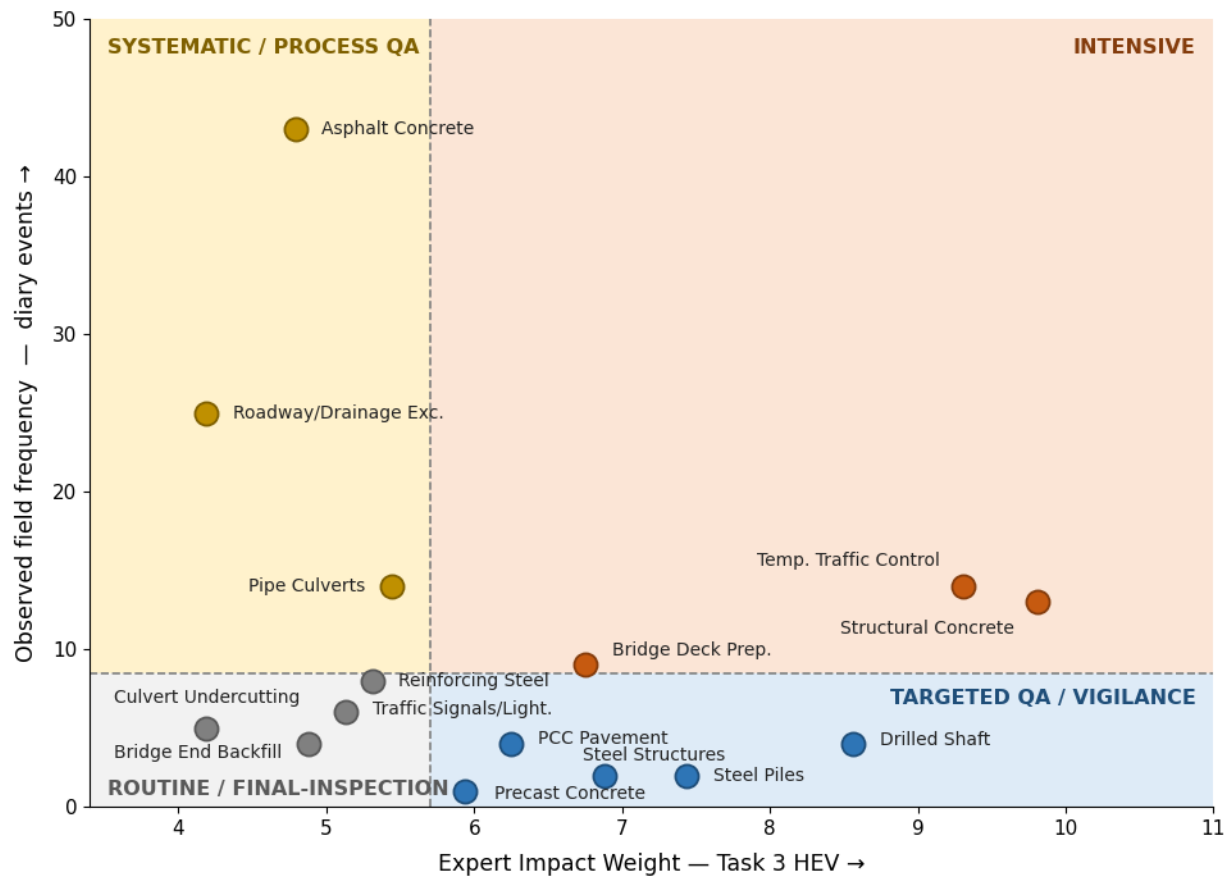


Figure 19: Construction inspection activities priority matrix

Step 3: Apply at the project level

Activity-level priorities assist inspectors in the field, and project-level risk density helps SDDOT determine where to concentrate field staffing resources. A severity-weight score was developed in this step using Equation 2.

As shown in [Table 64](#), ranking the 51 projects by severity-weight score shows that risk concentrates in larger, bridge-heavy, and multi-phase projects, consistent with the broader study's finding that project size and structural complexity are common drivers of field issues. The practical step is to funnel inspection staffing toward these higher-density projects and apply the Step 2 strategies.

Table 64: Project-level risk density (top 10 by severity-weighted score)

PCN	Project Description	No. of Events	No. of Major Events	No. of Moderate Events	No. of Minor Events	Severity-Weighted Score
08ED	Shared Use Path	14	5	9	0	33
04FC	Urban Reconstruction	13	8	4	1	33
04PD	Intersection Improvement	15	7	3	4	31
01DX	Bridge / New Construction	12	6	5	1	29
04X5	Mill & AC Overlay	12	6	4	2	28

PCN	Project Description	No. of Events	No. of Major Events	No. of Moderate Events	No. of Minor Events	Severity-Weighted Score
06CF	Bridge Preservation	10	7	3	0	27
06N7	Shared Use Path	13	4	7	0	26
04XT	Grading / Reconstruction	13	3	6	4	25
06RN	Mill & AC Overlay	10	4	6	0	24
04XK	Grading / Reconstruction	9	0	6	0	12

In summary, the daily diary evidence confirms that the activities experts ranked highest in the Task 2 risk assessment are, with few exceptions, those that generate the most field problems. The construction inspection activities rankings hold up against field severity. SDDOT can adopt relative scores as the primary priority metric, with an impact floor that keeps rare but severe activities under close inspection even when event evidence is low. Additionally, Asphalt Concrete and Roadway and Drainage Excavation and Embankment Construction inspection activities are under-ranked by SDDOT staff solely on impact, yet are the two highest-frequency activities in the daily diaries, so they should be managed through acceptance testing and process control. Finally, SDDOT should concentrate inspection resources on bridge-heavy and multi-phase projects, where field issues tend to occur more frequently.

4.4 Research Objective #4: Recommend ways to improve the efficiency of construction material testing and inspection

The research conducted for the previous objectives provides a basis for prioritizing efficiency improvements of the construction material testing and inspection program at SDDOT. The risk assessment from Task 3 and review of SDDOT projects in the MS&T in Task 6 allowed the research team to determine failure rates and frequencies for material testing. For construction inspection, the Task 3 risk assessment was complemented by the review of daily diaries for inspection information from 51 SDDOT construction projects. The collected daily diary events reflect issues identified when conducting construction inspection activities.

To provide recommendations on ways to improve the current SDDOT material testing and construction inspection program, the material testing activities analysis and daily diaries review are combined in the following sections to present suggestions on what material testing and inspection activities should take precedence and what material testing activities could be reduced in order to have more time for visual construction inspections when placing asphalt paving materials.

4.4.1 Decision Support for Material Testing and Construction Inspection

The information in this section outlines the approaches for material testing and construction inspection for the following areas of construction: Asphalt Construction; Asphalt Surface

Treatment and Asphalt Liquid; Subgrade and Earthwork Construction; PCC Pavement Construction; PCC Structures Construction; and Incidental Construction. Each section below outlines the material testing and construction inspection results from the previously presented analyses and provides suggested recommendations to reduce testing frequency and prioritize construction inspection activities. Each section uses the following approach to determine testing frequencies and inspection priorities:

- High-risk (Top 10 rankings from Task 3 risk assessment) material testing activities are not recommended for frequency reduction.
- Material testing activities with a Task 6 failure rate greater than 10% are not recommended for reducing testing frequency.
- Moderate-risk (Rankings 11-30 from Task 3 risk assessment) and low-risk (Rankings 31-72 from Task 3 risk assessment) material testing activities with a failure rate between 5-10% may be considered for testing frequency reduction, depending on the scope of work, testing requirements, and the potential impact when a failure occurs.
- Moderate-risk (Rankings 11-30 from the Task 3 risk assessment) and low-risk (Rankings 31-72 from the Task 3 risk assessment) material testing activities with a failure rate of less than 5% are recommended for reduced testing frequency.
- High-risk construction inspection activities (the Top 20 from the Task 3 risk assessment) with documented events from the daily diaries review are considered high-priority inspection activities.
- Low-risk (Rankings 21-35 from Task 3 risk assessment) construction inspection activities that have documented events from the daily diaries review are considered high-priority inspection activities.
- Low-risk (Rankings 21-35 from Task 3 risk assessment) construction inspection activities in which no evidence of documented events from the daily diaries review was identified are considered low-priority inspection activities.

4.4.1.1 Asphalt Construction

The following asphalt construction material testing activities are high and moderate risk activities:

- In-Place Density Testing for HMA Aggregate: Risk Rank – 3rd; Failure Rate – 1.3%.
- Asphalt Binder Content: Risk Rank – 28th; Failure Rate – 1.4%.
- HMA aggregate Sieve Analysis: Risk Rank – 30th; Failure Rate – 3.7%.

Based on the high ranking for In-Place Density for HMA Aggregate, this activity is not recommended for testing frequency reduction. However, the Asphalt Binder Content and HMA Aggregate Sieve Analysis are moderate risk with low failure rates (less than 5%), so these two tests can be considered for reducing testing frequency.

All other asphalt construction material testing activities fall outside the top 30 of the Task 3 risk assessment, which include the following:

- Types 1 & 2 Gradation Cover Aggregate Sieve Analysis: Risk Rank – 32nd; Failure Rate – 7.5%.
- MC-70 Asphalt for Prime: Risk Rank – 34th; Failure Rate – 0.0%.
- SS-1h or CSS-1h for Tack: Risk Rank – 34th; Failure Rate – 5.4%.
- SS-1h or CSS-1h for Flush Seal: Risk Rank – 34th; Failure Rate – 3.4%.
- SS-1h or CSS-h1 for Fog Seal: Risk Rank – 34th; Failure Rate – 25.0%
- Theoretical Maximum Specific Gravity (Rice): Risk Rank – 40th; Failure Rate – 0.0%.
- Type 3 Gradation Cover Aggregate Sieve Analysis: Risk Rank – 45th; Failure Rate – 0.0%.
- Asphalt Binder: Risk Rank – 47th; Failure Rate – 1.3%.
- Lime Content: Risk Rank – 48th; Failure Rate – 1.1%.
- Mixture Densification, Voids in Mineral Aggregate and Dust to Binder Ratio (Class Q): Risk Rank – 52nd; Failure Rate Not Calculated.
- Mineral Aggregate for Microsurfacing: Risk Rank – 59th; Failure Rate – 19.5%.
- Moisture Content of Class Q and HR: Risk Rank – 63rd; Failure Rate – 0.0%.
- Bulk Specific Gravity – Risk Rank: 67th; Failure Rate: 0.0%.

For low-risk material testing activities, SS-1h or CSS-1h for Fog Seal and Mineral Aggregate for Microsurfacing are not recommended for reduced testing frequency due to high failure rates for each activity. However, Types 1 & 2 Cover Aggregate Sieve Analysis and SS-1h or CSS-1h for Tack are low-risk activities with moderate failure rates, making them candidates for consideration for reduced testing frequency. All other low-risk activities have low failure rates, which makes them recommended for reducing testing frequency to prioritize construction inspection and higher risk testing activities. Table 65 lists the not recommended, considered, and recommended testing activities for Asphalt Construction.

Table 65: Testing activities recommendations for asphalt construction

Testing Activities Not Recommended for Testing Frequency Reduction (High Priority)	Testing Activities that May Be Considered for Testing Frequency Reduction (Medium Priority)	Testing Activities Recommended for Testing Frequency Reduction (Low Priority)
In-Place Density for HMA Aggregate SS-1h or CSS-1h for Fog Seal Mineral Aggregate for Microsurfacing	Asphalt Binder Content HMA Aggregate Sieve Analysis Types 1 & 2 Cover Aggregate Sieve Analysis SS-1h or CSS-1h for Tack	Theoretical Maximum Specific Gravity (Rice) Asphalt Binder Lime Content Mixture Densification, Voids in Mineral Aggregate and Dust to Binder Ratio (Class Q) Moisture Content of Class Q and HR Bulk Specific Gravity Type 3 Cover Aggregate Sieve Analysis MC-70 Asphalt for Prime SS-1h or CSS-1h for Flush Seal

Asphalt construction inspection activities include the following from the Task 3 risk assessment:

- Asphalt Concrete – Class Q: Risk Rank – 15th
- Asphalt Concrete – Class S: Risk Rank – 18th
- Asphalt Surface Treatment: Risk Rank – 22nd
- Asphalt Concrete, General: Risk Rank – 23rd
- Asphalt Concrete – Class D, E, G: Risk Rank – 24th
- Asphalt Concrete – Class HR: Risk Rank – 25th
- Prime, Tack, Fog, and Flush Seal: Risk Rank – 26th
- Asphalt Concrete Composite: Risk Rank – 34th

The daily diaries review identified 43 events, including 19 major events. Events related to inspection failures include gradation, density, and air-void failures; equipment issues; plant equipment failures; and high non-pay quantities. Therefore, Asphalt Concrete – Class Q and Class S are inspection activities ranked in the top 20, making these high-priority inspection activities for Asphalt Construction. All other inspection activities have lower priority than low-risk material testing activities, but do not take precedence over high-priority inspection activities or material testing activities not recommended for testing frequency reduction.

Table 66 outlines the priority levels for asphalt construction inspection activities.

Table 66: Priority levels for asphalt construction inspection activities

High Priority Inspection Activities	Low Priority Inspection Activities
Asphalt Concrete – Class Q Inspection	Asphalt Surface Treatment Inspection
Asphalt Concrete – Class S Inspection	Asphalt Concrete, General Inspection
	Asphalt Concrete – Class D, E, G Inspection
	Asphalt Concrete – Class HR Inspection
	Asphalt Concrete Composite Inspection
	Asphalt Surface Treatment
	Prime, Tack, Fog, and Flush Seal

4.4.1.2 Subbase, Base, and Granular Materials

The high-risk material testing activities for Subbase, Base, and Granular Materials are the following:

- Granular Bridge End Backfill Aggregate Sieve Analysis: Risk Rank – 5th; Failure Rate – 11.4%.
- In-Place Density for Granular Bridge End Backfill: Risk Rank – 6th; Failure Rate: 6.7%.
- In-Place Density for FDR: Risk Rank – 10th; Failure Rate: 0.8%.

These testing activities are not recommended for frequency reduction testing, since all three are ranked in the top 10 in the Task 3 risk assessment. However, certain circumstances may allow for reduced testing of In-Place Density for FDR, given the very low failure rate calculated in Task 6.

Moderate risk material testing activities for subbase, base, and granular materials include:

- In-Place Density for Pipe and Box Culvert Undercut Backfill: Risk Rank – 15th; Failure Rate – 11.0%.
- Subbase/Base Course Composite Aggregate Sieve Analysis: Risk Rank – 16th; Failure Rate – 12.1%.
- In-Place Density for Subbase/Base Course: Risk Rank – 18th; Failure Rate – 3.7%.
- Gravel Surfacing Sieve Analysis: Risk Rank – 22nd; Failure Rate – 7.7%.

With a failure rate of 11.0%, the In-Place Density for Pipe and Box Culvert Undercut Backfill is a moderate-risk, high failure rate material, and it should not be considered for testing frequency reduction. The Subbase/Base Course Composite Aggregate Sieve Analysis also has a high failure rate of 12.1%, indicating that this test should not be considered for testing frequency reduction. The Gravel Surfacing Sieve Analysis has a moderate failure rate of 7.7%

and, as a moderate-risk activity, should not be considered for testing frequency reduction. However, In-Place Density for Subbase/Base Course has a failure rate of 3.7%, which is low; therefore, this test can be considered for testing frequency reduction.

Low-risk material testing activities associated with subbase, base, and granular materials include the following:

- Gravel Cushion Sieve Analysis: Risk Rank – 31st; Failure Rate – 19.0%.
- MSE Backfill Aggregate Sieve Analysis: Risk Rank – 32nd; Failure Rate – not calculated.
- Standard Density for Subbase/Base Course: Risk Rank – 35th; Failure Rate – 0.0%.
- Standard Density for FDR: Risk Rank – 36th; Failure Rate – 0.0%.
- Standard Density for Pipe and Box Culvert Undercut Backfill: Risk Rank – 39th, Failure Rate – not calculated.

The failure rate for Gravel Cushion Sieve Analysis is 19.0%, indicating that, although this is a low-risk testing activity, the high failure rate suggests it should be done regularly, and testing should not be reduced. However, the failure rates for Standard Density for FDR and for Subbase/Base Course are 0.0%, making these tests candidates for test frequency reduction when resources are limited. Failure rates were not found for the MSE Backfill Sieve Analysis or Standard Density for Pipe and Box Culvert Undercut Backfill testing activities. [Table 67](#) lists the testing activities recommendations for Subbase, Base, and Granular Materials.

Table 67: Testing activities recommendations for subbase, base, and granular materials

Testing Activities Not Recommended for Testing Frequency Reduction (High Priority)	Testing Activities that May Be Considered for Testing Frequency Reduction (Medium Priority)	Testing Activities Recommended for Testing Frequency Reduction (Low Priority)
Granular Bridge End Backfill Aggregate Sieve Analysis In-Place Density for Granular Bridge End Backfill In-Place Density for Full-Depth Reclamation In-Place Density for Pipe and Box Culvert Undercut Backfill Subbase/Base Course Composite Aggregate Sieve Analysis Gravel Cushion Sieve Analysis Gravel Surfacing Sieve Analysis	In-Place Density for Subbase/Base Course	MSE Backfill Aggregate Sieve Analysis Standard Density for Base And Subbase Standard Density for FDR Standard Density for Pipe and Box Culvert Undercut Backfill

Inspection activities for Granular Bases and Surfacing construction include Granular Bases and Surfacing inspections (ranked 21st in the Task 3 risk assessment) and FDR inspections (ranked 31st). Both activities are lower risk due to their low risk assessment rankings. In

addition, the daily diaries review did not identify any events related to Granular Bases and Surfacing, or to FDR inspections. Therefore, these two inspection activities should be prioritized over low-risk material testing activities (See [Table 68](#)). Still, these two may be prioritized lower than some moderate- and high-risk material testing activities, based on the scope of work, testing requirements, potential impact of failure, and available resources.

Table 68: Priorities for granular bases and surfacing construction inspection activities

High Priority Inspection Activities	Low Priority Inspection Activities
None	Granular Bases and Surfacing Full Depth Reclamation (FDR)

4.4.1.3 Subgrade and Earthwork Construction

High-risk material testing activities for Subgrade and Earthwork construction include the following:

- Specified Density (In-Place) for Bridge End Embankments: Risk Rank – 7th; Failure Rate – 9.2%.
- Specified Density (In-Place) for Berms: Risk Rank – 8th; Failure Rate – 6.5%.

Due to the high risk and moderate failure rates, along with significant impacts to cost, safety, and service interruptions, material testing frequency for these two testing activities should not be reduced.

Moderate risk material testing activities for subgrade and earthwork construction are:

- Specified Density (In-Place) for Embankments: Risk Rank – 17th; Failure Rate – 2.9%.
- Specified Density (In-Place) for Pipe and Box Culvert Backfill: Risk Rank – 19th; Failure Rate – 2.9%.
- Specified Density (In-Place) for Pipe Undercut Backfill (Soil): Risk Rank – 23rd; Failure Rate – 3.4%.
- Moisture Content of Embankments: Risk Rank – 24th; Failure Rate – 1.2%.
- Moisture Content of Box and Pipe Culvert Backfill: Risk Rank – 25th; Failure Rate – 1.0%.
- Specified Density (in-place) for Cross Pipe Pre-Installation Undercut: Risk Rank – 26th; Failure Rate – 5.1%.

Specified Density (In-Place) for Cross Pipe Pre-Installation Undercut has a failure rate of 5.1%, making this activity a candidate for testing frequency reduction, depending on the project and the impact if a failure occurs. As shown in [Table 69](#), all other testing activities are

recommended for testing frequency reduction based on the low failure rates calculated in Task 6.

Table 69: Testing activities recommendations for subgrade and earthwork construction

Testing Activities Not Recommended for Testing Frequency Reduction (High Priority)	Testing Activities that May Be Considered for Testing Frequency Reduction (Medium Priority)	Testing Activities Recommended for Testing Frequency Reduction (Low Priority)
Specified Density (In-Place) for Bridge End Embankments Specified Density (In-Place) for Berms	Specified Density (In-Place) for Cross Pipe Pre-Installation Undercut	Specified Density (In-Place) for Embankments Specified Density (In-Place) for Pipe and Box Culvert Backfill Specified Density (In-Place) for Pipe Undercut Backfill (Soil) Moisture Content for Embankments Moisture Content for Box and Pipe Culvert Backfill

Construction inspection activities for Subgrade and Earthwork construction (See [Table 70](#)) include Roadway and Drainage Excavation and Embankment Construction (risk rank 19th), and Roadway Shaping (risk rank 30th). Roadway and Drainage Excavation and Embankment Construction inspections are a top-20 risk-ranked activity, meaning they should take precedence over material testing and other inspections due to the high risk and significant impact if a failure or defect occurs. Roadway Shaping is a lower-risk inspection activity that can be prioritized below other inspection activities and critical material testing activities, such as Specified Density (In-Place) Testing for Bridge-End Embankments and Berms. The daily diary review identified 25 events, 17 of which were classified as major, all related to inspection activities for Roadway and Drainage Excavation and Embankment Construction. No events related to Roadway Shaping were found in the daily diaries reviewed.

Table 70: Priorities for subgrade and earthwork construction inspection activities

High Priority Inspection Activities	Low Priority Inspection Activities
Roadway and Drainage Excavation and Embankment Construction	Roadway Shaping

4.4.1.4 PCC Pavement Construction

Fresh Concrete Tests, Compressive Strength Tests, and Fine and Coarse Aggregate Sieve Analysis testing activities are all ranked among the top 30 in the Task 30 risk assessment. High and moderate risk material testing activities for PCC Pavement construction are:

- Fresh Concrete Test (Air Content, Unit Weight, Slump, and Temperature): Risk Rank – 4th; Failure Rate – 8.0%.

- Compressive Strength Test: Risk Rank – 13th; Failure Rate – 2.1%.
- Fine and Coarse Aggregate Sieve Analysis: Risk Rank – 29th; Failure Rate – 3.0%.

The PCC Pavements Fresh Concrete Test activity should not be reduced in frequency due to the high risk, moderate failure rate, and significant impact when failures result. Compressive Strength Tests could be considered for reduction, but only after careful review of the project scope, testing requirements, and the potential impact of a failure. Fine and Coarse Aggregate Sieve Analysis may also be considered for reduced testing frequency, as it is a moderate-risk, low-failure-rate testing activity.

Other low-risk material testing activities for PCC Pavement construction include the following:

- Measurement Thickness: Risk Rank – 56th; Failure Rate – 1.3%.
- Fly Ash: Risk Rank – 62nd; Failure Rate – 0.0%.
- Cement: Risk Rank – 63rd; Failure Rate – 0.0%.

Given the low rankings, low risk, and low failure rate for each of these tests, SDDOT can consider reducing their frequency to free up more time for critical PCC pavement inspections. [Table 71](#) outlines recommendations for material testing activities for PCC pavement construction.

Table 71: Testing activities recommendations for PCC pavement construction

Testing Activities Not Recommended for Testing Frequency Reduction (High Priority)	Testing Activities that May Be Considered for Testing Frequency Reduction (Medium Priority)	Testing Activities Recommended for Testing Frequency Reduction (Low Priority)
Fresh Concrete Test	Compressive Strength Test Fine and Coarse Aggregate Sieve Analysis	Measurement Thickness Fly Ash Cement

Construction inspection activities related to PCC Pavement construction include PCC Pavement (risk rank 7th), Rubblize PCC Pavement (risk rank 34th), and Cracking and Sealing of PCC Pavement (risk rank 35th). Visual inspection observations related to the placement of PCC Pavement ranked as a top-20 Task 3 risk assessment activity, and, from the daily diaries review, a total of 8 events were found, of which 5 were major. The documented events for PCC Pavement construction inspection activities include improper joint spacing, incorrect dowel basket installation, failed pavement sections, and failed pavement testing. Therefore, PCC Pavement inspections are a high priority. Moreover, no diary events were found for the Rubblize PCC Pavement or Cracking and Sealing of PCC Pavement inspection activities, making these two inspection activities lower priorities, as shown in [Table 72](#).

Table 72: Priorities for PCC pavement construction inspection activities

High Priority Inspection Activities	Low Priority Inspection Activities
PCC Pavement	Rubblize PCC Pavement Cracking and Sealing of PCC Pavement

4.4.1.5 PCC Structures Construction

High-risk material testing activities for PCC Structures Construction are:

- Fresh Concrete Test (Air Content, Unit Weight, Slump, and Temperature): Risk Rank – 1st; Failure Rate – 4.8%.
- Compressive Strength Test: Risk Rank – 2nd; Failure Rate – 5.5%.
- Fine and Coarse Aggregate Sieve Analysis: Risk Rank – 9th; Failure Rate – 6.0%.

Fresh Concrete Tests, Compressive Strength Tests, and Fine and Coarse Aggregate Sieve Analysis tests are ranked 1st, 2nd, and 9th, respectively, in the Task 3 risk assessment, indicating they are high risk and not recommended for testing frequency reduction.

Other material testing activities for PCC Structures Construction include Cement (risk rank 49th) and Fly Ash (risk rank 46th), both of which are low-risk activities due to their rankings outside the top 30. Cement has a failure rate of 2.7%, and Fly Ash has a failure rate of 0.0%, making both candidates for reducing testing frequency and allowing more time for construction inspections of critical structures. [Table 73](#) outlines the testing activities recommendations for PCC structures construction.

Table 73: Testing activities recommendations for PCC structures construction

Testing Activities Not Recommended for Testing Frequency Reduction (High Priority)	Testing Activities that May Be Considered for Testing Frequency Reduction (Medium Priority)	Testing Activities Recommended for Testing Frequency Reduction (Low Priority)
Fresh Concrete Test Strength Test (Compressive Strength) Fine and Coarse Aggregate Sieve Analysis	None	Fly Ash Cement

For construction inspection activities, 12 of the top 20 Task 3 risk assessment rankings are related to structures construction:

- Structural Concrete: Risk Rank – 1st
- Drilled Shaft Construction: Risk Rank – 3rd
- Timber, Prestressed, and Steel Piles: Risk Rank – 4th
- Steel Structures: Risk Rank – 5th

- Bridge Deck Preparation and Resurfacing: Risk Rank – 6th
- Precast and Pretensioned Prestressed Concrete: Risk Rank – 8th
- Pipe Culverts: Risk Rank – 9th
- Bridge Deck Polymer Chip Seal: Risk Rank – 10th
- Reinforcing Steel: Risk Rank – 11th
- Steel Beam Guardrails: Risk Rank – 12th
- Structural Plate Pipe and Structural Plate Pipe Arch Culverts: Risk Rank – 13th
- Bridge End Backfill: Risk Rank – 16th
- Box, Pipe, and Plate Culvert Undercutting: Risk Rank – 20th

Due to the top 20 ranking for these types of construction inspections, each is considered high risk and high priority. In addition, the 12 top 20 task 3 construction inspection activities account for 63 daily diary events, of which 36 are classified as major (representing 30% of all major events found in the daily diaries across 51 projects reviewed). Deficiencies documented during structures construction inspections include concrete cracking, rejected trucks, staking errors, pipe size discrepancies, incorrect elevation installation, deck deterioration, Thrie/W-beam transition damage, misplacement of rebar, alignment errors, and grade conflicts. Therefore, field inspection observations should focus on these areas of Structures Construction and should take precedence over field material testing when resources are limited.

Two PCC Structures Construction inspection activities are ranked outside the top 20 in the Task 3 risk assessment: Bridge Field Painting, Repainting, and Paint Residue Containment; and Shop Painting. Both activities involve painting work, which is lower risk than other Structures Construction inspection activities. Table 74 provides the priorities for PCC Structures Construction inspection activities.

Table 74: Priorities for PCC structures construction inspection activities

High Priority Inspection Activities	Low Priority Inspection Activities
Structural Concrete	Bridge Field Painting, Repainting, and Paint Residue Containment
Drilled Shaft Construction	Shop Painting
Timber, Prestressed, and Steel Piles	
Steel Structures	
Bridge Deck Preparation and Resurfacing	
Precast and Pretensioned Prestressed Concrete	
Pipe Culverts	

High Priority Inspection Activities	Low Priority Inspection Activities
Bridge Deck Polymer Chip Seal	-
Reinforcing Steel	
Steel Beam Guardrails	
Structural Plate Pipe and Structural Plate Pipe Arch Culverts	
Bridge End Backfill	
Box, Pipe, and Plate Culvert Undercutting	

4.4.1.6 Miscellaneous Incidental Materials and Incidental Construction

For Miscellaneous Incidental and Manufactured or Fabricated Items material testing activities, four are moderate-risk based on the Task 3 risk assessment. Each of the following material testing activities can be considered for testing frequency reduction due to the moderate risk ranking, but low failure rates calculated in Task 6:

- Fresh Concrete Tests for Pre-Cast and Pre-Stressed Concrete: Risk rank – 11th; Failure rate – 0.6%.
- Compressive Strength Tests for Pre-Cast and Pre-Stressed Concrete: Risk rank - 12th; Failure rate – 1.2%.
- High Strength Bolts for Bolt Assemblies (risk rank: 20th); Failure rate not calculated.
- Fine and Coarse Aggregate Sieve Analysis for Pre-Cast and Pre-Stressed Concrete (risk rank: 27th), failure rate – 3.1%.

All other material testing activities for miscellaneous incidental and manufactured or fabricated items are low risk based on the Task 3 risk assessment. All low-risk testing activities are recommended for testing frequency reduction, which include the following:

- Pre-Cast and Pre-Stressed Concrete Piles: Risk Rank – 37th
- Cement for Pre-Cast And Pre-Stressed Concrete: Risk Rank – 38th
- Fly Ash for Pre-Cast And Pre-Stressed Concrete: Risk Rank – 44th
- Structural Steel: Risk Rank – 50th
- Timber Piles: Risk Rank – 51st
- Anchor Bolts, Nuts, and Washers for Bolt Assemblies: Risk Rank – 53rd
- Bridge Field Painting – Surface Preparation: Risk Rank – 54th
- Steel Beam or Sheet Piling: Risk Rank – 55th

- Bridge Field Painting – Paint Application: Risk Rank – 57th
- Reinforcing Bars, Deformed Dowel Bars, and Deformed Tie Bars: Risk Rank – 58th
- Corrugated Metal Pipe: Risk Rank – 66th
- HDPE Slip Line Pipe: Risk Rank – 68th
- Steel Pipe: Risk Rank – 69th

In many cases, these low-risk testing activities are accompanied by visual inspections that take precedence over testing. Additionally, many of these materials are found on the approved product list, and if the item is accepted for use, testing is typically minimal. Testing activities recommendations for miscellaneous incidental materials are shown in [Table 75](#).

Table 75: Testing activities recommendations for miscellaneous incidental materials

Testing Activities Not Recommended for Testing Frequency Reduction (High Priority)	Testing Activities that May Be Considered for Testing Frequency Reduction (Medium Priority)	Testing Activities Recommended for Testing Frequency Reduction (Low Priority)
None	Fresh Concrete Tests for Pre-Cast And Pre-Stressed Concrete Compressive Strength Tests for Pre-Cast and Pre-Stressed Concrete High-Strength Bolts for Bolt Assemblies Fine and Coarse Aggregate Sieve Analysis for Pre-Cast and Pre-Stressed Concrete	Pre-Cast and Pre-Stressed Concrete Piles Cement for Pre-Cast And Pre-Stressed Concrete Fly Ash for Pre-Cast And Pre-Stressed Concrete Structural Steel Timber Piles Anchor Bolts, Nuts, and Washers For Bolt Assemblies Bridge Field Painting – Surface Preparation Steel Beam or Sheet Piling Bridge Field Painting – Paint Application Reinforcing Bars, Deformed Dowel Bars, and Deformed Tie Bars Corrugated Metal Pipe HDPE Slip Line Pipe Steel Pipe

Construction inspection activities for Incidental Construction include the following:

- Temporary Traffic Control: Risk Rank – 2nd
- Steel Beam Guardrails: Risk Rank – 12th
- Traffic Signals and Roadway Lighting: Risk Rank – 14th

- Cable Guardrails: Risk Rank – 17th
- Drop Inlets: Risk Rank – 27th
- Manholes: Risk Rank – 29th

From the daily diary review, 20 events were identified for Temporary Traffic Control, and Traffic Signals and Roadway Lighting. No events were found for all other Incidental Construction inspection activities. Therefore, Temporary Traffic Control, Traffic Signals and Roadway Lighting, Steel Beam Guardrails, and Cable Guardrails are high-priority inspection activities as they are all ranked in the top 20 of the Task 3 risk assessment, and two of the inspection activities have recorded events in the daily diaries reviewed. Drop inlets and manholes are lower-priority activities, as shown in [Table 76](#).

Table 76: Priorities for incidental construction inspection activities

High Priority Inspection Activities	Low Priority Inspection Activities
Temporary Traffic Control	Drop Inlets
Steel Beam Guardrails	Manholes
Traffic Signals and Roadway Lighting	
Cable Guardrails	

4.4.2 Field Staffing for Material Testing and Construction Inspection

To assist SDDOT in field personnel staffing for material testing and construction inspections, a review of 96 SDDOT projects was conducted using staffing information provided by SDDOT. The 96 projects reviewed included information for item 3420, "Perform Inspection and Testing," which was reviewed for each project. The information collected included salary, benefits, hours, the number of SDDOT technicians working on each project, and start and finish dates. Equipment hours under function 2430 were not included in the analysis as the focus was on labor hours for SDDOT field technicians. In addition, functions 3440, 3445, and 3484 were reviewed but excluded from the analysis as these functions do not directly correspond to field technician inspection hours, which was the focus of the analysis.

Calculated values included total time in days and months, number of hours per field personnel technician, and the range of field personnel per project. Project location and description were also collected for each project from the MS&T by looking up the project's PCN. Information on travel time/distance to project sites, location of testing labs, plant/pit/scale locations was not provided and is not included in the analysis.

Thirteen of the 96 projects reviewed (PCNs 076A, 01DX, 084E, 05F9, 04FC, 0687, 04G5, 039L, 05EN, 06CM, 04E7, 04EM, and 04XW) involved consultant-performed construction inspection, material testing, or contract administration, so the state-force hours recorded

under item 3420 do not represent the full inspection effort on those projects. These 13 consultant-supported projects were excluded, and the analysis below is based on the remaining 83 state-administered projects. The following summarizes the field staffing review of the 83 projects. Appendix M: 83 SDDOT Projects Reviewed for Field Personnel Staffing lists the 83 projects included in the staffing analysis.

The results show that SDDOT recorded about 178,500 inspection hours across these 83 projects, totaling roughly \$7.2 million in inspection-labor costs. The blended cost is about \$40 per inspection hour and is remarkably consistent from one project to the next. Inspection hours are the focus over inspection cost throughout this section. Therefore, the sections below focus on hours and inspectors, with costs reported when necessary.

4.4.2.1 Staffing By Project Type

The 83 projects reviewed were grouped into 8 project type categories based on the descriptions of work collected from MS&T. The categories of project types include the following:

- Bridge/Structure (New or Replacement)
- Bridge Repair & Preservation
- Mill & Asphalt Overlay
- Asphalt Surfacing
- Surface Treatment & Sealing
- Grading & Reconstruction
- Urban Reconstruction
- Pavement Restoration

Then, each project was also classified as high, medium, or low profile using the following definitions:

- High-profile project: Interchange and complex urban or bridge/structure work
- Medium-profile project: Noncomplex bridge replacement and mill-and-overlay
- Low-profile project: Surface treatment, re-decking, and shared-use paths.

Using the project types and project profile classifications, Table 77 presents the findings of material testing and construction inspection staffing by project category. Staffing numbers in this section are reported as medians rather than means because per-project inspection effort is strongly right-skewed. In other words, a small number of very large reconstruction projects

carry far more inspectors and hours than a typical project and would skew the average upward. Therefore, the median reflects the staffing level of the typical project in each category and is not misrepresented by the high-effort outliers. The median columns (inspectors, hours, months) describe the typical project in each type. Total Hours and Total Duration are the sums across all projects in the category type. Inspection Hours Per Month is the median of each project's own hours-per-month. Then, the Average full-time equivalent (FTE) value, where needed, was calculated using Equation (3).

$$\text{FTE} = \frac{\text{Inspection Hours Per Month}}{173.3} \quad \text{Equation 3}$$

The inspection hours per month variable is calculated by dividing a project's total inspection hours by the project's total duration in months. The 173.3 hours represent the average number of worker-hours an inspector can work per month (using a 2,080-hour work year). Average FTE represents the mean number of full-time-equivalent inspectors on site over the life of the project, where 1.0 equals one full-time inspector; values below 1.0 mean the inspector was shared with other projects.

It is noted that the average FTE measures inspection intensity, indicating how concentrated the hours are within each month and how the work is paced. It does not count how many inspectors touched the project, nor does it measure total effort. Thus, a project type can have a large inspector roster with many total hours and still show a low average FTE if those hours are spread thinly across a long schedule. For example, the inspection demand for the bridge/new structure category arrives in stage-to-stage groupings with specialized inspectors who each rotate in for a short time: a piling specialist, a structural-concrete inspector, an electrical or lighting inspector. However, because each contributes a limited number of hours (and the work is spread over about 10 months), the typical bridge project carried only about 105 hours of inspection per month. Dividing 105 by 173.3 yields 0.6, roughly three-fifths of one full-time inspector's monthly hours, averaged over the project's life.

Table 77: Material testing and construction inspection staffing by project type

Project Type	Classification	No. of Projects	No. of Inspectors (median)	Min Inspectors	Max Inspectors	Hours (median)	Total Hours	Months (Median)	Total Duration (months)	Inspection Hrs/Month	Avg FTE
Urban Reconstruction	High	5	18	6	24	5,770	38,530	33.3	177	203	1.17
Grading / Reconstruction	High	6	15	4	25	3,083	21,189	16.1	103	236	1.36
Bridge / New Structure	High	14	11	5	27	1,334	32,136	10.3	241	105	0.60
Mill & AC Overlay	Medium	21	13	7	19	1,505	38,051	10.5	258	176	1.02

Project Type	Classification	No. of Projects	No. of Inspectors (median)	Min Inspectors	Max Inspectors	Hours (median)	Total Hours	Months (Median)	Total Duration (months)	Inspection Hrs/Month	Avg FTE
AC Surfacing	Medium	9	12	7	22	1,115	18,940	13.0	161	141	0.81
Bridge Preservation	Low	9	13	5	20	1,455	18,805	11.5	132	119	0.69
Pavement Restoration / Grinding	Low	4	7	3	19	591	2,344	7.7	39	94	0.54
Surface Treatment / Seal	Low	15	6	2	14	396	8,486	3.0	70	157	0.91

Findings from the staffing analysis by project category include the following themes and patterns from the 83 projects reviewed:

- Large rebuild projects use the most inspectors. For example, urban reconstruction and grading/reconstruction projects typically use 15-18 inspectors across several thousand inspection hours, several times as many as the lighter pavement-preservation projects, such as surface treatment/seal coats and pavement restoration/grinding, which use a median of roughly 6-7 inspectors each.
- Routine paving and bridge work, including new bridges, mill-and-overlay, bridge preservation, and asphalt surfacing, each require roughly 11-13 inspectors and about 1,100-1,500 hours.
- Light projects use the fewest inspectors, whereas surface treatments and sealing typically require about 6 inspectors over roughly 400 hours.
- The same project category can still vary widely. For instance, for bridges, the number of inspectors ranged from 5 to 27, because a single small culvert and a large girder bridge are both classified as bridge work, even though the scope of work for each project differs drastically.
- Longer duration projects use more inspection hours. Specifically, the categories that run the longest (urban reconstruction at about 33 months) also use the most hours; more months on site mean more inspections and testing.
- The Average FTE shows that most inspection staff have a part-time presence on projects rather than a dedicated full-time assignment. Only grading/reconstruction (1.36), urban reconstruction (1.17), and mill-and-overlay (1.02, marginally) average more than 1 full-time inspector over the life of the project, which makes sense since grading/reconstruction and urban reconstruction include a larger, more complex

scope of work than the other project categories. Every other category runs below 1.0, and across all 83 projects, only about 41% sustained an average of one or more full-time inspectors. This finding confirms that inspectors are routinely shared across several active projects at once, most likely due to limited resources, which is one of the reasons for conducting this research.

Figure 20 shows the full spread of inspection hours within each project type on a logarithmic scale. Because inspection hours span nearly three orders of magnitude (from under 100 to nearly 30,000 hours), a linear axis would compress the smaller projects into an unreadable cluster near zero. The boxes show the middle half of projects in each project type, and the orange line marks the median. The chart shows how much overlap exists between categories: a complex bridge can require as much inspection as an urban reconstruction, while a simple bridge can require as little as a surface treatment.

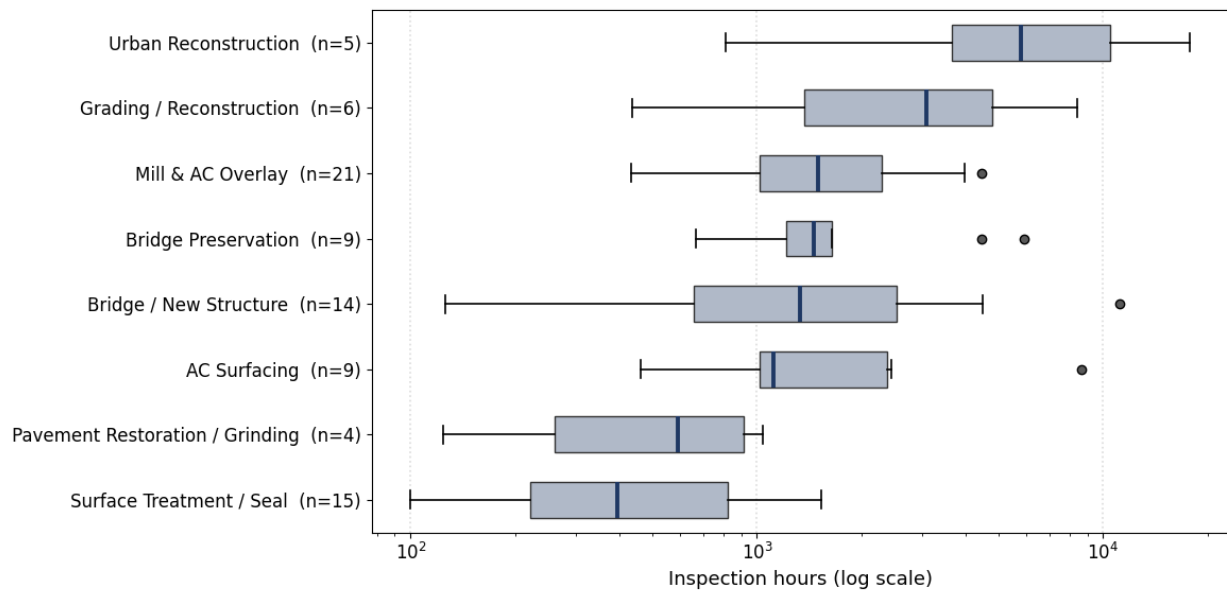


Figure 20: Distribution of construction-inspection hours by project type (n = 83 projects)

Figure 21 presents an inspector staffing benchmark, with the dot showing the median number of inspectors and a bar showing the interquartile range (IQR) for each project type. This benchmark is a quick reference tool for resource allocation. The value to the right of each bar is the median number of inspectors (the same value as the dot).

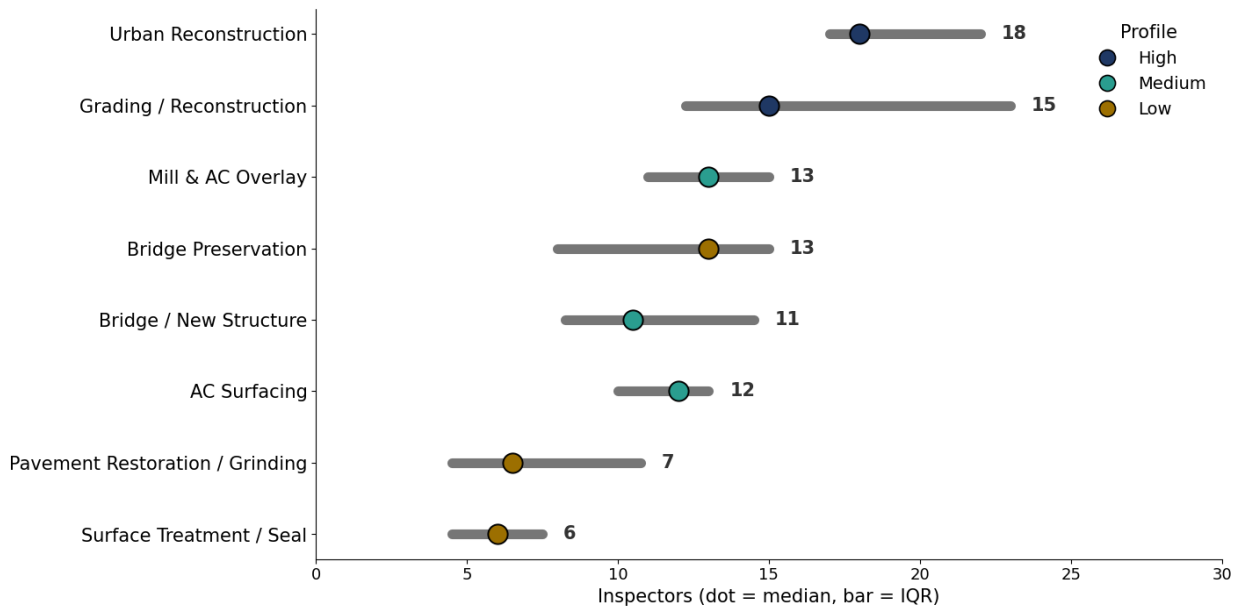


Figure 21: Staffing benchmark by project type (n = 83 projects)

4.4.2.2 Staffing By Region

Inspection staffing also differs by SDDOT region, but mostly because each region has a different mix of projects. A typical project in the Mitchell Region is the largest (about 15 inspectors and 1,600 hours), and a typical project in the Pierre Region is the smallest (about 7 inspectors and 760 hours), with Rapid City and Aberdeen in between, as shown in [Figure 22](#). These differences reflect each region's workload regarding how many large rebuild projects it carries, rather than a difference in how inspection is staffed from region to region.

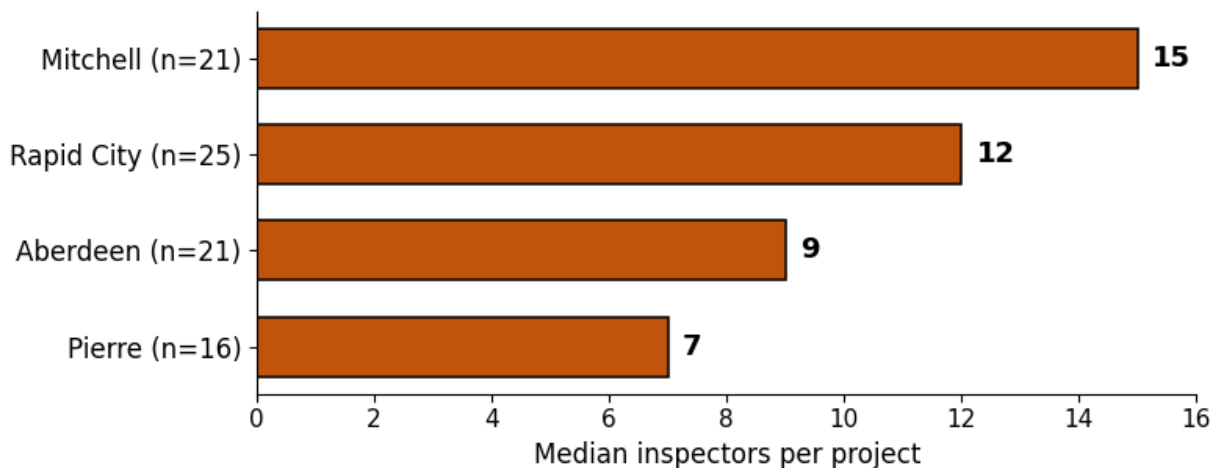


Figure 22: Median number of inspectors per project per SDDOT region (n = 83 projects)

Of the 83 projects analyzed for staffing, the four SDDOT regions have broadly similar numbers of projects: Rapid City has 25, Mitchell and Aberdeen each have 21, and Pierre has 16. So, the staffing gap is not about how busy a region is overall, but about what it builds.

The Mitchell Region’s portfolio leans toward larger structure and reconstruction work, which lifts its median project to about 15 inspectors and a median inspection cost of about \$65,000, whereas the Pierre Region produces a median project of about 7 inspectors and roughly \$28,000. As a result, when the smaller-project regions are active, they run lean but intense. Pierre and Aberdeen post the highest median hours-per-month on site (about 160 in Pierre and 157 in Aberdeen, versus about 119 in Mitchell), meaning their projects compress inspection into shorter, busier windows. The practical takeaway is that the project-type and profile benchmarks can serve as a reference for staffing a single project. The regional differences reflect the mix of work each region happens to perform.

4.4.2.3 Staffing by Project Profile

The High/Medium/Low project profile classification provides a practical way to estimate inspection staffing. [Figure 23](#) shows that staffing rises steadily with the project profile. For example,

- High-profile projects (n = 15) average roughly 17 inspectors, 3,655 hours, and 22 months.
- Medium-profile projects (n = 40) average about 12 inspectors, 1,398 hours, and 10 months.
- Low-profile projects (n = 28) average about 7 inspectors, 681 hours, and 7 months.

This consistent ordering across all three measures supports using the profiles as a reliable first-pass screen for inspection staffing.

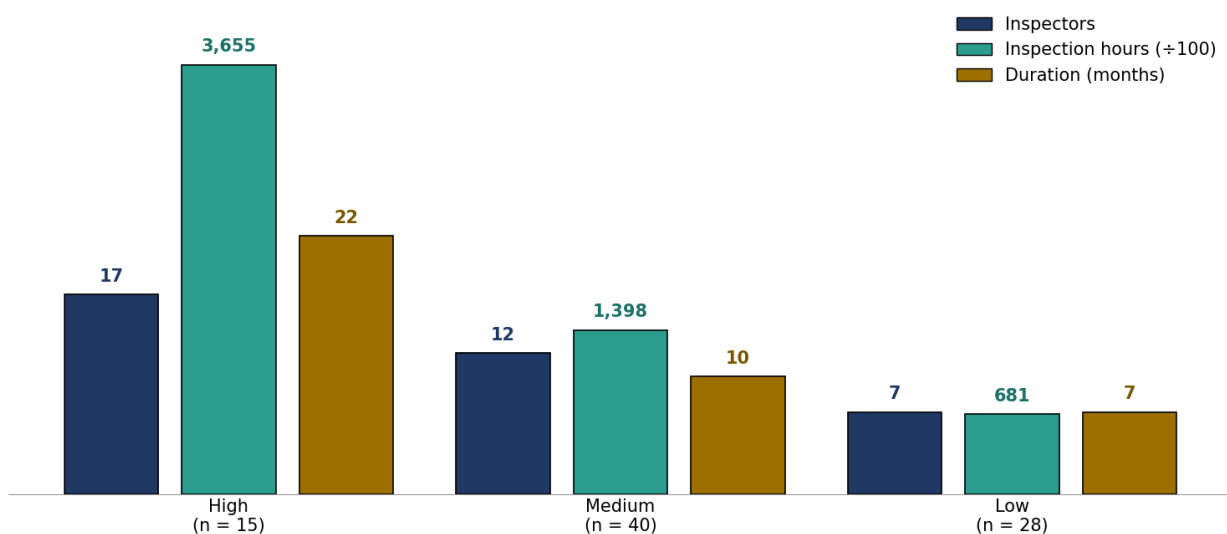


Figure 23: Staffing increase for high, medium, and low project profile classifications

4.4.2.4 Seasonality and Program Workload

Inspection demand is strongly seasonal and, in aggregate, substantial. About half of all projects (51%) begin during the April-to-August construction season, with starts peaking in May, and relatively few begin in the late-fall and early-winter months, as shown in [Figure 24](#). When the active periods of all 83 projects are overlaid on a calendar, the program runs a median of 17 concurrent projects and peaks at 34 simultaneously active projects, with an estimated peak demand of about 35 full-time-equivalent inspectors during the busiest stretches. This concentration of work means staffing plans should account not only for how many inspectors a single project needs, but also for how many projects compete for the same inspectors during the summer peak.

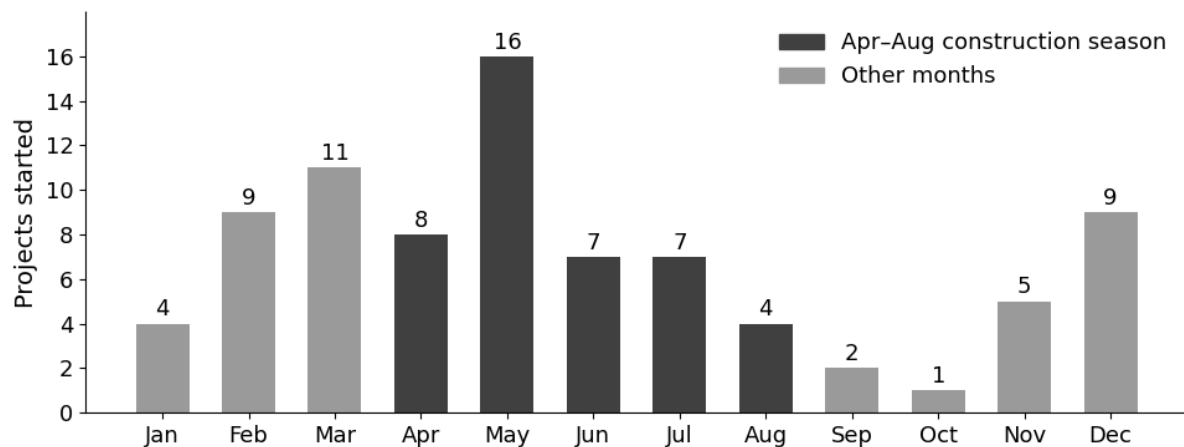


Figure 24: Number of projects started in each calendar month (n = 83 projects)

[Table 78](#) summarizes the program-level workload measures. The seasonal peak is demanding not only because many projects run at once, but because the inspection workload rests on a relatively small, experienced core. Across the 83 projects, the inspection workload was staffed by 156 distinct inspectors, and the hours are heavily concentrated: the busiest 10% of inspectors accounted for 58% of all inspection hours, the busiest 20% for 75%, and the least-active half of the workforce accounted for just 4%.

Table 78: Program-level workload measures (2020 – 2026) (n = 83 projects)

Measure	Value
Projects starting April – August	51% of projects
Peak month for starts	May (16 projects)
Median concurrent active projects	17
Peak concurrent active projects	34
Estimated peak inspector FTE demand	35 FTE

The results show that the construction inspection staffing workload has two practical patterns. First, a little over half of the inspectors (54%) appeared on only one project, while a core group of 16 inspectors (10%) worked on four or more projects, with one inspector logging nearly

4,800 hours. The median inspector logged only about 112 hours, so the expertise is not evenly spread. Second, the summer peak of about 35 full-time-equivalent inspectors must be drawn from this same pool at the very time when the most projects and the most high-risk concrete and structural work are active. Cross-training, deliberate succession planning, and using the benchmarks to forecast the peak crew in advance are the most direct ways to ensure inspection quality when demand is highest.

5.0 RECOMMENDATIONS

The research team completed 10 tasks to develop the final report. A literature review was conducted along with focus group interviews with SDDOT personnel, third-party consultants, and third-party contractors. Case studies were also conducted with five state DOTs. The analysis of data resulted in the risk assessment completed in Task 3, the quantitative project analysis conducted in Task 6, the staffing review, and the review of daily diaries for construction inspection activities. Based on this information, the research team compiled the following recommendations for SDDOT to consider when modifying the current material testing and construction inspection program.

5.1 Adopt a Risk-Based Framework for Material Testing and Construction Inspection

SDDOT should develop and adopt a formal risk-based framework that sets material testing frequencies and construction inspection effort based on each activity's assessed risk and demonstrated failure rate, rather than applying uniform requirements to every project.

The current program is grounded in the SD91-05 study and applies broadly similar testing and inspection requirements across activities regardless of their actual risk. This research developed a risk assessment of 72 material testing and 35 construction inspection activities, rated by 19 experienced SDDOT field personnel, and validated it against failure-rate data from 189 MS&T projects and 287 field daily diary events drawn from 51 projects. The combined evidence shows that risk is highly uneven across testing and inspection activities, meaning a uniform program over-inspects low-risk work while leaving limited resources for activities that impact cost, safety, and service. A risk-based framework directs SDDOT's limited testing and inspection workforce toward activities that deliver the greatest value while maintaining quality and safety. Implementing risk-based approaches should optimize the balance between mandatory testing compliance and critical inspection activities to achieve overall project quality objectives within existing resource constraints.

5.2 Maintain Full Testing Frequency for High-Priority Material Tests

SDDOT should not reduce testing frequency for high-priority material tests, defined as activities ranked in the top 30 of the risk assessment that also carry a high or moderate failure rate.

Twelve material testing activities meet the high-priority threshold ([Table 44](#)), including Fresh Concrete Tests for PCC Structures (ranked 1st), Compressive Strength for PCC Structures (2nd), Sieve Analysis and In-Place Density for Granular Bridge-End Backfill (5th and 6th respectively), and Specified Density (In-Place) for Bridge-End Embankments and Berms (7th and 8th respectively). Several of these combine a top-ranked risk with elevated failure rates — for example, Granular Bridge-End Backfill Sieve Analysis fails 11.4% of the time, and In-

Place Density for Pipe and Box Culvert Undercut Backfill fails 11.0%. Because failures in these activities carry high costs and significant safety and service impacts, these tests should continue to be performed at their current frequency on applicable SDDOT construction projects.

5.3 Reduce Testing Frequency for Low-Priority Material Tests

SDDOT should reduce testing frequency for low-priority material tests, defined as activities ranked outside the top 30 of the risk assessment with failure rates below 5%, to free time for higher value and higher risk work.

The project analysis identified numerous low-risk activities that rarely fail, including Theoretical Maximum Specific Gravity (Rice), Asphalt Binder, Lime Content, Bulk Specific Gravity, MC-70 Asphalt for Prime, Cement and Fly Ash for PCC pavements and PCC Structures, and Standard Density for Subbase/Base Course and Full-Depth Reclamation (FDR). Many of these activities recorded 0.0% failure rates across the 189 projects reviewed. Continuing to test these materials at full frequency consumes labor and laboratory resources without a corresponding quality benefit. Reducing their testing frequency and scaling to the project's scope of work and material requirements, allows SDDOT field staff to spend more time on critical material tests and on construction inspection.

5.4 Continue Routine Testing for Low-Risk Activities with High Failure Rates

SDDOT should continue routine testing for the small set of low-risk activities with high failure rates, rather than reducing their frequency solely based on risk ranking.

Risk ranking and failure rate do not always agree, and a few activities ranked outside the top 30 still fail frequently. SS-1h or CSS-1h Asphalt for Fog Seal fails 25.0% of the time, Mineral Aggregate for Microsurfacing fails 19.5%, and Sieve Analysis for Gravel Cushion Aggregate fails 19.0%. Because a high failure rate signifies quality variability regardless of the assessed impact, these activities should not be considered for frequency reduction even though their risk ranking is low. Using both risk ranking and observed failure rate as joint screening tools prevents the program from relaxing oversight on materials that routinely fall out of specification.

5.5 Tie Testing-Frequency Decisions to Project Scope and Characteristics

SDDOT should make testing-frequency decisions at the project level, based on each project's scope of work, materials, and characteristics.

The decision-support analysis applied a consistent set of rules: protecting top-10 activities and any activity with a failure rate above 10%, and allowing reductions for moderate- and low-risk activities with failure rates below 5%. However, the practical application of those rules depends on the scope of work for a given project. A surface-treatment, an urban reconstruction, and a new bridge project present different material risk profiles. Embedding

the high, medium, and low testing priorities into project-specific QA planning lets SDDOT focus testing on where each project's risk lies, while reducing redundant testing elsewhere.

5.6 Reduce Duplicative Testing Across SDDOT, Contractors, and Suppliers

Where material test results are consistently within specifications across SDDOT, contractors, and suppliers, the agency should reduce or eliminate redundant agency testing and rely more on certificates of compliance and the approved products list.

Interviews with personnel, contractors, and material suppliers found that many materials are tested at multiple points in the supply chain: by suppliers before shipment, by contractors during QC, and by SDDOT during QA. For low-risk items that consistently pass and for items already covered in the approved products list, where visual acceptance typically governs, this layered testing provides little additional assurance while adding cost and time for both SDDOT and contractors. Streamlining duplicative testing in these cases reduces overhead and frees field time without weakening QA.

5.7 Prioritize Construction Inspection Activities Using Combined Impact and Frequency

SDDOT should prioritize construction inspection activities using a relative score that multiplies each activity's assessed impact by how often it generates field events, sorting the 35 inspection activities into critical, high, and standard tiers.

Ratings from 19 SDDOT staff captured the impact of a single failure but not the frequency with which problems actually occur. Validating the risk rankings against 287 events in the daily diaries of 51 projects confirmed that nearly 90% of the top-ranked activities are borne out by field evidence, while also revealing that frequency matters. The relative score (impact multiplied by event frequency) places Structural Concrete, Temporary Traffic Control, Asphalt Concrete, and Roadway and Drainage Excavation and Embankment Construction in the high-priority critical tier. Using these combined, field-validated tools gives SDDOT a defensible basis for directing construction inspection focus.

5.8 Provide Continuous Inspection for High-Impact, High-Frequency Activities

SDDOT should provide full-time, continuous in-process inspection with defined hold points for activities that are both high-impact and high-frequency.

The impact-frequency matrix places Structural Concrete, Temporary Traffic Control, and Bridge Deck Preparation and Resurfacing in the intensive quadrant. Structural Concrete was the highest-ranked inspection activity and produced 13 daily diary field events, including repeated fresh concrete test failures, rejected truckloads, and cracked panels. Temporary Traffic Control produced 14 events, including a flagger fatality and a work-zone collision. Because these activities are both severe and common, they warrant the most inspector

hours and should be inspected continuously, with hold points at critical stages to catch defects before they are locked into the work.

5.9 Manage High-Frequency, Lower-Severity Activities Through Acceptance Testing and Process Control

SDDOT should manage high-frequency, lower-severity inspection activities primarily through acceptance testing and statistical process control rather than continuous visual observation.

Asphalt Concrete and Roadway and Drainage Excavation and Embankment Construction generated the two highest daily diary event counts in the dataset (43 and 25 events, respectively), yet most individual events are moderate rather than catastrophic. These systematic, process-QA activities are best controlled by monitoring gradation, density, and air-void testing results and acting on trends, which addresses the recurring nature of the issues more efficiently than by stationing an inspector to continuously observe the work. This approach matches the inspection method to the failure pattern, freeing inspectors to work on hold-point tasks elsewhere.

5.10 Use Hold-Point Inspections for High-Impact, Low-Frequency Activities

SDDOT should use targeted hold-point inspections at critical, hard-to-correct stages for high-impact activities that occur infrequently.

Construction inspection activities such as Drilled Shaft Construction, PCC Pavement, Steel Structures, Piles, and Precast Concrete fall in the targeted quadrant — their failures are serious and difficult to remedy after the fact, but they generate relatively few events. For example, Drilled Shaft Construction ranked 3rd in impact but documented only 4 events. For these activities, inspectors should focus their efforts on the specific stages where a defect becomes permanent rather than maintaining a continuous presence, ensuring critical verifications occur without overcommitting limited field staff resources.

5.11 Apply Standardized Checklists for Routine, Low-Risk Inspection Activities

SDDOT should manage routine, low-risk and low event rate inspection activities using standardized checklists and final-inspection or punch-list verification.

Activities in the routine, final-inspection quadrant, including Reinforcing Steel, Traffic Signals and Lighting, Box, Pipe, and Plate Culvert Undercutting, Bridge End Backfill, and Steel Beam Guardrails, generate occasional events but seldom produce major consequences.

Standardized checklists ensure consistent verification of inspection items while minimizing the time inspectors spend on them. Consistent checklists also improve documentation quality and make it easier to confirm that final and punch-list items have been addressed

before acceptance. In general, checklists can be developed for all inspection activities regardless of risk to improve the efficiency of field staff.

5.12 Maintain an Impact Minimum So That Rare but High-Impact Inspection Activities Stay Under Close Observation

SDDOT should retain an impact floor in its prioritization so that rare but high-consequence activities remain under close inspection even when little field evidence is recorded.

Because a high calculated relative score increases priority and frequency, a purely score-driven approach may lead to under-inspecting activities that are significant to a project but uncommon. As an example, Structural Plate Pipe and Plate Pipe Arch Culverts, ranked 13th in the risk assessment, appeared in none of the diaries for 51 selected projects, which most likely reflects project selection rather than this activity being low risk. Therefore, an impact floor keeps activities such as Drilled Shafts Construction and Steel Structures under appropriate scrutiny regardless of how often they appear in project records and protects against a false sense of low risk from limited data.

5.13 Use Staffing Benchmarks and Seasonal Demand to Plan Inspector Assignments

SDDOT should use the project-type and staffing benchmarks, along with the seasonal demand profile, to plan inspector assignments and concentrate resources on high-risk projects.

The staffing analysis of 83 projects established median inspectors counts and hours by project category and by high, medium, and low-profile project classifications, and found that inspection demand peaks sharply in the April-to-August construction season, with as many as 34 concurrent projects and an estimated peak demand of about 35 full-time-equivalent inspectors. Most project categories average fewer than one full-time inspector, confirming that inspectors are routinely shared across projects. The benchmarks and seasonal profile let SDDOT forecast peak crews in advance, reduce understaffing during the busy summer months, and avoid overstaffing lower-intensity work. All the while, project risk levels direct staff to the bridge-heavy, multi-phase projects where field issues are more impactful.

5.14 Protect the Experienced Inspection Core Through Cross-Training and Succession Planning

SDDOT should protect the core of experienced inspectors through cross-training and succession planning to ensure inspection quality remains high during peak demand.

Across 83 projects reviewed for staffing, 156 distinct inspectors recorded inspection hours, but the work is heavily concentrated: the busiest 10% of inspectors logged 58% of all hours, and the busiest 20% logged 75%, while the median inspector logged only about 112 hours. This concentration becomes a risk during the summer peak, when the most projects and the

most high-risk concrete and structural work compete for the same experienced staff. Cross-training, succession planning, and using the staffing benchmarks to forecast peak crews are ways to ensure that critical inspections are covered by qualified personnel when demand is highest.

5.15 Modernize the Data System and Adopt Field Technologies to Support Risk-Based Management

SDDOT should replace the legacy MS&T system with a modern tracking platform and pilot field technologies such as electronic ticketing, mobile inspection applications, and intelligent compaction to support ongoing risk-based management.

The research documented existing and emerging technologies, including e-ticketing, mobile and laptop field applications, intelligent compaction, ground-penetrating radar, and unmanned aerial systems, that peer DOTs such as California, Ohio, Virginia, and Washington State use to improve data quality and reduce inspection burden. A modern data platform would replace the manual MS&T system, improve data consistency, and provide the infrastructure needed to track failure rates and inspection events over time, which is essential to sustaining a risk-based program. Consistent with the experience of peer states, SDDOT should adopt these tools through field pilots before full deployment and engage contractors and consultants to develop and test program changes to build buy-in and maintain a cooperative QA environment.

6.0 RESEARCH BENEFITS

The objective of this research was to assess the current construction material testing and inspection program and the frequency and use of these activities on highway construction projects. Strategies, recommendations, and implementation have been developed for SDDOT to consider when modifying the construction material testing and inspection frequencies, which assist with directing workforce resources to provide the most value for construction activities.

This research provides SDDOT with a comprehensive, data-driven foundation for modernizing its construction material testing and inspection program. The primary benefits of this research are described below.

Improved allocation of inspection resources. By identifying the risk levels of 72 material testing activities and 35 construction inspection activities, the research enables SDDOT to direct its workforce toward the activities that impact a project the most. High-risk activities, such as Fresh Concrete Tests for PCC Structures, In-Place Density for HMA Aggregate, Structural Concrete inspection, and Drilled Shaft construction inspection, have been identified as priorities requiring consistent, full-frequency testing or oversight. At the same time, the research identified numerous low-risk, low-failure-rate activities that are candidates for reduced testing frequency, freeing up inspector time for higher-value work. This reallocation of effort improves the overall effectiveness of the testing and inspection program without compromising quality or safety.

Cost savings through targeted testing frequency reductions. The project analysis of 189 SDDOT projects from the MS&T system established actual failure rates for the most common material testing activities. Many low-risk activities showed failure rates below 5%, indicating that current testing frequencies for those activities may exceed what is necessary to assure quality. Reducing testing frequency for these activities, when the risk and evidence support it, can lower costs associated with material testing without increasing risk to project quality or the traveling public.

Reduced duplication of testing across project stakeholders. The research found that materials are tested at multiple points in the supply chain: by suppliers before leaving the plant or quarry, by contractors during QC, and by SDDOT during QA. Where test results are consistently within specification across all three parties, the research supports reducing or eliminating redundant testing. This streamlining reduces duplicative effort for both SDDOT personnel and contractors, decreasing project overhead while maintaining assurance of material quality.

Enhanced workforce planning and staffing efficiency. The staffing analysis of 83 SDDOT projects established benchmarks for inspector staffing by project category and complexity.

The research found that inspection demand peaks during the spring and summer construction season, with concurrent inspector demand of approximately 35 FTE. Most project types require an average of less than a full-time inspection presence, highlighting the need for flexible staffing strategies. The benchmarks and seasonal demand profiles developed in this research give SDDOT the tools to proactively plan inspector assignments, reduce understaffing during peak periods, and avoid overstaffing on lower-intensity projects.

A foundation for technology adoption and program modernization. The research documented a range of existing and emerging technologies—including intelligent compaction, ground-penetrating radar, uncrewed aerial systems, mobile field inspection platforms, and e-ticketing systems—that can support more efficient and consistent construction material testing and inspection. By identifying how these technologies align with SDDOT’s current program and where they can add the most value, the research provides SDDOT with options for technology investment. In addition, replacing the current MS&T system with a modern tracking platform would improve data consistency, reduce administrative burden on field personnel, and provide the data infrastructure needed to support ongoing risk-based program management.

Alignment with national best practices and peer state DOT experience. The literature review, AASHTO and FHWA requirements review, and case studies with California, Ohio, South Carolina, Virginia, and Washington State DOTs confirmed that risk-based approaches to construction material testing and inspection are established in the transportation construction industry and have been successfully implemented in agencies with programs similar to SDDOT’s. The research findings position SDDOT to adopt a program that aligns with current national standards while remaining consistent with SDDOT’s project types, regional circumstances, and workforce capacity.

Improved relationships with contractors and consultants. The research included interviews with SDDOT personnel, contractors, consultants, and material suppliers across SDDOT regions. These stakeholders consistently expressed that collaboration and transparency are essential to the success of any program changes. By engaging contractors and consultants to develop recommendations and participate in any future pilot testing, SDDOT can improve program buy-in, reduce the risk of pricing increases driven by perceived contractor risk-shifting, and foster a cooperative QA environment that benefits all parties.

In summary, this research provides practical, actionable guidance for SDDOT to improve the efficiency and effectiveness of its construction material testing and inspection program. The recommendations, decision support tools, staffing benchmarks, and prioritization strategies developed through this project will help SDDOT protect infrastructure quality, make better use of a limited field workforce, and position the agency for continued program improvements as new technologies and methods become available.

7.0 REFERENCES

- AASHTO (2016). Survey Finds a Growing Number of State DOTs Are Using Drones to Improve Safety and Collect Data Faster and Better: Saving Time and Money. Transportation TV Special Report. <https://indd.adobe.com/view/78d3b1d3-13c3-42c0-8bf2-75ea8c534d1a>
- American Petroleum Institute (2016). API Recommended Practice 580, Risk-Based Inspection, Third Edition, Washington, D.C., February.
- Anderson, K.W., Uhlmeyer, J.S., Kinne, C., Pierce, L.M., & Muench, S. (2009). Use of the Maturity Method in Accelerated PCCP Construction. Report No. WA-RD 698.1. Washington State Department of Transportation Office of Research & Library Services. April. <https://www.wsdot.wa.gov/research/reports/fullreports/698.1.pdf>
- Baker, T.E., Molohon, R.J., & McIntyre, R.W. (2010). Materials Risk Analysis. Washington State Department of Transportation, Research Report WA-RD 745.1, Office of Research & Library Services. <https://www.wsdot.wa.gov/research/reports/fullreports/745.1.pdf>
- Cai, H., Zhang, Y., Jeon, J., & Yang, L. (2022). Risk-based Inspection. Final Report FHWA-SC-22-03. South Carolina Department of Transportation, Federal Highway Administration. <https://rosap.ntl.bts.gov/view/dot/66411>
- Caltrans (2024a). Construction Manual. Division of Construction, California Department of Transportation. <https://dot.ca.gov/-/media/dot-media/programs/construction/documents/policies-procedures-publications/construction-manual/cmsearchabledoc.pdf>
- Caltrans (2024b). Standard Specifications. California Department of Transportation. https://dot.ca.gov/-/media/dot-media/programs/design/documents/2024_stdspecs-a11y.pdf
- Caltrans (2023). Construction Quality Assurance Program Manual. Division of Construction, California Department of Transportation. <https://dot.ca.gov/-/media/dot-media/programs/construction/documents/policies-procedures-publications/quality--assurance-manual-a11y.pdf>
- Caltrans (2022). Materials Engineering and Testing Services: Source Inspection Guidelines for Local Agencies. Office of Structural Materials. California Department of Transportation. <https://mets.dot.ca.gov/manuals/SIGLA/>
- Caltrans (2014). The Use of Unmanned Aerial Systems for Steep Terrain Investigation. Preliminary Investigation, California Department of Transportation Division of Research, Innovation and System Information, August 14. <https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/preliminary-investigations/unmanned-aerial-systems-pi-rev8-14-14-a11y.pdf>

- Chockalignam, J., Kumar, P., Gupta, K., Dev Garg, R., Sinha, A., Avishek, K., & Hebbale, R. (2017). Remote Sensing and GIS for Civil Engineering Applications and Human Development. *International Journal of Advancement in Remote Sensing, GIS, and Geography*, 5(1): 1–18.
- Choudhry, R.M., Aslam, M.A., Hinze, J.W., & Arain, F.M. (2014). Cost and Schedule Risk Analysis of Bridge Construction in Pakistan: Establishing Risk Guidelines. *ASCE Journal of Construction Engineering and Management*, 140(7):04014020.
[https://doi.org/10.1061/\(ASCE\)CO.1943-7862.0000857](https://doi.org/10.1061/(ASCE)CO.1943-7862.0000857)
- Colorado DOT (2026). Field Materials Manual.
<https://www.codot.gov/business/designsupport/materials-and-geotechnical/manuals>
- Colorado DOT (2025). Standard Specifications for Road and Bridge Construction.
<https://www.codot.gov/business/designsupport/cdot-construction-specifications/2025-construction-specifications/2023-specs-book/2025-cdot-specs-book.pdf>
- Colorado DOT (2013). Frequency Guide Schedule for Minimum Materials Sampling, Testing, and Inspection. Colorado Department of Transportation Quality Assurance Program.
- Crumal, Z. (2019). What Is a Robotic Total Station? Here's Everything You Need to Know. September 13.
- Daniels, D.J. (2005). Ground-Penetrating Radar. *Encyclopedia of RF and Microwave Engineering*. April. <https://doi.org/10.1002/0471654507.eme152>
- De Carlo, F., Borgia, O., & Tucci, M. (2011). Risk-based inspections enhanced with Bayesian networks, *Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability*. 225(3): 375–386. <https://doi.org/10.1177/1748006XJRR368>
- Dick, G.P.M. (2000). ISO 9000 certification benefits, reality or myth? *The TQM Journal*, 12(6): 365–371. <https://doi.org/10.1108/09544780010351517>
- FHWA (2017). Effective Use of Geospatial Tools in Highway Construction. Publication No. FHWA HIF-19-089, Federal Highway Administration, Research Development, and Technology.
<https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/19089/19089.pdf>
- FHWA (2014a). Intelligent Compaction Technology for Asphalt Applications: Generic—IC Specifications for Asphalt Materials.
https://www.fhwa.dot.gov/construction/ictssc/ic_specs_hma.pdf
- FHWA (2014b). Intelligent Compaction Technology for Soils Applications: Generic—IC Specifications for Soils. https://www.fhwa.dot.gov/construction/ictssc/ic_specs_soils.pdf

- FHWA (2012a). Best Practices in Geographic Information Systems-Based Transportation Asset Management. Office of Planning. January.
https://www.gis.fhwa.dot.gov/documents/GIS_AssetMgmt.pdf.
- FHWA (2012b). Construction Quality Assurance. Project Construction and Contract Management. Companion Guide to Video. <https://www.fhwa.dot.gov/federal-aidessentials/companionresources/16quality.pdf>
- FHWA (2006). Guide to Risk Assessment and Allocation for Highway Construction Management. Report No. FHWA-PL-06-032, Office of International Programs, Office of Policy.
https://international.fhwa.dot.gov/pubs/pl06032/guide_to_risk_assessment_allocation_for_highway.pdf
- FHWA (2004). Use of Contractor Test Results in the Acceptance Decision, Recommended Quality Measures, and the Identification of Contractor/Department Risks. Technical Advisory T-6120.3, Office of Pre-Construction, Construction, and Pavements.
<https://www.fhwa.dot.gov/construction/t61203.cfm>
- Florida DOT (2025). Standard Specifications for Road and Bridge Construction. FY 2025-26.
https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/specifications/by-year/fy-2025-26/ebook/2025-26-ebook-compressed.pdf?sfvrsn=a07d3f95_2
- Gan, L., Shen, Q., Xu, D., & Wang, W. (2014). Quality Risk Control for GSC Dynamic Alliance in Large-Scale Construction Projects. 2014 Seventh International Joint Conference on Computational Sciences and Optimization, Beijing, China. 631–635.
<https://doi.org/10.1109/CSO.2014.151>
- Illinois DOT (2024). Project Procedures Guide: Sampling Frequencies for Materials Testing and Inspection. Bureau of Materials and Physical Research. Springfield, IL.
<https://public.powerdms.com/IDOT/documents/2144679/Project%20Procedures%20Guide>
- Indiana DOT (2026). Standard Specifications.
<https://www.in.gov/dot/div/contracts/standards/book/sep25/2026%20Standard%20Specifications.pdf>
- Indiana DOT (2025). Manual for Frequency of Sampling and Testing and Basis for Use of Materials. Division of Materials and Tests, June. Indianapolis, IN.
<https://www.in.gov/indot/doing-business-with-indot/files/frequency-manual.pdf>
- Indiana DOT (2024). 2024 Standard Specifications, Indianapolis, IN.
<https://www.in.gov/dot/div/contracts/standards/book/sep23/sep.htm>

- Jarkas, A.M. & Haupt, T.C. (2015). Major construction risk factors considered by general contractors in Qatar. *Journal of Engineering, Design, and Technology*, 13(1): 165–194. <https://doi.org/10.1108/JEDT-03-2014-0012>
- Jaselskis, E., Sankar, A., Yousif, A., Clark, B., & Chinta, V. (2015). Using telepresence for real-time monitoring of construction operations. *ASCE Journal of Management in Engineering*, 31(1). [https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000336](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000336)
- Kansas DOT (2022). "Construction Manual Part V". Kansas Department of Transportation <https://www.ksdot.gov/home/showpublisheddocument/918/638943114384500000>
- Kamsu-Foguem, B. (2016). Information structuring and risk-based inspection for the marine oil pipelines. *Applied Ocean Research*, 56: 132-142. <https://doi.org/10.1016/j.apor.2016.01.009>
- Kokosing Construction Company, Inc. (2017). How Can Drones Stop My Projects from Going Late and Over-budget? Identified Technologies. <https://www.identifiedtech.com/wp-content/uploads/2017/04/Identified-Technologies-Kokosing-Case-Study.pdf>
- Lake Land College (2023). Illinois DOT Quality Management Training Program. <https://learn.lakelandcollege.edu/IDOT/course-manuals.jsp>
- Lao, A.S., Radanovic, M., Liu, Y., Hu, S., Fang, Y., Khoshelham, K., Palanswami, M., & Ngo, T. (2022). Real-time monitoring of construction sites: Sensors, methods, and applications. *Automation in Construction*, 136. <https://doi.org/10.1016/j.autcon.2021.104099>
- Li, Z., Zhu, Q., & Gold, C. (2005). *Digital Terrain Modeling: Principles and Methodology*. CRC Press. https://nguyenduyliemgis.wordpress.com/wp-content/uploads/2014/11/digital-terrain-modeling-principles-and-methodology_2005.pdf
- Mahboub, K.C., Goodrum, P.M., Glasgow, A., Enlow, J., Hendrix, N., and Uddin, M. (2008). QC/QC: Evaluation of effectiveness in Kentucky. Final Report No. KTC 08-19/SPR347-07-IF. Kentucky Transportation Center, University of Kentucky. https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1081&context=ktc_researchreports
- McCrea, A., Chamberlain, D., & Navon, R. (2002). Automated inspection and restoration of steel bridges – a critical review of methods and enabling technologies. *Automation in Construction*, 11(4): 351-373. [https://doi.org/10.1016/S0926-5805\(01\)00079-6](https://doi.org/10.1016/S0926-5805(01)00079-6)
- Mississippi Department of Transportation (2021). Risk-Based Inspection and Material Testing Guide: Local Public Agency Projects. Local Public Agency Division. September. <https://mdot.ms.gov/documents/LPA/Guides/Risk%20Based%20Inspection/Risk%20Based%20Inspection%20and%20Material%20Testing%20Guide.pdf>

- Minnesota Department of Transportation (2025). MnDOT Standard Specifications for Construction. St. Paul, MN. <https://www.dot.state.mn.us/pre-letting/spec/>
- Minnesota Department of Transportation (2008). Materials Laboratory Manual No. 5-695. Minnesota DOT Laboratory Manual, St. Paul, MN. <https://www.dot.state.mn.us/materials/labmanual.html>
- Mohamed, M., & Tran, D. (2022). Approach to Determination of Risk-Based Inspection Workload for Highway Construction Projects. Transportation Research Record, 2676(6): 1–12. <https://doi.org/10.1177/03611981211069958>
- Mohamed, M., & Tran, D. (2021). Risk-Based Inspection Model for Hot Mix Asphalt Pavement Construction Projects. ASCE Journal of Construction Engineering and Management, 147(6). [https://doi.org/10.1061/\(ASCE\)CO.1943-7862.0002053](https://doi.org/10.1061/(ASCE)CO.1943-7862.0002053)
- Mostafavi, A., & Abraham, D. (2012). INDOT Construction Inspection Priorities. Publication No. FHWA/IN/JTRP-2012/09. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, IN. <https://doi.org/10.5703/1288284314669>
- Mostafavi, A., Abraham, D., Noureldin, S., Pankow, G., Novak, J., Walker, R., Hall, K., George, B. (2013). Risk-Based Protocol for Inspection of Transportation Construction Projects Undertaken by State Departments of Transportation. ASCE Journal of Construction Engineering and Management, 139(8). [https://doi.org/10.1061/\(ASCE\)CO.1943-7862.0000664](https://doi.org/10.1061/(ASCE)CO.1943-7862.0000664)
- National Academies of Sciences, Engineering, and Medicine (2025). State DOT Certification Programs for Materials Sampling and Testing Personnel. NCHRP Synthesis 638. Washington, DC: The National Academies Press. <https://doi.org/10.17226/28849>
- National Academies of Sciences, Engineering, and Medicine (2023). Risk-Based Construction Inspection: A Guide. NCHRP Report 1039. Washington, DC: The National Academies Press. <https://doi.org/10.17226/27099>
- National Academies of Sciences, Engineering, and Medicine (2022). Highway Infrastructure Inspection Practices for the Digital Age. Washington, DC: The National Academies Press. <https://doi.org/10.17226/26592>
- National Academies of Sciences, Engineering, and Medicine (2020). Electronic Ticketing of Materials for Construction Management. NCHRP Synthesis 545. Washington, DC: The National Academies Press. <https://doi.org/10.17226/25839>
- National Academies of Sciences, Engineering, and Medicine (2019). Emerging Technologies for Construction Delivery. NCHRP Synthesis 534. Washington, DC: The National Academies Press. <https://doi.org/10.17226/25540>

- National Academies of Sciences, Engineering, and Medicine (2017). Guidelines for Optimizing the Risk and Cost of Materials QA Programs. NCHRP Research Report 838. Washington, DC: The National Academies Press. <https://doi.org/10.17226/23691>
- National Academies of Sciences, Engineering, and Medicine (2016a). Uses of Mobile Information Technology Devices in the Field for Design, Construction, and Asset Management. NCHRP Synthesis 491. Washington, DC: The National Academies Press. <https://doi.org/10.17226/23410>
- National Academies of Sciences, Engineering, and Medicine (2016b). Civil Integrated Management (CIM) for Departments of Transportation – Volume 1: Guidebook. NCHRP Report 831. Washington, DC: The National Academies Press. <https://doi.org/10.17226/23690>
- National Academies of Sciences, Engineering, and Medicine (2014). Proposed Guidelines for Reliability-Based Bridge Inspection Practices. NCHRP Report 782. Washington, DC: The National Academies Press. <https://doi.org/10.17226/22277>
- National Academies of Sciences, Engineering, and Medicine (2013). Guidelines for the Use of Mobile LiDAR in Transportation Applications. NCHRP Report 748. Washington, DC: The National Academies Press. https://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_748.pdf
- National Academies of Sciences, Engineering, and Medicine (2007). Emerging Technologies for Construction Delivery. NCHRP Synthesis 372. Washington, DC: The National Academies Press. <https://doi.org/10.17226/23126>
- North Dakota Department of Transportation (2007). Training Manual for Robotic and Conventional Total Stations. <https://www.dot.nd.gov/manuals/design/surveymanual/total-station.pdf>
- O'Brien, J.J. (2012). Construction Inspection Handbook: Quality Assurance/Quality Control, Springer Science & Business Media.
- Ohio DOT (2023). State of Ohio Department of Transportation Construction & Material Specifications. <https://www.dot.state.oh.us/Divisions/ConstructionMgt/OnlineDocs/Pages/2023-Online-Spec-Book.aspx>
- Ohio DOT (2025). Construction Administration Manual of Procedures. <https://www.dot.state.oh.us/Divisions/ConstructionMgt/OnlineDocs/Pages/2025-MOP.aspx>
- Parker, M., Merkel, H., and Armstrong, M. (2014). Improving Performance with the Robotic Total Station. Nabholz Construction. <https://nabholz.com/blog/improving-performance-with-the-robotic-total-station/>

- Rush, S. (2021). Risk-Based Construction Inspection. MSc. Thesis. University of Kentucky. https://uknowledge.uky.edu/ce_etds/106
- Schneider, C. (2013). 3D, 4D, and 5D Engineered Models for Construction. Executive Summary, Report No. FHWA-HIF-13-048, Federal Highway Administration Tech Brief. <https://www.fhwa.dot.gov/construction/pubs/hif13048.pdf>
- Shi, L., & Hou, X. (2017). Research on the application of remote video monitoring system in construction site management. *Advances in Social Science, Education, and Humanistic Research*, 120.
- Shuai, J., Han, K., Xu, X. (2012). Risk-based inspection for large-scale crude oil tanks, *Journal of Loss Prevention in the Process Industries*, 25(1): 166–175. <https://doi.org/10.1016/j.jlp.2011.08.004>
- Soares, W.A., Vasconcelos, V., and Rabello, E.G. (2015). Risk-based inspection in the context of nuclear power plants. 2015 International Nuclear Atlantic Conference, Sao Paulo, Brazil, October 4-9. <https://doi.org/10.13140/RG.2.1.1750.3128>
- South Carolina DOT (2023). SCDOT Quality Acceptance Sampling & Testing Guide. Amendment to Figure 106B & 106C of the SCDOT Construction Manual. <https://www.scdot.org/content/dam/scdot-legacy/business/pdf/materials-research/QAST.pdf>
- South Carolina DOT (2021). SCDOT Construction Manual. <https://www.scdot.org/business/scdot-construction-manual.html>
- South Carolina DOT (2004). Construction Manual. <https://www.scdot.org/content/dam/scdot-legacy/business/pdf/constructionmanual/CompleteManual.pdf>
- South Dakota DOT (2025a). Standard Specifications for Roads and Bridges. <https://dot.sd.gov/media/035a1wt1/2025-sddot-specbook-final.pdf>
- South Dakota DOT (2025b). Materials Testing and Inspection Certification Program Manual. <https://dot.sd.gov/media/bqzntdtm/certification-program-manual-field-06-2025.pdf>
- South Dakota DOT (2024). Materials Manual. Division of Planning /Engineering, Office of Materials and Surfacing, August. <https://dot.sd.gov/media/23qptrdf/2024-sddot-materials-manual.pdf>
- Snow, M., White, G., Katara, S., Willoughby, K., & Garcia, R. (2013). Project Inspection Using Mobile Technology – Phase I: An investigation into existing business processes and areas for improvement using mobile technology. Washington State Department of Transportation, Research Report WA-RD 840.1, Office of Research & Library Services. <https://www.wsdot.wa.gov/research/reports/fullreports/840.1.pdf>

- Tatum, M. & Liu, J. (2017). Unmanned Aircraft System Applications in Construction. *Procedia Engineering*, 196: 167–175. <https://doi.org/10.1016/j.proeng.2017.07.187>
- Taylor, T., Rush, S., Waddle, S., Nassereddine, H., Griffith, R., and Hatoum, M.B. (2021). Risk-Based Construction Inspection. KTC-21-19/SPR19-569-1F. Kentucky Transportation Center Research Report 1802. Kentucky Transportation Cabinet. https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=2811&context=ktc_researchreports
- Texas DOT (2025). Material Inspection Guide. Materials and Tests Division, Texas Department of Transportation. September. <https://ftp.txdot.gov/pub/txdot/mtd/mig.pdf>
- Texas DOT (2024). Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges. <https://www.txdot.gov/content/dam/docs/specifications/2024/spec-book-0924.pdf>
- Texas DOT (2022). Quality Assurance Program for Design-Bid-Build Projects. Texas Department of Transportation Materials and Test Division. January. https://ftp.txdot.gov/pub/txdot/mtd/qap_dbb.pdf
- Texas DOT (2017). Quality Assurance Program for CDA / Design-Build Projects with a Capital Maintenance Agreement with Three Optional 5-Year Terms. https://ftp.txdot.gov/pub/txdot-info/cst/qap_db.pdf
- Tran, D. & Mohamed, M. (2021). Development of Risk-Based Protocol for KDOT Construction Inspection. Report No. K-TRAN: KU-19-3. Kansas Department of Transportation.
- Virginia DOT (2024). Materials Manual of Instruction. <https://www.vdot.virginia.gov/doing-business/technical-guidance-and-support/technical-guidance-documents/materials-manual-of-instructions/#d.en.49524>
- Virginia DOT (2020). Road and Bridge Specifications. https://www.vdot.virginia.gov/media/vdotvirginiagov/doing-business/technical-guidance-and-support/technical-guidance-documents/construction/VDOT_2020_RB_Specs_acc071522.pdf
- Virginia DOT (2018a). Inspection Manual. Construction Division, VDOT Governance Document. March. https://www.virginiadot.org/business/resources/const/Inspection_Manual_acc091322.pdf
- Virginia DOT (2018b). Minimum Requirements for Quality Assurance and Quality Control on Design Build and Public-Private Transportation Act Projects. https://www.vdot.virginia.gov/media/vdotvirginiagov/doing-business/technical-guidance-and-support/technical-guidance-documents/alternative-project-delivery/2018_DB-PPTA_QAQC_Guide_Final_Clean_Copy_acc06062023_PM.pdf

- Vonderohe, A. (2009). Status and Plans for Implementing 3D Technologies for Design and Construction in the Wisconsin Department of Transportation. WisDOT Project ID: 0657-45-11, Construction and Materials Support Center, University of Wisconsin – Madison, Department of Civil and Environmental Engineering.
https://rosap.ntl.bts.gov/view/dot/48825/dot_48825_DS1.pdf
- Wang, X., Al-Shabbani, Z., Sturgill, R., Kirk, A., & Dadi, G. (2017). Estimating Earthwork Volumes Through Use of Unmanned Aerial Systems. Transportation Research Record, 2630(1): 1-8. <https://doi.org/10.3141/2630-01>
- Washington State DOT (2026). Standard Specifications: For Road, Bridge, and Municipal Construction. M 41-10. <https://www.wsdot.wa.gov/publications/manuals/fulltext/M41-10/SS.pdf>
- Washington State DOT (2025a). Construction Manual. M 41-01.47, Multimodal Development and Delivery (M2D2), State Construction Office.
<https://www.wsdot.wa.gov/publications/manuals/fulltext/M41-01/Construction.pdf>
- Washington State DOT (2025b). Materials Manual. M 46-01.47. Engineering and Regional Operations, State Materials Laboratory.
<https://www.wsdot.wa.gov/publications/manuals/fulltext/M46-01/Materials.pdf>
- Wight, R., Alvarado, A., Chaput, M., Clayton, D., Garcia, R. R., Hoyne, D., Lewis, J., Lutz, R. A., and Smith, R. (2017). Developing and Maintaining Construction Inspection Competence. Scan 15-01 Report prepared as part of NCHRP Project 20-68A.
https://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-68A_15-01.pdf
- Wisconsin Department of Transportation (2018). Construction Critical Inspection Manual.
<https://wisconsindot.gov/Documents/doing-bus/eng-consultants/cnslt-rsrcs/con-inspect.pdf>
- Xia, T. & Huston, D. (2016). High Speed Ground-Penetrating Radar for Road Pavement and Bridge Structural Inspection and Maintenance. Project No. SPR-RSCH017-738. University of Vermont Transportation Research Center. <https://scholarworks.uvm.edu/trc/40>
- Xu, X., Jeon, J., Zhang, Y., Yang, L., and Cai, H. (2021). Automatic Generation of Customized Checklists for Digital Construction Inspection. Transportation Research Record, 2675(5): 418-435. <https://doi.org/10.1177/0361198121995825>
- Xu, X., Zhang, Y., Yuan, C., Cai, H., Abraham, D.M., & Bowman, M.D. (2019). Risk-Based Construction Inspection, Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2019/06. West Lafayette, IN. Purdue University.
<https://doi.org/10.5703/1288284316916>

- Yamaura, J. and Muench, S.T. (2018). Assessing the impacts of mobile technology on public transportation project inspection. *Automation in Construction*, 96, 55-64.
<https://doi.org/10.1016/j.autcon.2018.08.021>
- Yamaura, J., White, G., Katara, S., Willoughby, K., Garcia, R., & Beer, M. (2015). Project Inspection Using Mobile Technology – Phase II: Assessing the Impacts of Mobile Technology on Project Inspection. Washington State DOT Research Report WA-RD 840.2, Office of Research & Library Services.
<https://www.wsdot.wa.gov/research/reports/fullreports/840.2.pdf>
- Yuan, C.; Park, J., Xu, X., Cai, H., Abraham, D.M., & Bowman, M.D. (2018). Risk-Based Prioritization of Construction Inspection. *Transportation Research Record*, 2672(26), 96–105. <https://doi.org/10.1177/0361198118782025>

8.0 Appendix A: Annotated Bibliography

Arambula, E., and Gharaibeh, N. (2014). Methods for accumulating construction and material quality test results and their effect on acceptance decisions. ASCE Journal of Construction Engineering and Management, 140(8).

This paper compares contractor and agency test results for highway construction projects in Kansas. The study adopted two sampling methods to apply to actual KDOT projects. The first one is continuous-cumulative sampling, and the other is chain lot sampling. These results are compared using the F-test and t-test approaches. The F-test was used to assess the variance between the contractor and KDOT data sets, while the t-test was used to compare the averages of each party under the null hypothesis. The results of applying these tests on HMA showed high correlation coefficients when the tests showed similar results.

Arizona Department of Transportation. (2005). Construction Manual: Chapter 10 – Materials

Chapter 10 of the ADOT construction manual describes the material QC process within the department, in which two logging systems exist (manual logs and computer material logs). Specific steps have to be considered in every system. Additionally, the specifications determine two types of material resources: Department-furnished and contractor-furnished. All materials have to be analyzed for environmental compliance. ADOT has a list of material sources that are environmentally approved. The contractor must submit an environmental analysis for the contractor-furnished materials, either using the department's list or providing one in accordance with 104.12 requirements. Usually, material sources are the contractor's responsibility, but the DOT engineer must watch closely to ensure the desired final quality.

Cai, H., Zhang, Y., Jeon, J., Yang, L. (2022). Risk-based Inspection. South Carolina Department of Transportation.

The main deliverables of this research project were the digital risk-based inspection system and the inspection summary document. When implemented, these deliverables are expected to greatly reduce the workload of construction inspectors, allocate limited resources to the most critical construction activities that carry high risk, ensure consistency in the QA/QC process, and support documentation of construction inspections. Inspectors can use the digital system as a single-stop, central location to retrieve applicable quality requirements for the pay items under inspection. The system generates easy-to-use checklists to guide field inspectors. There is no longer a need to manually review lengthy construction documents to retrieve necessary information and quality requirements. As such, the digital inspection system can improve construction inspection efficiency by at least 25% and could reduce SCDOT's risk of accepting or overpaying for low-quality construction.

California Department of Transportation. (2017). Construction Manual MCT 17-1.

Chapter 6 of the Caltrans Construction Manual illustrates the classification of materials, sampling and testing, acceptance procedures, and requirements followed in Caltrans highway construction projects. Section 6-102 classifies the different types of sampling and testing into six groups, including the following:

1. Preliminary samples and tests are made before the award of a contract.
2. Initial samples and tests are performed on materials proposed for use in the project.
3. Acceptance samples and tests are generally performed on materials that will be incorporated into the work.
4. Dispute resolution samples to address the resolution of discrepancies occurring between the verification sampling and testing, and the QC sampling and testing.
5. Investigate samples and tests when material issues arise.
6. Research samples and tests for research and testing purposes

California Department of Transportation. (2015). Construction Quality Assurance Manual.

As stated in this manual, the main role of the QA program at Caltrans is to provide confidence that the quality of materials and workmanship on highway projects complies with the project plans and specifications. The manual covers design–bid–build and construction manager/general contractor delivery systems. However, it does not cover public–private partnerships or design–build delivery systems.

California Department of Transportation. (2013). Design–Build Demonstration Program: Quality Manual Outline

This manual describes the Department’s requirements for the QMP. The QMP is developed by the design-builder and approved by Caltrans. The Designer–Builder is primarily responsible for the overall quality, QC, and validation of each construction element of the project. These responsibilities include construction activities performed by a subcontractor, supplier, fabricator, or any other entity with contractual obligations to complete the design or construction elements of the highway project.

California Department of Transportation. (2012). Project Risk Management Handbook: A Scalable Approach. Version 1. Risk Management Task Group.

This handbook is the Caltrans guide to risk and risk management. It describes the basic concepts and processes that guide risk management planning and implementation during project development.

Chapman, R.J. (1998). The effectiveness of working group risk identification and assessment techniques. International Journal of Project Management. 1;16(6):333-43.

This paper compares the effectiveness of three risk identification techniques used in the construction industry, which are:

- brainstorming,
- nominal group technique, and
- The Delphi technique.

The strengths and weaknesses of all three methods are considered, and summaries of the elements needed to make each technique effective are provided.

Colorado Department of Transportation. (2013). Quality Assurance Procedures for Construction and Material Sampling and Testing.

This QA procedures document describes the requirements of 23 CFR 637 for construction QA.

Colorado Department of Transportation. (2013). Frequency Guide Schedule for Minimum Materials Sampling, Testing, and Inspection.

This guide provides information on materials sampling and testing, with detailed requirements for tiers based on material types. The guide also outlines the guidelines for reducing test frequency.

Federal Highway Administration (2013). Performance Specifications for Rapid Highway Renewal (R07). Second Strategic Highway Research Program (SHRP2).

This SHRP 2 research project addressed the importance of identifying and assessing risks related to QA, particularly for material and product measurement and testing, as well as for other acceptance methods, including certification and field inspection observations. The report identified gaps related to measurement and testing technology, such as the accuracy and reliability of current measurement and testing technologies, which can limit the extent to which measured values reflect quality or performance. A related risk is that, while measurements may be objective, sampling may be inconsistent or insufficiently representative of actual conditions. Another identified risk is making an incorrect acceptance decision or assigning the wrong pay adjustment. These are often referred to as the seller's risk, defined as the risk to the contractor of having acceptable material or workmanship rejected, and the buyer's risk, defined as the risk to the agency of accepting material or workmanship at an unacceptable quality level.

Federal Highway Administration (2012). Construction Quality Assurance for Design–Build Highway Projects, Publication FHWA-HRT- 12-039.

This FHWA Tech Brief addresses the requirements of 23 CFR Part 637 in the context of Design–Build, which shifts material QA roles and responsibilities to the industry. The purpose of the FHWA Tech Brief was to clarify these roles and responsibilities for DB projects. Given the trend among DOTs toward using contractor QC data in acceptance decisions for material types and projects.

Federal Highway Administration (2011). 23 CFR Ch. I. Subpart B—Quality Assurance Procedures for Construction.

This document describes procedures and guidelines to ensure the quality of materials and construction for all federal-aid highway projects in the National Highway System. It goes through the acceptance and IA programs, samples, laboratories, QA, and verification sampling and testing. The policies, programs, and laboratories for QA are described in general terms. The federal regulations 23 CFR 637, Subpart B—Quality Assurance Procedures for Construction, further require a comprehensive construction QA program to consist of the following six core elements: QC, acceptance, IA, dispute resolution, personnel qualification, and laboratory accreditation/qualification.

Federal Highway Administration (2011). Federal regulations 23 CFR 637, subpart B, Construction Inspection, and Approval.

The FHWA issued the CFR, including policies, procedures, and guidelines to ensure material quality and workmanship in all federal-aid highway construction projects. The CFR referred to that the state DOT, through the quality acceptance program, should conduct the following: A) frequency guide schedules to verify the sampling and testing, which will give general guidance, B) identifying the locations of the construction operation where the verification sampling and testing are needed, and C) identifying the attributes to be inspected to confirm the required quality of the finished product.

Federal Highway Administration. (2007). Quality Assurance in Materials and Construction.

According to the FHWA national program evaluation report and various QA stewardship reviews, over 34 DOTs use contractor QC test results in acceptance decisions. Still, many of these DOTs lack the proper systems to verify contractor test data. Without these controls, the risks of accepting nonconforming materials are higher. The FHWA report recommends developing risk-based evaluation tools to assess appropriate testing frequencies and risks for various materials. The report also noted that the 23 CFR 637 needed to be updated to address alternative delivery methods, to formally address construction inspection and

processes for acceptance of manufactured materials, and to be more applicable to all federal aid projects regardless of system, class, or type.

Goulias, D., and Karimi, S. (2013). Material Quality Assurance Risk Assessment. State Highway Administration, Research Report, Maryland Department of Transportation, and University of Maryland.

This materials QA research report addresses risks related to materials QA and provides good examples of current QA processes used by MDSHA for aggregate, precast concrete, structural steel, rebar, coatings, and neoprene strip seal, and how these processes could be improved. One recommended approach is to use a statistical PWLs approach for a graded aggregate base to balance payment risks. The report also addresses bringing manufactured products more into conformance with 23 CFR 637 requirements.

Illinois Department of Transportation. (2024). Project Procedures Guide: Sampling Frequencies for Materials Testing and Inspection. Central Bureau of Materials.

The Project Procedures Guide (PPG) describes the range of materials acceptance in Section 200. The document addresses QC/QA programs for asphalt binder, emulsified asphalt, PCC, precast concrete, and reinforcement bars/fabric, and provides detailed information through a web-based system. Manufacturer certifications are also used to accept certain materials and products, and visual inspection is required on the project site when possible. Visual inspection is acceptable when sampling is impractical, destructive, or involves small quantities.

Illinois Department of Transportation. (2008). Minimum Requirements for Construction Materials Testing Laboratories—Department-Operated Laboratories. Bureau of Materials & Physical Research Policy Memorandum.

This memorandum establishes the minimum qualifications for materials testing laboratories operated by the Illinois DOT. It applies to soils, aggregates, HMA, and PCC laboratories operated by the DOT.

Mississippi Department of Transportation. (2019). Construction Engineering, Inspection, and Testing requirements for Local Public Agency Projects.

This manual details the QA inspection process for locally administered federal aid projects. A risk-based optimization system for inspection, material sampling, and testing is presented with implementation recommendations. The recommendations are based on project type and scope of work. The project type lies in two categories based on risk level: high or low. Inspections are divided into three levels: full-time, part-time, and intermittent.

Mostafavi, A., and Abraham, D. M. (2012). INDOT Construction Inspection Priorities. FHWA/IN/JTRP- 2012/09, Joint Transportation Research Program, Indiana Department of Transportation and Purdue University.

This report developed an inspection and testing protocol, including a table summarizing inspection activities and their priority levels. The priority rating weight for an individual inspection activity is the probability of occurrence multiplied by a safety effect. The report states that the on-site sequence of work progress impacts the staffing resources needed to perform an inspection.

National Academies of Sciences, Engineering, and Medicine (2023). NCHRP Report 1039: Risk-Based Construction Inspection: A Guide.

This guide has been prepared under NCHRP Project 10-102, “A Guidebook for Risk-Based Construction Inspection,” to help agencies identify opportunities for optimization. The guide addresses the range of current and evolving practices in today’s inspection programs, considering current national standards for highway construction inspection, and provides practical strategies for immediately implementing a risk-based construction inspection program. This document aims to provide a flexible methodology for risk-based inspection that can be applied at the programmatic level to a standard construction inspection program or at the project level to prioritize highway construction inspection activities and optimize the resources applied to a given project.

National Academies of Sciences, Engineering, and Medicine (2017): NCHRP Scan 15-01: Developing and Maintaining Construction Inspection Competence.

This scan research publication investigated what DOTs are doing to develop and maintain a skilled construction inspector workforce amid an aging workforce, changing missions and business practices, shifting priorities, and shrinking budgets. The publication focused on the aspects of knowledge management methods, understanding the role of training programs, certifications related to construction inspection, incorporating new technologies, what state DOTs are doing to recruit construction inspectors and the skills they look for, details about consultant engineering services, and what agencies are doing internally to develop construction inspector roles and responsibilities.

National Academies of Sciences, Engineering, and Medicine (2008). NCHRP Synthesis 376: Quality Assurance in Design–Build (DB) Projects.

This synthesis provides an overview of the QA state of practice across different DOTs. It emphasizes the responsibilities of the DOT and the contractor in different delivery methods. DBB QA programs are compared to the different types of DB QA programs.

New Hampshire Department of Transportation. (2010). Standard Specifications for Road and Bridge Construction.

Section 700 of the Standard Specifications describes the range of acceptance methods that, in addition to sampling and testing, address Certificates of Compliance and a QPL. A definition of small projects is provided, with sampling and testing requirements modified accordingly. Details for the testing frequencies of a wide range of materials are described in Section 703.3.

Oechler, E., Molenaar, K.R., Hallowell, M., and Scott, S. (2018). State of practice for risk-based quality assurance in state departments of transportation. Engineering, Construction and Architectural Management, 25(7), pp.958-970.

This paper examined the approaches state DOTs use to optimize QA and identified the impact of project-specific factors. The findings of the paper point out that approaches to QA management are very diverse. These approaches can be classified into different levels, from visual inspection of materials to DOT-managed sampling and testing requirements. Factors such as project size, location, and complexity strongly influence the selection of a QA approach. DOT demographics and project delivery methods are less significant.

Selvik, J.T., Scarf, P., and Aven, T. (2011). An extended methodology for risk-based inspection planning. Reliability, Theory & Applications. Volume 2.

This paper discusses inspection planning activities in the process industry that use risk-based inspection. The inspection process focuses on examining mechanical equipment in piping networks. The inspection prioritization is based on the risk expressed as expected values (EV), the product of the likelihood and impact of failure. The authors suggest expanding the risk beyond expected values. The probability is replaced with uncertainty in the definition of risk.

Schuyler, J. (2001). Risk and Decision Analysis in Projects, 2nd edition. Project Management Institute, Newton Square, PA.

This book provides information on numerous topics within risk and decision analysis. Some topics include multi-criteria decision-making, decision trees, Monte Carlo analysis, and sensitivity analysis. The book provides conceptual and practical frameworks for using these techniques and methods.

Texas Department of Transportation (2010). Guide to Schedule of Sampling and Testing.

This guide illustrates that the Department's and the Contractor's risk of either rejecting "good" material or accepting "bad" material ranges from 20% to 40%. To reduce this risk, the guide recommends increasing the sampling rate during initial production, for high-variability

materials, and when tests do not meet specifications. A fourfold increase in testing frequency will generally reduce risk to approximately 5%.

Texas Department of Transportation (2011). Design–Build Quality Assurance Program Implementation Guide.

This guide provides a programmatic approach to QA for DB projects where the developer's test results are used in the acceptance decision, regardless of how the project is funded. The guide is designed to provide TxDOT personnel and consultants with the procedures to implement a QA program for DB projects.

Texas Department of Transportation (2011). Quality Assurance Program for Design–Build Projects with an Optional 15-Year Capital Maintenance Agreement.

This report is a guide for projects where contractor test results can be part of the acceptance decision. TxDOT developed two types of acceptance procedures for DB projects with optional maintenance agreements. The first type uses TxDOT-performed acceptance testing and inspection, where only TxDOT testing and inspection results are used in the acceptance decision. The second type of acceptance is contractor-performed, in which the contractor's or developer's construction QA firm performs frontline acceptance testing and inspection. Under this approach, the contractor must submit a CQMP (Construction QMP). Under contractor-performed acceptance, statistically-based QA and owner verification tests serve as the basis for acceptance, with an IA program and periodic TxDOT-independent audits of the contractor CQMP.

Transportation Research Board (2005). Glossary of High-Quality Assurance Terms. Third Edition. Transportation Research Circular Number E-C074.

The circular provides a reference to common highway QA terminology. It lists abbreviations, symbols, and references as a glossary for frequently misinterpreted, misunderstood, or generally confusing terms. It also provides some diagrams to exemplify QA system elements or to detail accountability for quality, sampling, or performance.

Transportation Research Board (2013). Glossary of Quality Assurance Terms. Sixth Edition. Transportation Research Circular Number E-C173.

The circular provides a reference to common highway QA terminology. It lists abbreviations, symbols, and references as a glossary for frequently misinterpreted, misunderstood, or generally confusing terms. It also provides diagrams to exemplify QA system elements or to detail accountability for quality, sampling, or performance.

Virginia Department of Transportation (June 2011). Materials Manual: Chapter II—Methods and Frequencies of Sampling.

This manual specifies the minimum requirements for QA sampling and testing. In Chapter II, the specification limits, frequencies, and sample sizes are provided and depend on the material type and its use.

Ward, S. C., Chapman, C. B., and Curtis, B. (1991). On the allocation of risk in construction projects. International Journal of Project Management, 9(3): 140–147.

According to this paper, an organization's willingness to take on risk in a construction project depends on its ability to charge a premium for it. The paper outlines some implications of risk allocation and presents four response options for a party bearing a risk. The authors argued that appropriate risk allocation leads to better project risk management and more successful projects.

Washington State Department of Transportation (2018). Construction Manual.

This manual addresses construction activity inspections, including detailed performance measures. In addition, this manual describes the documentation and payment process for roadway projects in WSDOT. Chapter 9 covers the quality and evaluation of materials for acceptance through various methods, including testing samples, visual inspection, and certification of compliance. The manual states: "Types of acceptance methods are sampling and testing, WSDOT fabrication inspection, manufacturer certificates of compliance, miscellaneous certificates of compliance, shop drawings, catalog cuts, optional approval/acceptance for materials, visual acceptance, or reduced acceptance criteria. Sampling and testing are the most widely accepted methods for demonstrating conformance to the requirements. All designated acceptance documentation is to be approved and retained before the material is placed, except for verification samples and manufacturer certificates of compliance within the restraints of WSDOT Standard Specifications."

Washington State Department of Transportation (2013). Project Inspection Using Mobile Technology-Phase I. REPORT NO. WA-RD 840.1

For Phase I, this report identified opportunities for process improvement using mobile technologies and measured the outcomes of incorporating mobile tools in project inspection work.

Washington State Department of Transportation (2015). Project Inspection Using Mobile Technology-Phase II. REPORT NO. WA-RD 840.2

In Phase II, additional characteristics were observed to evaluate other aspects of using mobile tools for project inspection. These characteristics focus on how an agency may deploy

mobile technology. A pilot program was included in this phase, in which a mobile technology solution was used in field trials to measure outcomes.

Washington State Department of Transportation (2025). Materials Manual. M46-01.47.

A comprehensive manual that establishes the test and acceptance procedures for all highway construction materials. It divides the materials in the table of contents by aggregate, HMA, PCC, chemical, electrical, traffic, geotechnical-soils, geotextile and steel, paint, pavement soils, and standard practices.

Wideman, R. M. (1992). Project and Program Risk Management: A Guide to Managing Project Risk and Opportunities. PMI, Newton Square, PA.

This handbook is published as part of the Project Management Body of Knowledge. It provides an understanding of the nature of risk and methods for reducing a project's risk exposure. The handbook includes tools and techniques for risk identification, assessment, contingency management, and mitigation.

Wisconsin Department of Transportation (2013). Construction and Materials Manual. Chapter 8: Materials Testing, Sampling, and Acceptance.

This manual includes the materials approval procedures, quality management program, IA program, quality verification, and QA/QC for materials. It describes price reductions due to nonconforming materials. Chapter 8 includes documentation requirements for different types of acceptance and differentiates between approved materials (For example, from an approved source or supplier) and acceptance of materials through inspection or testing when incorporated into the project. The Wisconsin DOT includes the full range of acceptance levels and types for different materials incorporated into projects. Different sampling, testing, and inspection frequencies and scopes are used as needed to ensure adequate QC and compliance with specifications. The manual also lists low-risk or noncritical materials that may be accepted through visual inspection and do not require documentation.

Wisconsin Department of Transportation (2017). Construction Critical Inspection.

The objective of this manual is to guide construction critical inspections throughout the life of a construction project. The Inspection Level, Priority, Inspector Experience, Inspection Objective, and Activities before/during work are listed for each construction operation and are reflective of the typical size or complexity of a construction project.

Wyoming Department of Transportation (2012). Materials Testing Manual.

This manual ensures that materials meet applicable WYDOT acceptance requirements. Forms exist for construction testing and certification requirements. Sampling and testing frequencies are identified in Form T-128, and manufactured products accepted by

certification use Forms T-168 and T-131. Verification of acceptance for certain materials and manufactured products may also use Form T-132. Qualified suppliers for certain materials are also identified and listed on the WYDOT website.

Appendix B: Interview Questions for SDDOT Personnel

Section 1: Construction Material Testing and Inspection at SDDOT

1. What do field personnel do, and how much time is typically needed for material testing and inspection activities (For example, materials testing and quality inspection, measurement of quantities, maintenance of traffic, environmental compliance, labor compliance)?
2. What tracking or information systems does SDDOT use for statewide materials management and inspection processes? (For example, AASHTOWare – SiteManager, spreadsheets, ledgers, or databases)
3. Does SDDOT have internal training and advancement programs for construction material inspection and testing staff? If yes, please describe the format, frequency, and topics covered.
4. How does SDDOT evaluate data from Quality Control (QC), Quality Assurance (QA), verification, and other types of inspections and test results?
5. Most of the DOT research and risk programs are related to materials testing, not inspections of field operations. Are there statistical data sampling and probabilistic procedures for field inspections? Should the focus of the guide to be developed in this research be more on material acceptance vs field inspection?
6. Do field personnel use technology tools (For example, drones, laser scanners, smart sensors, cameras) for inspection data or information collection? If yes, which tools are in use, and for which activities?

Section 2: Risk-Based Construction Material Testing and Inspection

A risk assessment was conducted to review the SDDOT minimum sample and test requirements (MSTR) material testing activities. The MSTR Material Testing List is provided in [Appendix E: Material Testing Activities Compiled from SDDOT Materials Manual – MSTR Information](#). The list contains information on the impact of a failed test on cost, safety, and service interruption for field material testing activities. Please refer to this list to discuss Question 7.

7. The following SDDOT MSTR material testing categories are grouped into four risk zones: critical, high, moderate, and low, with the major consequences in cost, safety, and service interruption. Please describe the impact of failure/nonconformance related to cost, safety, and service interruption that you have observed for these activities.

Category	Risk Zone	Major Impact
Asphalt Construction	Moderate	Cost

Category	Risk Zone	Major Impact
Subbase, Base Course, and Cushion Construction	Moderate	Cost
Miscellaneous Granular Materials	Moderate	Cost
Subgrade Construction (Embankments)	Moderate	Cost
Portland Cement Concrete Paving Construction	Low to Moderate	Cost, service interruption
Portland Cement Concrete Structure Construction	Moderate	Cost, service interruption
Portland Cement Concrete Miscellaneous Construction – Class M	Low	Cost
Roadway Lighting and Traffic Control	Low	Cost
Miscellaneous Incidental and Manufactured or Fabricated Items	Low to Moderate	Cost, safety, service interruption
Pavement Restoration	Low to Moderate	Cost
Bridge Deck Restoration	Low	Cost

A risk assessment was conducted to create a core list of SDDOT construction inspection activities, which is provided in [Appendix G: Construction Inspection Activities Compiled from SDDOT Manuals](#). The list contains information on the impact of failed or non-conformance inspections on cost, safety, and service interruption for construction inspection activities. Please refer to this list to discuss Question 8.

8. The following SDDOT construction inspection divisions are grouped into four risk zones: critical, high, moderate, and low, with the major consequences in cost, safety, and service interruption. Please describe the impact of failure/nonconformance related to cost, safety, and service interruption that you have observed for these activities.

Division	Risk Zone	Major Impact
Earthwork	Low to Moderate	Cost
Granular Bases and Surfacing	Low to Moderate	Cost
Asphalt Construction	Low to Moderate	Cost
Rigid Pavement	Low to Moderate	Cost
Structures	Low to High	Cost, safety, service interruption
Incidental Construction	Low to High	Safety, service interruption

9. What checkpoints and hold points are built into SDDOT's construction inspection workflow, and how do you verify compliance at each?
10. When construction inspections uncover issues, what criteria determine whether immediate corrective action is required versus continued monitoring?
11. Have you worked on projects where the inspection frequency was adjusted based on project risk factors (For example, new techniques, weather impacts, or past performance)? How did you adapt your inspection efforts accordingly?

12. How do you incorporate risk assessment into your inspection planning? For example, do you allocate more inspection effort to complex or high-impact elements (Structures and Incidental Construction) versus lower-risk tasks?

Section 3: Expectations & Feedback

13. What is your expectation of a risk-based inspection and testing guide or tool for SDDOT construction projects?
14. Are there any additional comments or recommendations for improving risk-based construction inspection and materials testing practices?

Appendix C: Interview Questions for Contractors and Consultants

Section 1: Compliance with SDDOT Standards and Contract Specifications

1. What are the primary quality-control/inspection tasks your field crews perform on SDDOT projects (For example, in-place density testing, form and reinforcement checks, slump tests)?
2. How do you ensure all materials and workmanship comply with SDDOT and contract standards (For example, materials, mix designs, tolerances)? How do you ensure data completeness and timeliness?
3. How do you incorporate contract requirements (For example, standard details, notes, special provisions) into daily inspection/quality control practices?
4. What records (certificates, test reports, required forms) do you maintain to demonstrate adherence to SDDOT standards and specifications?
5. Do you employ advanced tools (For example, GPS-enabled devices, drones, non-destructive testing devices) for field inspection/quality control? If so, for which tasks? What are the main challenges you have encountered when integrating technologies for quality control?

Section 2: Risk-Based Construction Inspection

A risk assessment was conducted to create a core list of SDDOT construction inspection activities, which is provided in [Appendix G: Construction Inspection Activities Compiled from SDDOT Manuals](#). The list contains information on the impact of failed or non-conformance inspections on cost, safety, and service interruption for construction inspection activities. Please refer to this list to discuss Question 6.

6. The following SDDOT construction inspection divisions are grouped into four risk zones: critical, high, moderate, and low, along with the major impact. Please comment on the impact of failure/nonconformance related to cost, safety, and service interruption that you have observed for these inspection divisions.

Division	Risk Zone	Major Impact
Earthwork	Low to Moderate	Cost
Granular Bases and Surfacing	Low to Moderate	Cost
Asphalt Construction	Low to Moderate	Cost
Rigid Pavement	Low to Moderate	Cost
Structures	Low to High	Cost, safety, service interruption
Incidental Construction	Low to High	Safety, service interruption

7. When a test result falls below specification, what immediate steps do field crews take?
8. What is your internal approval process for accepting or rejecting non-conforming materials, including any thresholds for escalation to senior management at your company or SDDOT personnel?
9. Have you or your company worked on SDDOT projects where the inspection frequency was adjusted based on project risk factors (For example, new techniques, weather impacts, past performance)? How did you adapt your quality control efforts?
10. How do you document and report identified risks or unusual conditions to SDDOT field personnel so that inspection oversight can be aligned with those priorities?
11. How would you and your company support a risk-based field inspection and material testing approach while still ensuring overall quality?

Section 3: Expectations & Feedback

12. What are your recommendations for streamlining joint SDDOT-Contractor inspection/Quality Control processes and reducing duplication?
13. Do you have any additional comments on improving risk-based practices in field inspection and material testing operations?

Appendix D: Interview Questions for Material Suppliers

Section 1: Compliance with SDDOT Standards

1. Do you have a formal quality control plan for your material production? What are your inspection checkpoints during material production?
2. How often are internal audits or third-party verifications conducted?
3. Which digital platforms or records systems do you use to log batch test results, material certificates, and shipment inspections?
4. How do you ensure traceability from plant to project site?
5. What training programs do you have in place for lab technicians and Quality Assurance (QA) managers to maintain compliance with SDDOT specifications?
6. How do you track certification renewals and skill development for material testers?

Section 2: Risk-Based Construction Material Testing and Notification

A risk assessment was conducted to review the SDDOT minimum sample and test requirements (MSTR) material testing activities. The MSTR Material Testing List is provided in [Appendix F: Material Testing Activities Compiled from SDDOT Materials Manual – MSTR Information](#). The list contains information on the impact of a failed test on cost, safety, and service interruption for field material testing activities. Please refer to this list to discuss Question 7.

7. The following SDDOT MSTR material testing categories are grouped into four risk zones: critical, high, moderate, and low, along with the major impacts in terms of cost, safety, and service interruption. Please describe the impact of failure/nonconformance related to cost, safety, and service interruption that you have observed for material testing in each of the categories listed.

Category	Risk zone	Major impact
Asphalt Construction	Moderate	Cost
Subbase, Base Course, and Cushion Construction	Moderate	Cost
Miscellaneous Granular Materials	Moderate	Cost
Subgrade Construction (Embankments)	Moderate	Cost
Portland Cement Concrete Paving Construction	Low to Moderate	Cost, service interruption
Portland Cement Concrete Structure Construction	Moderate	Cost, service interruption
Portland Cement Concrete Miscellaneous Construction – Class M	Low	Cost
Roadway Lighting and Traffic Control	Low	Cost

Category	Risk zone	Major impact
Miscellaneous Incidental and Manufactured or Fabricated Items	Low to Moderate	Cost, safety, service interruption
Pavement Restoration	Low to Moderate	Cost
Bridge Deck Restoration	Low	Cost

8. How do you handle borderline or out-of-specification results for materials?
9. When a test fails to meet project specifications, what is your procedure for alerting the contractor and SDDOT (For example, within how many hours, via which channels)?
10. What corrective-action plans do you propose, and how quickly can revised material be supplied?
11. Do you employ sensors or remote monitoring (For example, temperature loggers in asphalt production, inline scanners for steel)? If so, how does that data feed into your risk assessments?
12. How would you like a risk-based inspection tool to interface with your plant-level Quality Control (QC) systems?
13. What data visualizations or reports would help you identify and mitigate high-risk material batches?

Section 3: Expectations & Feedback

14. From your perspective, what joint initiatives could SDDOT, contractors, and suppliers undertake to reduce material-related rework and delays?
15. Any suggestions to enhance transparency and trust across the supply chain?

Appendix E: Case Study Questionnaire

Discussions will be conducted with state transportation agency personnel with experience in using risk-based field material testing and construction inspection. The questions below will be used with each case study to collect in-depth information for developing recommendations, prioritization, and implementation strategies for the frequencies of construction material testing and inspection, staffing needs, and use of emerging technologies for the SDDOT material testing and inspection program.

General Information

1. Provide the following information:
 - a. Name
 - b. Agency
 - c. Division/Section/Department you work in at your agency
 - d. Email
 - e. Phone
 - f. Years of construction experience
 - g. Years of experience in risk based materials testing and/or construction inspection
2. Does your agency have dedicated central office materials division staff responsible for materials quality assurance (QA)? If so, what are the responsibilities of the materials division/staff?
3. Do contractors, producers/suppliers, or industry groups provide input or contribute to current materials QA practices?
4. Does your agency have internal documents, manuals, or reports addressing the required material testing and construction inspection activities? If yes, can you please share those with the research team?
5. Does your agency use different sampling, material testing, and inspection approaches based on project attributes (For example, project type, size, materials, risks)? Please explain. Does your agency have an inspection protocol or guidance to use different levels/types of inspection for construction projects? Please explain.

Risk-based Material Testing

6. Have you been using risk-based field material testing practices for construction projects? Please explain.
7. How and to what extent have you used risk-based analysis for field material testing?
8. What levels of risk does your agency use for risk-based field material testing?
9. What are the practices used at your agency for field material testing frequencies with risk-based considerations?

10. When using risk-based material testing, what materials require higher frequencies of field testing for construction projects?
11. Has risk-based material testing caused an increase in the testing frequency for any construction materials? If yes, which materials?
12. How has your agency identified and evaluated the level of risk for field material testing frequencies?
13. What issues in material quality have occurred when reducing construction material testing frequencies? Have these issues led to any changes in your DOT's risk-based approach? Has your DOT considered abandoning risk-based approaches to material testing altogether? Please explain.
14. For the following major materials categories, what are the risks (likelihood and consequences) related to non-compliance or failure of materials or products?
 - a. Project-Produced: Earthwork, Base Courses, Pavements, and Structures.
 - b. Plant Produced/Prefabricated Materials: Engineered Retaining Walls, Precast Concrete Structures/Pipe, and Structural Steel.
 - c. Standard Manufactured Products: Geotextiles, Barriers, Pavement Markings, and Steel Poles.

Risk-based Construction Inspection

15. Have you been using risk-based construction inspection practices? Please explain.
16. How and to what extent have you used risk-based analysis for construction inspections?
17. What levels of risk does your agency use for risk-based construction inspection?
18. What are the practices used at your agency for construction inspection frequencies with risk-based considerations?
19. What components of construction require higher frequencies of inspection?
20. How has your agency identified and evaluated the level of risk for construction inspection frequencies?

Staffing for Material Testing and Construction Inspection

21. How is staffing for field material testing and construction inspection determined for construction projects?
22. What are the staffing needs at your agency for field material testing and construction inspection based on risk levels?
23. What is the impact to staffing when using risk-based approaches to material testing and construction inspection?
24. Does your agency have internal training and advancement programs for your inspection and testing staff? Please explain.
25. How does your agency offset the shortage in the number of in-house inspectors?

26. Does your agency outsource inspection activities? If yes, why and to what extent do you outsource inspection activities?

Emerging Technologies for Risk-Based Testing and Inspection

27. What are the current and emerging technologies in use for field material testing at your agency?
28. What are the current and emerging technologies in use for construction inspection at your agency?
29. How do technologies assist with using risk-based approaches to field material testing and construction inspection?

Final Thoughts and Lessons Learned

30. What improvements would you like to see to your current risk-based program for field material testing and construction inspection?
31. What would you recommend to other state transportation agencies that are considering establishing and implementing a risk-based approach to field material testing and construction inspection?
32. What best practices/lessons learned can you share that have been used successfully for risk-based field material testing and construction inspection?

Appendix F: Material Testing Activities Compiled from SDDOT Materials Manual – MSTR Information

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	A. Aggregate, Composite	DOT 69	Yes
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	B. Asphalt Binder	SD 301	Yes
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	C. Asphalt Binder Content	DOT 89	Yes
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	D. RAP Content	DOT 93	No
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	E. RAP in Asphalt Concrete	SD 305	No
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	F. Lime Content	DOT-33Q	Yes
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	G. Density, In-Place	DOT-42	Yes
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	H. Theoretical Maximum Specific Gravity (Rice)	DOT-42	Yes
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	I. Bulk Specific Gravity	DOT-86	Yes
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	J. Mixture Densification, Voids in Mineral Aggregate and Dust to Binder Ratio (Class Q)	DOT-86	Yes
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	K. Moisture Content of Mix (Class Q and HR)	DOT-35	Yes
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	L. Drain Down (Class S)	DOT-91	No
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	M. Stabilizing Additive (Class S)	DOT-94	No
1. Asphalt Construction	1.2 Cold In-Place Recycling	A. Aggregate	DOT-3	No
1. Asphalt Construction	1.2 Cold In-Place Recycling	B. Density Standard	DOT-28	Yes
1. Asphalt Construction	1.2 Cold In-Place Recycling	C. Density In-Place	DOT-41	Yes
1. Asphalt Construction	1.2 Cold In-Place Recycling	D. Moisture Content (Prior to Compaction)	DOT-35	No
1. Asphalt Construction	1.2 Cold In-Place Recycling	E. Moisture Content (After Compaction)	DOT-35	No
1. Asphalt Construction	1.3 Asphalt Surface Treatment	A. Cover Aggregate, Types 1 & 2	DOT-3 & DOT-61	Yes
1. Asphalt Construction	1.3 Asphalt Surface Treatment	B. Cover Aggregate, Type 3	DOT-3 & DOT-61	Yes
1. Asphalt Construction	1.3 Asphalt Surface Treatment	C. Mineral Aggregate for Microsurfacing	DOT-3	Yes
1. Asphalt Construction	1.4 Asphalt Liquid	A. Material	DOT-1	Yes
1. Asphalt Construction	1.5 Crack Sealing of Asphalt Concrete	B. Sealant	DOT-1	No

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
1. Asphalt Construction	1.5 Crack Sealing of Asphalt Concrete	C. Backer Rod	DOT-1	No
1. Asphalt Construction	1.6 Milling	D. Cold Milling	DOT-55A	No
1. Asphalt Construction	1.6 Milling	E. Micro-Milling	DOT-55A	No
2. Subbase, Base Course, and Cushion Construction	2.1 Subbase and Base Course	A. Aggregate, Composite	DOT-3	Yes
2. Subbase, Base Course, and Cushion Construction	2.1 Subbase and Base Course	B. Density, In-Place	DOT-41	Yes
2. Subbase, Base Course, and Cushion Construction	2.1 Subbase and Base Course	C. Density, Standard	DOT-41	Yes
2. Subbase, Base Course, and Cushion Construction	2.2 Gravel Cushion	A. Aggregate, Composite	DOT-3	Yes
3. Miscellaneous Granular Materials	3.1 Gravel and Sand for Maintenance Stockpiles	A. Aggregate	DOT-3	No
3. Miscellaneous Granular Materials	3.2 Gravel Surfacing	A. Aggregate	DOT-3	Yes
3. Miscellaneous Granular Materials	3.3 Blotting Sand for Prime Coat and Sand for Flush Seal	A. Aggregate	DOT-3	No
3. Miscellaneous Granular Materials	3.4 Granular Bridge End Backfill	A. Aggregate	DOT-3	Yes
3. Miscellaneous Granular Materials	3.4 Granular Bridge End Backfill	B. Density, In-Place	NA	Yes
3. Miscellaneous Granular Materials	3.5 Gabion Fill	A. Aggregate	NA	No
3. Miscellaneous Granular Materials	3.6 Porous Backfill	A. Aggregate	DOT-3	No
3. Miscellaneous Granular Materials	3.7 Riprap	A. Aggregate	NA	No
3. Miscellaneous Granular Materials	3.8 Pit Run	A. Aggregate	DOT-3	No
3. Miscellaneous Granular Materials	3.8 Pit Run	B. Density, In-Place	DOT-41	No
3. Miscellaneous Granular Materials	3.8 Pit Run	C. Density, Standard	DOT-41	No
3. Miscellaneous Granular Materials	3.9 Slope Protection Aggregate	A. Aggregate	DOT-3	No
3. Miscellaneous Granular Materials	3.10 Salvaged and Full Depth Reclamation Materials	A. Aggregate	DOT-3	No
3. Miscellaneous Granular Materials	3.10 Salvaged and Full Depth Reclamation Materials	B. Density, In-Place	DOT-41	Yes

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
3. Miscellaneous Granular Materials	3.10 Salvaged and Full Depth Reclamation Materials	C. Density, Standard	DOT-28	Yes
3. Miscellaneous Granular Materials	3.11 Pipe and Box Culvert Undercut Backfill (Granular)	A. Aggregate	DOT-3	No
3. Miscellaneous Granular Materials	3.11 Pipe and Box Culvert Undercut Backfill (Granular)	B. Density, In-Place	DOT-41	Yes
3. Miscellaneous Granular Materials	3.11 Pipe and Box Culvert Undercut Backfill (Granular)	C. Density, Standard	NA	Yes
3. Miscellaneous Granular Materials	3.12 Cold Milled Asphalt Concrete and Placing Cold Milled Material	A. Milled Material	DOT-3	No
3. Miscellaneous Granular Materials	3.13 MSE Backfill	A. Aggregate	DOT-3	Yes
3. Miscellaneous Granular Materials	3.14 Granular Material for Box Culvert and Pipe Bedding	A. Aggregate	DOT-3	No
3. Miscellaneous Granular Materials	3.15 Miscellaneous Granular Material	A. Aggregate	DOT-3	No
3. Miscellaneous Granular Materials	3.15 Miscellaneous Granular Material	B. Rock, Clay, Sand Filler, and Miscellaneous Granular Material	NA	No
3. Miscellaneous Granular Materials	3.15 Miscellaneous Granular Material	C. Density, In Place	NA	No
3. Miscellaneous Granular Materials	3.15 Miscellaneous Granular Material	D. Density, Standard	DOT-41	No
4. Subgrade Construction (Embankments)	4.1 Specified Density (In-Place)	A. Embankment (Includes Subgrade Topping, Ordinary, and Heavy Roadway Shaping)	DOT-41	Yes
4. Subgrade Construction (Embankments)	4.1 Specified Density (In-Place)	B. Berms	DOT-41	Yes
4. Subgrade Construction (Embankments)	4.1 Specified Density (In-Place)	C. Bridge End Embankment	DOT-41	Yes
4. Subgrade Construction (Embankments)	4.1 Specified Density (In-Place)	D. Cross Pipe Pre-Installation Density/Undercut (Does not include utility, storm sewer, gas, or water main)	DOT-41	Yes
4. Subgrade Construction (Embankments)	4.1 Specified Density (In-Place)	E. Pipe Undercut Backfill (Soil)	DOT-41	Yes
4. Subgrade Construction (Embankments)	4.1 Specified Density (In-Place)	F. Pipe and Box Culvert Backfill	DOT-41	Yes
4. Subgrade Construction (Embankments)	4.1 Specified Density (In-Place)	G. Density, Standard (Target)	DOT-41	No
4. Subgrade Construction (Embankments)	4.2 Ordinary Compaction Method	A. Density	DOT-41	No
4. Subgrade Construction (Embankments)	4.2 Ordinary Compaction Method	B. Density, Standard (Target)	DOT-41	No

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
4. Subgrade Construction (Embankments)	4.3 Moisture Content	A. Embankment (Includes Select Subgrade Material, Berms, Box Culvert, and Pipe Backfill; Excludes Ordinary Compaction)	NA	Yes
4. Subgrade Construction (Embankments)	4.3 Moisture Content	B. Box Culvert, Pipe Backfill	DOT-35	Yes
4. Subgrade Construction (Embankments)	4.3 Moisture Content	C. Moisture, Standard (Target)	DOT-35	Yes
5. Portland Cement Concrete (PCC) Paving Construction	5.1 Materials	A. Aggregate, Fine and Coarse	DOT-3/ DOT-68	Yes
5. Portland Cement Concrete (PCC) Paving Construction	5.1 Materials	B. Aggregate, Fine and Coarse, Moisture Content	DOT-35	No
5. Portland Cement Concrete (PCC) Paving Construction	5.1 Materials	C. Cement	DOT-1	Yes
5. Portland Cement Concrete (PCC) Paving Construction	5.1 Materials	D. Water	DOT-1	No
5. Portland Cement Concrete (PCC) Paving Construction	5.1 Materials	E. Chemical Admixtures (Includes Air Entraining, Water Reducing, Accelerators, Retarders)	DOT-1	No
5. Portland Cement Concrete (PCC) Paving Construction	5.1 Materials	F. Fly Ash	DOT-1	Yes
5. Portland Cement Concrete (PCC) Paving Construction	5.2 Strength Tests	A. Compressive Strength	NA	Yes
5. Portland Cement Concrete (PCC) Paving Construction	5.3 Fresh (Plastic) Concrete Test	A. Air Content, Unit Weight, Slump, and Temperature	DOT-23	Yes
5. Portland Cement Concrete (PCC) Paving Construction	5.4 Measurements	A. Longitudinal Surface	DOT-29	No
5. Portland Cement Concrete (PCC) Paving Construction	5.4 Measurements	B. Texture	SD 418	No
5. Portland Cement Concrete (PCC) Paving Construction	5.4 Measurements	C. Thickness	NA	Yes
5. Portland Cement Concrete (PCC) Paving Construction	5.4 Measurements	D. Width	NA	No
5. Portland Cement Concrete (PCC) Paving Construction	5.5 Curing Materials	A. Liquid Membrane Curing Compound	DOT-1	No
5. Portland Cement Concrete (PCC) Paving Construction	5.5 Curing Materials	B. Burlap and Cotton Mat	NA	No

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
5. Portland Cement Concrete (PCC) Paving Construction	5.5 Curing Materials	C. Polyethylene Sheeting	NA	No
5. Portland Cement Concrete (PCC) Paving Construction	5.6 Joint Materials	A. Preformed Expansion Type (Includes Non-Extruding and Resilient Bituminous and Non-Bituminous Types)	NA	No
5. Portland Cement Concrete (PCC) Paving Construction	5.6 Joint Materials	B. Hot-Poured Elastic Type	DOT-1	No
5. Portland Cement Concrete (PCC) Paving Construction	5.6 Joint Materials	C. Backer Rod (Hot Pour)	DOT-1	No
5. Portland Cement Concrete (PCC) Paving Construction	5.6 Joint Materials	D. Silicone	DOT-1	No
5. Portland Cement Concrete (PCC) Paving Construction	5.6 Joint Materials	E. Backer Rod (Silicone)	NA	No
5. Portland Cement Concrete (PCC) Paving Construction	5.7 Keyways	A. Material	NA	No
6. Portland Cement Concrete (PCC) Structures Construction	6.1 Materials	A. Aggregate, Fine and Coarse	DOT-3	Yes
6. Portland Cement Concrete (PCC) Structures Construction	6.1 Materials	B. Aggregate, Fine and Coarse, Moisture Content	DOT-35	No
6. Portland Cement Concrete (PCC) Structures Construction	6.1 Materials	C. Cement	DOT-1	Yes
6. Portland Cement Concrete (PCC) Structures Construction	6.1 Materials	D. Water	DOT-1	No
6. Portland Cement Concrete (PCC) Structures Construction	6.1 Materials	E. Chemical Admixtures (Includes Air Entraining, Water Reducer, Accelerators, Retarders)	DOT-1	No
6. Portland Cement Concrete (PCC) Structures Construction	6.1 Materials	F. Fly Ash	DOT-1	Yes
6. Portland Cement Concrete (PCC) Structures Construction	6.2 Strength Tests	A. Compressive Strength	DOT-23	Yes
6. Portland Cement Concrete (PCC) Structures Construction	6.3 Fresh (Plastic) Concrete Tests	A. Air Content, Unit Weight, Slump, and Temperature	DOT-23	Yes
6. Portland Cement Concrete (PCC) Structures Construction	6.4 Curing Materials	A. Liquid Membrane Curing Compound	DOT-1	No

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
6. Portland Cement Concrete (PCC) Structures Construction	6.4 Curing Materials	B. Burlap	NA	No
6. Portland Cement Concrete (PCC) Structures Construction	6.4 Curing Materials	C. Film (Sheet Materials Including Waterproof Paper, Polyethylene Sheeting, White Burlap-Polyethylene Sheeting)	NA	No
6. Portland Cement Concrete (PCC) Structures Construction	6.5 Joint Materials	A. Strip Seal and Preformed Elastomeric Open Cell Compression Type with Lubricant/Adhesive	NA	No
6. Portland Cement Concrete (PCC) Structures Construction	6.5 Joint Materials	B. Preformed Expansion Type (Includes Non-Extruding and Resilient Bituminous and Non-Bituminous Types)	NA	No
6. Portland Cement Concrete (PCC) Structures Construction	6.5 Joint Materials	C. Hot-Poured Elastic Type	DOT-1	No
6. Portland Cement Concrete (PCC) Structures Construction	6.5 Joint Materials	D. Silicone	NA	No
6. Portland Cement Concrete (PCC) Structures Construction	6.5 Joint Materials	E. Backer Rod	NA	No
6. Portland Cement Concrete (PCC) Structures Construction	6.6 Commercial Textured and Special Surface Finish	A. Materials	NA	No
6. Portland Cement Concrete (PCC) Structures Construction	6.7 Abutment Backwall Coating	A. Materials	NA	No
6. Portland Cement Concrete (PCC) Structures Construction	6.8 Measurement of Texture	A. Tined Surface	SD 418	No
6. Portland Cement Concrete (PCC) Structures Construction	6.9 Measurement of Deck Roughness	A. Surface	DOT-29	No
7. Portland Cement Concrete Miscellaneous Construction – Class M	7.1 Materials and Plant	A. Requirements	DOT-23	Yes
7. Portland Cement Concrete Miscellaneous Construction – Class M	7.1 Materials and Plant	B. Preformed Expansion Type Joint Material (Includes Non-Extruding and Resilient Bituminous and Non-Bituminous Types)	DOT-1	No
8. Roadway Lighting and Traffic Control	8.1 Materials	A. Standard Items of Electrical Equipment	NA	Yes
8. Roadway Lighting and Traffic Control	8.1 Materials	B. Miscellaneous Hardware Items	NA	No
8. Roadway Lighting and Traffic Control	8.1 Materials	C. Items that are on the Approved Products List (APL)	NA	No
8. Roadway Lighting and Traffic Control	8.1 Materials	D. Items Requiring Approval of Catalog Cuts or Shop Drawings	NA	Yes
8. Roadway Lighting and Traffic Control	8.1 Materials	E. Items Requiring an Umbrella Certificate for the Material	NA	Yes

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
9. Erosion and Sediment Control	9.1 Materials	A. Erosion Control Devices	NA	No
9. Erosion and Sediment Control	9.1 Materials	B. Fertilizer	NA	No
9. Erosion and Sediment Control	9.1 Materials	C. Fiber Mulch	NA	No
9. Erosion and Sediment Control	9.1 Materials	D. Seeds	SD 512	No
9. Erosion and Sediment Control	9.1 Materials	E. Mulch	NA	No
9. Erosion and Sediment Control	9.1 Materials	F. Mycorrhizal Inoculum	NA	No
10. Buildings and Rest Area Construction	10.1 Materials	A. Brick	NA	No
10. Buildings and Rest Area Construction	10.1 Materials	B. Insulation	NA	No
10. Buildings and Rest Area Construction	10.1 Materials	C. Building Block (Hollow or Solid)	NA	No
10. Buildings and Rest Area Construction	10.1 Materials	E. Basin and Manhole Block	NA	No
10. Buildings and Rest Area Construction	10.1 Materials	F. Miscellaneous Hardware Items	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.1 Aluminum	A. Cast, Framing, Handrail, Hardware, and Sheet (Includes Extruded Types)	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.2 Bearing Pads	A. Bronze or Copper	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.2 Bearing Pads	B. Elastomeric	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.2 Bearing Pads	C. Preformed Fabric	DOT-1	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.3 Bolt Assemblies (Bolts, Nuts, Washers, and Direct Tension Indicators)	A. High Strength Bolts	DOT-99	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.3 Bolt Assemblies (Bolts, Nuts, Washers, and Direct Tension Indicators)	B. Anchor Bolts, Nuts, and Washers	NA	Yes

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.3 Bolt Assemblies (Bolts, Nuts, Washers, and Direct Tension Indicators)	C. Tie Bolts (Precast Box Culvert and Reinforced Concrete Pipe)	DOT-99	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.4 Bridge Deck Drains / Abutment Joint Drains	A. Material	DOT-99	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.5 Bridge Paint	A. Bridge Paint and Primer	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.5 Bridge Paint	B. Bridge Field Painting – Surface Preparation	NA	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.5 Bridge Paint	C. Bridge Field Painting – Paint Application	NA	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.6 Castings and Cast Iron	A. Bridge Hardware	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.6 Castings and Cast Iron	B. Drop Inlet Frames, Grates, Box Curb Assemblies	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.6 Castings and Cast Iron	C. Grid Floor	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.7 Cattle Guards	A. Material	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.8 Chloride	A. Calcium, Sodium, and Magnesium	DOT-1	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.9 Controlled Density Fill/Flowable Fill	A. Material	DOT-77	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.10 Drainage Fabric	A. Material	DOT-99	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.11 Epoxy-Resin Adhesive	A. Material	NA	No

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.12 Fencing	A. Barb and Smooth Wire	DOT-1	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.12 Fencing	B. Chain-Link System (Includes Fabric, Posts, Rails, Fittings, And Hardware)	DOT-1	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.12 Fencing	C. Woven Wire	DOT-1	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.12 Fencing	D. Brace Wire	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.12 Fencing	E. Miscellaneous Fasteners, Staples, Ties	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.12 Fencing	F. Gates (Tubular Frame)	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.12 Fencing	G. Steel Posts	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.12 Fencing	H. Wood Posts	DOT-1	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.13 Gabion Baskets	A. Material	DOT-1	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.14 Mailbox Assemblies	A. Material	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.15 MSE/Geotextile Fabric	A. Material	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.16 Pavement Markings	A. Traffic Marking Paint (Regular & Epoxy)	DOT-1	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.16 Pavement Markings	B. Permanent Plastic Pavement Markings	NA	No

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.16 Pavement Markings	C. Reflective Media	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.17 Piling	A. Pre-Cast and Pre-Stressed Concrete	NA	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.17 Piling	B. Steel Beam or Sheet (Includes Corrugated)	DOT-203 & DOT- 204	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.17 Piling	C. Timber (Treated)	NA	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.17 Piling	D. Piling Shoes	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.17 Piling	E. Pile Tip Reinforcement	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.18 Pipe	A. Concrete	DOT-1, DOT-3	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.18 Pipe	B. Corrugated Metal	DOT-1	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.18 Pipe	C. PVC	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.18 Pipe	D. Polyethylene Underdrain	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.18 Pipe	E. High-Density Polyethylene	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.18 Pipe	F. Steel Pipe	NA	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.18 Pipe	G. HDPE Slip Line Pipe	NA	Yes

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.19 Polyethylene Sheeting	A. Material	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.20 Polymer Modified Asphalt Growth Joint and Asphalt Bridge Joint	A. Joint System	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.20 Polymer Modified Asphalt Growth Joint and Asphalt Bridge Joint	B. Binder	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.21 Pre-Cast and Pre-Stressed Concrete	A. Aggregate, Fine and Coarse	DOT-3	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.21 Pre-Cast and Pre-Stressed Concrete	B. Cement	DOT-99	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.21 Pre-Cast and Pre-Stressed Concrete	C. Chemical Admixtures (Includes Air Entraining, Water Reducer, Accelerators, Retarders)	DOT-99	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.21 Pre-Cast and Pre-Stressed Concrete	D. Fly Ash	NA	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.21 Pre-Cast and Pre-Stressed Concrete	E. Water	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.21 Pre-Cast and Pre-Stressed Concrete	F. Concrete, Strength Tests	DOT-23, DOT-54	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.21 Pre-Cast and Pre-Stressed Concrete	G. Fresh (Plastic) Concrete Tests. (Air Content, Unit Weight, Slump, and Temperature)	DOT-23, DOT-54	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.21 Pre-Cast and Pre-Stressed Concrete	H. Metal Components	DOT-99	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.22 Precast Concrete Products Miscellaneous	A. Material	DOT-214, DOT-1, DOT-3	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.23 Signing Materials	A. Aluminum (Sheet and Extruded)	DOT-99	No

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.23 Signing Materials	B. Posts	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.23 Signing Materials	C. Reflective Sheeting	DOT-99	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.24 Steel	A. Guardrail Cable	DOT-99	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.24 Steel	B. Smooth Dowel Bars (Includes Bars in Dowel Bar Assemblies)	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.24 Steel	C. Support Baskets for Dowel Bars & Tie Bars	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.24 Steel	D. Reinforcing Bars, Deformed Dowel Bars, and Deformed Tie Bars	DOT-1	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.24 Steel	E. Wire Ties and Spacers	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.24 Steel	F. Reinforcing Wire Mesh (Miscellaneous)	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.24 Steel	G. Structural (Includes Steel Bridge Girders, Trusses, Arches, Main Supporting Members, Steel Bridge Rail, Steel Diaphragms, Sign Bridges, Splice Plates, and Bearings)	NA	Yes
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.24 Steel	H. Miscellaneous Steel (Includes all Steel not addressed in 11.24.G)	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.24 Steel	I. Guardrail and Steel Guardrail Posts	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.24 Steel	J. W Beam Guardrail Flared End Terminal, and W Beam Guardrail Tangent End Terminal	NA	No
11. Miscellaneous Incidental and Manufactured or Fabricated Items	11.24 Steel	K. High Tension Cable Guardrail	NA	No

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
11. Miscellaneous Incident and Manufactured or Fabricated Items	11.24 Steel	L. Insert Assemblies for Guardrail	NA	No
11. Miscellaneous Incident and Manufactured or Fabricated Items	11.24 Steel	M. Rebar Splice	NA	No
11. Miscellaneous Incident and Manufactured or Fabricated Items	11.24 Steel	N. Concrete Insert	NA	No
11. Miscellaneous Incident and Manufactured or Fabricated Items	11.25 Timber	A. Structural	NA	No
11. Miscellaneous Incident and Manufactured or Fabricated Items	11.25 Timber	B. Guardrail Posts	DOT-1	No
11. Miscellaneous Incident and Manufactured or Fabricated Items	11.25 Timber	C. Plank	NA	No
11. Miscellaneous Incident and Manufactured or Fabricated Items	11.26 Concrete Patching Materials	A. Material	NA	No
12. Pavement Restoration	12.1 PCC Pavement Repair	A. Silicone	SD 421	No
12. Pavement Restoration	12.1 PCC Pavement Repair	B. Backer Rod	NA	No
12. Pavement Restoration	12.1 PCC Pavement Repair	C. Hot-Poured Elastic Type	NA	No
12. Pavement Restoration	12.1 PCC Pavement Repair	D. Backer Rod (Hot Pour)	DOT-1	No
12. Pavement Restoration	12.2 Joint and Spall Repair	A. Concrete from Ready-Mix Plants	NA	Yes
12. Pavement Restoration	12.2 Joint and Spall Repair	B. Commercial Pre-Packaged Mix	NA	No
12. Pavement Restoration	12.2 Joint and Spall Repair	C. Fly Ash	NA	Yes
12. Pavement Restoration	12.2 Joint and Spall Repair	D. Silicone	SD 421	No
12. Pavement Restoration	12.2 Joint and Spall Repair	E. Backer Rod	NA	No
12. Pavement Restoration	12.2 Joint and Spall Repair	F. Hot Poured Elastic Type	NA	No
12. Pavement Restoration	12.2 Joint and Spall Repair	G. Backer Rod (Hot Pour)	DOT-1	No
12. Pavement Restoration	12.2 Joint and Spall Repair	H. Epoxy Resin	NA	No
12. Pavement Restoration	12.3 Pavement Jacking and Undersealing	A. Portland Cement	NA	No
12. Pavement Restoration	12.3 Pavement Jacking and Undersealing	B. Fly Ash	NA	No
12. Pavement Restoration	12.3 Pavement Jacking and Undersealing	C. Water	NA	No

Category	QA Sub-Category	MSTR Testing Activity	Requirements	Core Activity?
12. Pavement Restoration	12.3 Pavement Jacking and Undersealing	D. Strength Tests	NA	No
12. Pavement Restoration	12.3 Pavement Jacking and Undersealing	E. Flow Test	ASTM C 939	Yes
12. Pavement Restoration	12.3 Pavement Jacking and Undersealing	F. Jacking Foam	NA	No
13. Bridge Deck Restoration	13.1 Density Tests, Low Slump Bridge Deck Concrete	A. Density, In-Place	DOT-56	No
13. Bridge Deck Restoration	13.1 Density Tests, Low Slump Bridge Deck Concrete	B. Density, Standard	DOT-56	No
13. Bridge Deck Restoration	13.2 Bridge Deck Polymer Chip Seal	A. Polymer	NA	Yes
13. Bridge Deck Restoration	13.2 Bridge Deck Polymer Chip Seal	B. Concrete Patching Material	NA	No
13. Bridge Deck Restoration	13.2 Bridge Deck Polymer Chip Seal	C. Aggregate	DOT-35	No
13. Bridge Deck Restoration	13.3 Measurement of Bridge Deck Texture	A. Tined Surface	SD 418, DOT-55	No
13. Bridge Deck Restoration	13.4 Measurement of Bridge Deck Roughness	A. Surface	SD 417	No

Appendix G: Construction Inspection Activities Compiled from SDDOT Manuals

QA	Inspection Activity	Specification Section	Core Activity?
Earthwork	Clearing and Grubbing	100	No
Earthwork	Removal of Structures and Obstructions	110	No
Earthwork	Roadway and Drainage Excavation and Embankment Construction	120	Yes
Earthwork	Dust Control	205	No
Earthwork	Roadway Shaping	210	Yes
Earthwork	Salvaging, Stockpiling, and Placing Topsoil	230	No
Earthwork	Obliterating Old Roads	240	No
Earthwork	Incidental Work	250	No
Granular Bases and Surfacing	Granular Bases and Surfacing	260	Yes
Granular Bases and Surfacing	Salvaging, Processing, and Stockpiling Granular Bases and Asphalt Concrete Mix Materials	270	No
Granular Bases and Surfacing	Full Depth Reclamation	280	Yes
Asphalt Construction	Asphalt Concrete, General	320	Yes
Asphalt Construction	Asphalt Concrete - Class D, E, G	321	Yes
Asphalt Construction	Asphalt Concrete - Class Q (New Section)	322	Yes
Asphalt Construction	Asphalt Concrete Composite	324	Yes
Asphalt Construction	Asphalt Concrete - Class S	325	Yes
Asphalt Construction	Asphalt Concrete - Class HR	326	Yes
Asphalt Construction	Asphalt Concrete - Class HR	330	Yes
Asphalt Construction	Cold Milling Asphalt Concrete	332	No
Asphalt Construction	Asphalt Concrete Crack Sealing	350	No
Asphalt Construction	Asphalt Surface Treatment	360	Yes
Asphalt Construction	Cold in Place Recycling (CIR) of Asphalt Concrete	370	No
Rigid Pavement	Portland Cement Concrete Pavement	380	Yes
Rigid Pavement	Concrete Spall Repair	390	No
Rigid Pavement	Undersealing	391	No
Rigid Pavement	Pavement Jacking	392	No
Rigid Pavement	Cracking and Sealing of PCC Pavement	393	Yes
Rigid Pavement	Rubblize PCC Pavement (New Section)	394	Yes
Structures Construction	Steel Structures	410	Yes
Structures Construction	Shop Painting	411	Yes
Structures Construction	Bridge Field Painting, Repainting, and Paint Residue Containment	412	Yes
Structures Construction	Structure Excavation	420	No
Structures Construction	Box, Pipe, and Plate Pipe Culvert Undercutting	421	Yes

QA	Inspection Activity	Specification Section	Core Activity?
Structures Construction	Drainage Fabric Protection for Cast-in-Place Reinforced Concrete Box Culverts	422	No
Structures Construction	Temporary Works	423	No
Structures Construction	Bridge End Backfill	430	Yes
Structures Construction	Approach Slab Underdrain System (New Section)	435	No
Structures Construction	Structural Plate Pipe and Structural Plate Pipe Arch Culverts	440	Yes
Structures Construction	Pipe Culverts	450	Yes
Structures Construction	Structural Concrete	460	Yes
Structures Construction	Concrete for Incidental Construction - Class M	462	No
Structures Construction	Controlled Density Fill (New Section)	464	No
Structures Construction	Drilled Shaft Construction	465	Yes
Structures Construction	Railing	470	No
Structures Construction	Reinforcing Steel	480	Yes
Structures Construction	Bridge Deck Polymer Chip Seal	491	Yes
Structures Construction	Timber, Prestressed, and Steel Piles	510	Yes
Structures Construction	Bridge Deck Preparation and Resurfacing	550	Yes
Structures Construction	Precast and Pretensioned Prestressed Concrete	560	Yes
Incidental Construction	Field Laboratory	600	No
Incidental Construction	Haul Roads	601	No
Incidental Construction	Fly Ash	605	No
Incidental Construction	Cattle Guards	610	No
Incidental Construction	Right-of-Way Fencing	620	No
Incidental Construction	Chain Link Fencing	621	No
Incidental Construction	Cable Guardrail	629	Yes
Incidental Construction	Steel Beam Guardrail	630	Yes
Incidental Construction	Highway Signs and Delineators	632	No
Incidental Construction	Pavement Marking	633	No
Incidental Construction	Temporary Traffic Control	634	Yes
Incidental Construction	Traffic Signals and Roadway Lighting	635	Yes
Incidental Construction	Concrete Curb and Gutter	650	No
Incidental Construction	Concrete Sidewalk	651	No
Incidental Construction	Drop Inlets	670	Yes
Incidental Construction	Manholes	671	Yes
Incidental Construction	Underdrains	680	No
Incidental Construction	Riprap	700	No
Incidental Construction	Bank and Channel Protection Gabions	720	No

QA	Inspection Activity	Specification Section	Core Activity?
Incidental Construction	Seeding	730	No
Incidental Construction	Fertilizing	731	No
Incidental Construction	Mulching	732	No
Incidental Construction	Sodding	733	No
Incidental Construction	Erosion Control and Water Pollution Control	734	No
Incidental Construction	Aggregate for Maintenance Stockpiles	740	No

Appendix H: Summary of Material Testing and Construction Inspection Technologies

Concrete Temperature and Maturity Meter (CTMM)

Maturity testing is a method that establishes the relationship between concrete temperature, time, and strength gain, represented by an index that can be measured in real time on-site. This technology monitors early-age concrete temperatures to enhance QA, prevent cracking, and estimate strength development. It also helps determine the optimal timing for surface texturing, post-tensioning, joint sawing, form removal, and opening to traffic. Concrete maturity testing offers a reliable way to assess concrete compressive strength, providing a more accurate estimation of in-situ strength than traditional methods such as concrete cylinders, which can be time-consuming and less representative. As a non-destructive testing method for QA/QC, the maturity method reduces the need for extensive field testing of specimens such as beams and cylinders, which may not accurately reflect the actual pavement strength.

Additionally, it allows for faster project completion by enabling earlier opening to traffic. Maturity meters are widely used to measure and record internal concrete temperature over time. They serve two primary purposes:

1. Monitoring temperature gradients in mass concrete, and
2. Applying the maturity method to evaluate early-age strength development.

Digital Terrain Modeling (DTM)

DTM, also known as Digital Elevation Modeling (DEM), is the process of creating a digital representation of bare-ground topography and terrain for a given area. Unlike Digital Surface Models (DSMs), which include objects on the ground's surface, DTMs focus solely on the underlying terrain. These models are developed using various techniques, often relying on remote sensing methods such as photogrammetry rather than traditional surveying. DTMs have many applications, particularly in automated machine guidance (AMG) when integrating 3D engineered models. In addition to improving ground surface visualization, such as drainage features, DTMs enhance earthwork quantity calculations, providing greater accuracy compared to the traditional cross-section average-end method.

When combined with advanced surveying equipment, DTMs and 3D models can significantly reduce surveying workload. Some states have even eliminated manual earthwork quantification by paying based on plan quantities, leveraging the precision of DTMs. Beyond construction, DTMs enhance transportation agency capabilities in element location, GIS applications, and system planning. DTMs provide digital surface elevations and geographic locations, created from known data points connected through surfaces of varying

geometries. The density of these points determines the accuracy of the model. Since DTMs represent only the ground surface, they maintain accuracy over longer periods than other models. These digital terrain representations are a valuable tool for planning, design, construction, and asset management in transportation agencies. As the foundation of digital construction management and 3D engineered modeling, DTMs have become a standard practice in many transportation agencies due to their broad benefits. In construction and surveying, they help reduce staffing requirements for surveying tasks and earthwork quantity verification, making project management more efficient.

e-Ticketing

In the traditional ticketing process, inspectors manually record the quantity of materials used in a project using haul tickets. A truck driver receives a haul ticket upon loading construction materials. When the truck arrives at the construction site, the inspector collects the ticket and logs the delivery details. E-ticketing technology, which integrates GPS and software, automates the tracking and recording of material deliveries to construction sites (NASEM, 2019; NASEM, 2020). By eliminating paper-based processes, e-ticketing enables inspectors to track, document, and archive material tickets in real time on mobile devices. This paperless system improves workforce safety and removes the need for a full-time ticket taker, significantly reducing inspection labor costs. E-ticketing simplifies ticket management by enabling electronic and digital transactions, ensuring efficient documentation of construction material deliveries. This technology commonly tracks HMA, PCC, and earthwork materials.

Electronic Field Books

Electronic field books refer to handheld digital devices, such as laptops or tablets, that can store, retrieve, and manage text and graphical data remotely while running multiple software applications (NASEM, 2007). These devices can maintain a continuous connection to remote servers for real-time data access or synchronize their data when within range of a hotspot (cellular or Wi-Fi). Electronic field books enhance construction staff productivity by integrating and automating information systems, enabling them to manage multiple projects across larger geographic areas. Key benefits include:

- Improved organization of field-generated data.
- Faster data availability for construction teams.
- Reduced time spent on contract administrative tasks.

In portable device applications, electronic field books enable construction personnel to complete daily field reports remotely and access real-time project information, ensuring more accurate, timely responses to contractor inquiries. Their primary purpose is to assist professionals in efficiently processing construction and inspection data. Electronic field books

support data organization, documentation, exchange, and access, improving overall workflow efficiency in construction management.

Geographic Information System (GIS)

GIS is a computer-based platform that offers a data-rich environment for managing geographic asset information (FHWA, 2012a). GIS is a spatial system that creates, organizes, analyzes, and visualizes various types of data. GIS links data to maps, combining location-based information (where things are) with descriptive details (what those locations represent). This technology can help minimize the number of inspection personnel on projects by leveraging automated mapping and monitoring capabilities. It is particularly beneficial when states face legal mandates to reduce staff or encounter workforce shortages with the necessary skills for a project.

Additionally, GIS functionalities—such as utility location, detour planning, and traffic control phasing—can save time and improve project efficiency. GIS supports project management, data collection and analysis, surveying, and verifying project compliance with specifications. GIS is a fundamental tool for mapping and analysis, widely used across various industries, including construction. GIS enhances users' ability to identify patterns, understand relationships, and analyze geographic contexts. Key benefits include improved communication, increased efficiency, and more effective management and decision-making.

Global Navigation Satellite System (GNSS)

GNSS is a satellite-based technology that provides geospatial positioning anywhere on Earth. Examples of GNSS include the United States' GPS and the European Union's Galileo system. GNSS can collect and analyze critical location-based data when integrated with cloud technology. Locating construction elements such as equipment and materials on large construction sites can be time-consuming and inefficient. GNSS technology enables real-time tracking and positioning of construction resources, helping inspectors monitor site activities more effectively. As a widely used geospatial technology, GNSS ensures data consistency by aligning information within a common coordinate system, allowing it to be presented in context with its surroundings. Advancements in research and development have enabled GNSS measurements to achieve survey-grade accuracy in real time and post-processing. GNSS-based surveys are particularly advantageous for large-scale surveys spanning several miles, where traditional surveying techniques may experience significant error propagation. Additionally, GNSS facilitates data collection at remote locations, improving accessibility and efficiency in surveying operations.

Ground-Penetrating Radar (GPR)

GPR is a non-destructive measurement technique that transmits electromagnetic waves (ranging from 10 to 1000 Hz) into the material being examined, such as soil or other subsurface layers (Daniels, 2005). As these waves encounter discontinuities, such as boundaries or interfaces between materials with different dielectric properties, they reflect back to the receiver. By analyzing the amplitudes and arrival times of reflected signals, GPR can identify the nature and location of these discontinuities (Xia & Huston, 2016).

Determining pavement layer thickness is crucial for construction QA of new pavements and for estimating the structural capacity of existing ones. This information is vital for pavement management systems to ensure the safety, serviceability, and longevity of pavement networks. In Ground Penetrating Radar (GPR), the transmitter antenna emits electromagnetic waves into the subsurface. The velocity of these waves depends primarily on the permittivity (dielectric constant) of the underlying material. When the waves encounter objects or features with different electrical properties, they reflect and are captured by the receiver antennas. Signal velocity and amplitude variations due to material properties result in distinct reflection waveforms. By analyzing these distinct reflection signals, the subsurface's structural characteristics can be identified. GPR is particularly useful for underground utilities, objects, or individual elements within a homogeneous medium.

Intelligent Compaction (IC)

IC is an equipment-based technology designed to enhance QC and extend pavement lifespan. IC machines are vibratory rollers equipped with accelerometers mounted on the drum axle, a GPS device, infrared temperature sensors, and onboard computers that generate real-time, color-coded maps to track roller passes, surface temperatures, and material stiffness. IC technology can be applied to all pavement layer materials, from the subgrade to the surface. It enhances compaction uniformity, boosts productivity, and visually maps material stiffness values. Inspectors can use IC to measure surface temperatures and compaction stiffness, ensuring consistent compaction while reducing reliance on traditional inspection and testing methods. Conventional compaction machines often result in inconsistent or inadequate material densities, a major cause of premature pavement failure. IC addresses inadequacies by optimizing the compaction process and determining the ideal number of roller passes to prevent over- or under-compaction. This leads to fuel and operational savings and improved pavement quality. The use of IC has been proven to enhance compaction uniformity and consistency across roadway projects.

Light Detection and Ranging (LiDAR)

LiDAR, also known as 3D laser scanning, is a remote sensing technology that uses pulsed laser beams to measure distances (NASEM, 2019). This geospatial technology, relatively new

to the construction industry, enables efficient, highly detailed collection of critical geometric data. LiDAR provides a time-efficient method for collecting highway construction site geometry with accuracy comparable to that of traditional surveying (NASEM, 2013). It requires fewer work hours from highway agency staff, supports faster construction schedules, and enhances safety by reducing the time survey crews and inspectors spend near traffic. This technology aids project management and surveying by emitting light pulses (ranging from thousands to millions of points per second) to capture X, Y, Z (3D) coordinates, creating a point cloud. The resulting high-resolution 3D point cloud is a digital representation of the physical environment, allowing engineers and inspectors to repeatedly analyze, explore, and extract critical information. LiDAR enhances construction and maintenance inspections by providing data for analysis and simulation, identifying repair and maintenance needs, and enabling precise, rapid surveys at the project's outset. Additional applications include measuring lengths, stockpile volumes, and excavation volumes. The integration of UAS, handheld, and backpack-mounted LiDAR expands its capabilities. The FHWA (2017) has also launched a research initiative to assess the mini-LiDAR capabilities embedded in Apple consumer products, which could potentially integrate LiDAR into phones and tablets, making it a widely accessible inspection tool for field personnel.

Mobile Technology and Software Applications

Mobile technology encompasses hardware and software that enable field access to and collection of project-related information (Yamaura et al., 2015; Yamaura & Muench, 2018). Portable devices, such as tablets, smartphones, and laptops, are handheld electronic tools capable of running multiple applications for sharing, storing, and retrieving text, graphics, and other project data (Snow et al., 2013). These technologies enhance field data productivity, reduce the time needed to make information available to construction staff, and streamline contract administrative tasks. Construction inspectors must ensure contractors adhere to plans and specifications while maintaining proper records. Advanced tools, such as tablet computers, have improved accessibility by enabling the use of 3D surface models instead of traditional 2D paper plans, as well as the creation, storage, and transfer of electronic records rather than paper-based documentation. Portable devices and mobile applications enable inspection staff to complete daily field reports remotely, access project information, and provide faster, more accurate responses to contractor inquiries. Additionally, mobile applications help inspectors manage and report construction inspections in a paperless format, supporting construction progress tracking and safety inspections. As mobile technology has become more accessible and affordable, transportation agencies can leverage it to streamline inspection operations and improve project management efficiency.

Paver-Mounted Thermal Profiler (PMTP)

PMTP technology consists of two primary components:

1. Infrared sensors or a thermal camera mounted on a paver.
2. A radar system that scans the entire surface of the paved material.

PMTP is often integrated with Intelligent Compaction (IC) to enhance asphalt paving quality.

Mounted on a paver, PMTP provides real-time, two-dimensional infrared thermal maps of the mat behind it. Its non-contact surface temperature measurements help detect thermal segregation, which can make achieving proper field density more challenging. Severe segregation can lead to pavement distress, ultimately reducing the pavement's service life. Beyond temperature monitoring, PMTP is a QC tool that improves uniformity by providing insights into paving speed, hauling times, loading efficiency, mechanical issues, and stoppage frequency. Apart from conventional inspection methods, which can be time-consuming, PMTP identifies temperature segregation issues in real time, providing immediate feedback on paving quality and assisting with HMA inspection (NASEM, 2020; Torres et al., 2018). As a non-destructive QA/QC method, PMTP scans the entire asphalt surface as HMA is laid, allowing inspectors to detect segregation problems immediately and make necessary adjustments during construction. Additionally, PMTP enhances monitoring and QC of the asphalt mat and is a valuable visual tool for training industry professionals and agency personnel.

Remote Video Monitoring

Remote video monitoring enables real-time oversight of construction site conditions, work progress, security, and safety (McCrea et al, 2002; Shi & Hou, 2017). These systems use Internet Protocol (IP) cameras and video management software to remotely monitor specific locations. By reducing the need for on-site visits, remote video monitoring allows project management personnel to oversee construction activities from off-site locations. These systems provide live or recorded video feeds, offering stakeholders—including company executives, subcontractors, government agencies, and the public—direct access to project status updates (Jaselskis et al., 2015). Additionally, remote video monitoring helps reduce transportation costs and improve incident response times by providing real-time video surveillance of construction sites. Project managers, engineers, executives, and security personnel can use remote video systems to monitor job sites remotely. The cameras are connected to a subscriber unit, which transmits the IP video feed to an on-site access point. From there, the real-time video is relayed over the Internet, allowing clients to view footage from their devices.

Robotic Total Stations (RTS)

RTS is an advanced version of a total station that enables a single operator to perform site layout measurements efficiently (Crumal, 2019). While RTS can conduct standard horizontal and vertical measurements like traditional total stations, it can also automatically track the operator's prism or be remotely controlled. Additionally, RTS technology supports e-Construction and paperless data collection, allowing 2D and 3D models to be uploaded directly for surveying and layout tasks. Using RTS significantly improves field surveying efficiency and productivity (NDDOT 2007). Uploading 2D/3D plans enables more accurate, streamlined project layouts, reducing errors and ensuring locations match the as-designed plans. The system also facilitates paperless documentation, including the creation of as-built plans, making it an essential tool for agencies transitioning to e-Construction and Civil Integrated Management (CIM) processes. Due to single-operator functionality, labor requirements are drastically reduced, and the automatic prism tracking can increase productivity by 500% to 600%. Total stations are optical-electronic instruments equipped with electronic distance measurement, onboard computing, and data storage capabilities. These features allow real-time surveying calculations, facility layout from input coordinates, and data collection for electronic field books, as-built plans, and asset management (Parker et al., 2014). Point measurement and layout accuracy depend on the RTS's setup and communication with a reflective prism target. RTSs enhance these functions by improving efficiency, automating prism location, and allowing a single operator to conduct the survey. RTSs can replace conventional total stations in most surveying tasks, particularly when limited resources affect workload capacity. Given the significant investment required for these instruments, RTSs are a cost-effective alternative, offering enhanced productivity that can justify their adoption as a replacement for traditional total stations.

Sensors

A sensor is a device that measures various properties, such as pressure, position, temperature, or acceleration, and provides feedback in response (Chockalingam et al., 2017). This technology converts heat, light, sound, and motion into electrical signals and can be integrated with other systems, including drones, GPR, and visualization models. Sensor and health monitoring technologies enable real-time reporting, assisting construction inspectors in evaluating construction performance and quality (Rao et al., 2022). They also enable tracking of materials on construction sites and support equipment management by providing status and productivity data. Additionally, sensors can monitor worksite conditions that affect safety. By collecting real-time data on construction elements, they provide information for immediate evaluation, alerting project staff to potential issues. This allows for proactive intervention to prevent delays or major failures. Sensors are often combined with 3D modeling technologies to create detailed visual representations of construction surfaces.

With real-time capabilities, sensors enhance material tracking, site condition monitoring, and worker safety (Chockalingam et al., 2017).

Uncrewed Aircraft Systems (UAS)

A UAS consists of an uncrewed aircraft vehicle (UAV), a control system, ground and satellite communications, and a human operator (NASEM, 2016). This rapidly growing technology offers a wide range of relatively cost-effective applications. However, recent Federal Aviation Administration (FAA) regulations and restrictions have slowed their widespread adoption in recreational and commercial settings to ensure public and aviation safety. Beyond basic operational functions, advanced software and applications allow UAS-collected data to be used for tasks such as generating 3D models from aerial images and flight data (Kokosing Construction Company, Inc., 2017). The use of UAS technology has expanded significantly in recent years. A 2016 AASHTO survey reported that 33 DOTs were exploring their potential applications (AASHTO, 2016). While aerial photography and videography are the most common uses, UAS technology is also valuable for aerial mapping, surveying, and photogrammetry. Drones can perform remote visual inspections, particularly in unsafe or inaccessible areas where in-person inspections are not feasible.

Additionally, UAS inspections can reduce the need for on-site personnel by identifying priority areas requiring closer examination. UAS-generated mapping and photogrammetry can produce highly detailed 3D models, enabling applications such as as-built modeling and earthwork volume calculations (Tatum & Liu, 2017). The technology enhances efficiency and speed, minimizing traffic disruptions during operations. According to an AASHTO report, using UAS for certain inspections can yield up to 95% in cost savings (AASHTO, 2016). Many ready-to-use UAS solutions are available, along with options for customized configurations. Typical UAS setups consist of an aerial vehicle equipped with navigation controls, GPS, and photography or videography capabilities (Wang et al., 2017). Depending on their intended use and battery life requirements, UAS platforms can be rotorcraft or fixed-wing aircraft.

UAS can integrate various remote sensing technologies, including LiDAR sensors, thermal imaging cameras, and digital single-lens reflex (DSLR) cameras, with varying costs and functionality. These flexible configurations enable state agencies and contractors to use UAS for data collection and analysis in construction and inspection projects, making UAS a valuable inspection tool. Several resources present varying applications in the highway construction sector, but the most popular are:

- Aerial photography and videography,
- Photogrammetry and 3D modeling,

- Remote inspection (For example, landslides, hard-to-reach areas, structures, and confined spaces),
- Surveying, quantity estimates, measurement, and calculations (For example, volumes, areas, and perimeters),
- Collection of as-built information (For example, photos, videos, and models),
- Traffic volume and flow monitoring, and
- Forensic investigation (For example, thermal imaging and LiDAR).

UAS technology is expected to become a standard tool for improving the efficiency and productivity of construction field staff, much as digital cameras, mobile phones, and tablets have. Currently, UAS applications are most beneficial in scenarios where construction inspection teams can utilize alternative methods for surveying, visual data capture, and remote inspections. Successfully adopting UAS technology is more likely in DOTs with a strong technology culture and among construction teams that have already embraced mobile technologies to support their workflow. Since UAS technology is rapidly evolving, its effective implementation requires substantial time investment to maximize its capabilities. Alternatively, agencies can contract UAS consultants to capture and process aerial data, thereby leveraging the technology without in-house expertise.

Visualization and Modeling Technologies (3D, 4D, and 5D)

Visualization and image modeling technologies create a virtual representation of project components and work progress. 3D engineered models, for example, use points, lines, and surfaces to depict highway projects and their surrounding environments in three dimensions. The FHWA's Everyday Counts program (Rounds 2 and 3) recommends 3D modeling for its ability to accelerate highway construction, improve design communication, and enhance constructability. Additionally, 3D engineered models can be expanded to include project scheduling data (4D) or both scheduling and cost data (5D). These visualization and image modeling technologies help mitigate inspection risks and address staffing shortages across various project types.

Relying on this technology can help construction inspectors efficiently complete various field and office tasks while electronically collecting visual inspection data (O'Brien et al., 2016). 3D/4D technology also improves communication, constructability, and productivity in highway construction projects. 3D engineered models are a foundation for integrating other advanced technologies, such as automated machine control, clash detection, measurement, and quantity verification. These technologies can significantly impact construction staffing needs, including the role of inspectors. While many of these tools support project inspection

staff, 3D-engineered models specifically reduce the workload related to surveying, grade verification, cross-section analysis, quantity checks, and locating project elements.

3D models represent highway projects in X, Y, and Z dimensions, allowing them to be tilted, rotated, and adjusted for enhanced visualization and communication (Schneider, 2013). This technology can also provide data to automate construction activities. By depicting projects in 3D, 3D modeling improves information transfer among designers, general contractors, subcontractors, and agency inspection staff, leading to clearer communication and better project coordination. Adopting 3D/4D/5D technologies will differ depending on the type of work being inspected and the specific inspection tasks.

Appendix I: Material Testing Activities Average Expected Values and Ranking

The table below outlines the 72 testing activities ranked in the Task 3 risk assessment. The table is organized by the Task 3 risk ranking, with higher-risk activities at the top and lower-risk activities at the bottom. The MSTR category and MSTR QA sub-category section numbers are included for clarity.

Category	QA Sub-Category	MSTR Testing Activity	Cost Impact EV	Safety Impact EV	Service Interruption Impact EV	Highest Expected Value (HEV)	Task 3 Risk Rank
6. PCC Structure Construction	6.3 Fresh (Plastic) Concrete Tests	Air Content, Unit Weight, Slump, and Temperature	8.69	7.38	7.50	8.69	1 st
6. PCC Structure Construction	6.2 Strength Tests	Compressive Strength	7.75	6.94	6.88	7.75	2 nd
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	In-Place Density	7.44	2.50	5.75	7.44	3 rd
5. PCC Paving Construction	5.3 Fresh (Plastic) Concrete Test	Air Content, Unit Weight, Slump, and Temperature	7.25	4.50	5.25	7.25	4 th
3. Miscellaneous Granular Materials	3.4 Granular Bridge End Backfill	Aggregate Sieve Analysis	6.38	3.25	4.50	6.38	5 th
3. Miscellaneous Granular Materials	3.4 Granular Bridge End Backfill	In-Place Density	6.38	3.19	4.81	6.38	6 th
4. Subgrade Construction	4.1 Specified Density (In-Place)	Bridge End Embankment	6.38	3.06	4.38	6.38	7 th
4. Subgrade Construction	4.1 Specified Density (In-Place)	Berms	6.31	2.75	5.13	6.31	8 th
6. PCC Structure Construction	6.1 Materials	Aggregate, Fine and Coarse Sieve Analysis	5.19	4.31	6.19	6.19	9 th
3. Miscellaneous Granular Materials	3.10 Salvaged and Full-Depth Reclamation Materials	In-Place Density	6.13	2.88	4.50	6.13	10 th
11. Miscellaneous Incidental	11.21 Pre-Cast and Pre-Stressed Concrete	Fresh (Plastic) Concrete Tests. (Air Content, Unit Weight, Slump, and Temperature)	6.00	5.06	5.94	6.00	11 th
11. Miscellaneous Incidental	11.21 Pre-Cast and Pre-Stressed Concrete	Compressive Strength	5.88	4.81	5.88	5.88	12 th
5. PCC Paving Construction	5.2 Strength Tests	Compressive Strength	5.88	3.19	4.31	5.88	13 th
1. Asphalt Construction	1.2 Cold In-Place Recycling	Density In-Place	5.88	2.69	4.50	5.88	14 th
3. Miscellaneous Granular Materials	3.11 Pipe and Box Culvert Undercut Backfill (Granular)	In-Place Density	5.81	2.44	4.19	5.81	15 th
2. Subbase, Base Course, and Cushion Construction	2.1 Subbase and Base Course	Aggregate, Composite Sieve Analysis	5.75	2.25	3.94	5.75	16 th
4. Subgrade Construction	4.1 Specified Density (In-Place)	Embankments	5.69	2.44	4.38	5.69	17 th

Category	QA Sub-Category	MSTR Testing Activity	Cost Impact EV	Safety Impact EV	Service Interruption Impact EV	Highest Expected Value (HEV)	Task 3 Risk Rank
2. Subbase, Base Course, and Cushion Construction	2.1 Subbase and Base Course	In-Place Density	5.63	2.63	5.06	5.63	18 th
4. Subgrade Construction	4.1 Specified Density (In-Place)	Pipe and Box Culvert Backfill	5.50	2.81	4.50	5.50	19 th
11. Miscellaneous Incidental	11.3 Bolt Assemblies	High Strength Bolts	4.44	5.38	4.50	5.38	20 th
12. Pavement Restoration	12.2 Joint and Spall Repair	Concrete from Ready-Mix Plants	5.31	3.06	4.44	5.31	21 st
3. Miscellaneous Granular Materials	3.2 Gravel Surfacing	Aggregate Sieve Analysis	5.19	3.88	4.81	5.19	22 nd
4. Subgrade Construction	4.1 Specified Density (In-Place)	Pipe Undercut Backfill (Soil)	5.13	2.31	4.06	5.13	23 rd
4. Subgrade Construction	4.3 Moisture Content	Embankments	5.13	2.19	3.94	5.13	24 th
4. Subgrade Construction	4.3 Moisture Content	Box & Pipe Culvert Backfill	5.13	2.19	3.69	5.13	25 th
4. Subgrade Construction	4.1 Specified Density (In-Place)	Cross Pipe Pre-Installation Density/Undercut	5.00	2.50	3.81	5.00	26 th
11. Miscellaneous Incidental	11.21 Pre-Cast and Pre-Stressed Concrete	Aggregate, Fine and Coarse Sieve Analysis	3.88	3.69	4.94	4.94	27 th
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Asphalt Binder Content	4.63	2.25	3.88	4.63	28 th
6. PCC Paving Construction	6.1 Materials	Aggregate, Fine and Coarse Sieve Analysis	4.44	2.94	4.63	4.63	29 th
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Aggregate, Composite Sieve Analysis	4.38	1.81	3.19	4.38	30 th
2. Subbase, Base Course, and Cushion Construction	2.2 Gravel Cushion	Aggregate, Composite Sieve Analysis	4.38	1.94	2.81	4.38	31 st
1. Asphalt Construction	1.3 Asphalt Surface Treatment	Cover Aggregate, Types 1 & 2 Gradation Sieve Analysis	4.31	3.00	3.06	4.31	32 nd
3. Miscellaneous Granular Materials	3.13 MSE Backfill	Aggregate Sieve Analysis	4.31	2.13	2.94	4.31	33 rd
1. Asphalt Construction	1.4 Asphalt Liquid	Material	4.25	2.69	2.88	4.25	34 th
2. Subbase, Base Course, and Cushion Construction	2.1 Subbase and Base Course	Standard Density	4.13	1.75	2.56	4.13	35 th
3. Miscellaneous Granular Materials	3.10 Salvaged and Full-Depth Reclamation Materials	Standard Density	4.06	1.88	2.63	4.06	36 th
11. Miscellaneous Incidental	11.17 Piling	Pre-Cast and Pre-Stressed Concrete	4.00	3.19	4.00	4.00	37 th

Category	QA Sub-Category	MSTR Testing Activity	Cost Impact EV	Safety Impact EV	Service Interruption Impact EV	Highest Expected Value (HEV)	Task 3 Risk Rank
11. Miscellaneous Incidental	11.21 Pre-Cast and Pre-Stressed Concrete	Cement	3.31	3.31	3.94	3.94	38 th
3. Miscellaneous Granular Materials	3.11 Pipe and Box Culvert Undercut Backfill (Granular)	Standard Density	3.88	1.88	2.75	3.88	39 th
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Theoretical Maximum Specific Gravity (Rice)	3.81	1.88	2.69	3.81	40 th
7. Portland Cement Concrete Miscellaneous Construction – Class M	7.1 Materials and Plants	Requirements	3.81	2.25	2.69	3.81	41 st
1. Asphalt Construction	1.2 In-Place Recycling	Density Standard	3.75	1.38	2.56	3.75	42 nd
4. Subgrade Construction	4.3 Moisture Content	Moisture, Standard (Target)	3.75	1.56	2.69	3.75	43 rd
11. Miscellaneous Incidental	11.21 Pre-Cast and Pre-Stressed Concrete	Fly Ash	3.13	3.19	3.75	3.75	44 th
1. Asphalt Construction	1.3 Asphalt Surface Treatment	Cover Aggregate, Type 3 Gradation Sieve Analysis	3.69	2.25	2.63	3.69	45 th
6. PCC Structure Construction	6.1 Materials	Fly Ash	3.63	2.50	3.50	3.63	46 th
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Asphalt Binder	3.56	1.56	2.50	3.56	47 th
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Lime Content	3.56	1.13	2.94	3.56	48 th
6. PCC Structure Construction	6.1 Materials	Cement	3.56	2.56	3.56	3.56	49 th
11. Miscellaneous Incidental	11.24 Steel	Structural (Includes Steel Bridge Girders, Trusses, Arches, Main Supporting Members, Steel Bridge Rail, Steel Diaphragms, Sign Bridges, Splice Plates, and Bearings)	3.56	2.81	3.06	3.56	50 th
11. Miscellaneous Incidental	11.17 Piling	Timber (Treated)	3.44	3.19	3.56	3.56	51 st
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Mixture Densification, Voids in Mineral Aggregate and Dust to Binder Ratio (Class Q)	3.50	1.31	2.25	3.50	52 nd
11. Miscellaneous Incidental	11.3 Bolt Assemblies	Anchor Bolts, Nuts, and Washers	3.06	3.50	3.13	3.50	53 rd
11. Miscellaneous Incidental	11.5 Bridge Paint	Bridge Field Painting – Surface Preparation	3.38	1.63	2.13	3.38	54 th
11. Miscellaneous Incidental	11.17 Piling	Steel Beam or Sheet (Includes Corrugated)	3.31	3.06	3.19	3.31	55 th

Category	QA Sub-Category	MSTR Testing Activity	Cost Impact EV	Safety Impact EV	Service Interruption Impact EV	Highest Expected Value (HEV)	Task 3 Risk Rank
5. PCC Paving Construction	5.4 Measurements	Thickness	3.25	2.13	3.13	3.25	56 th
11. Miscellaneous Incidental	11.5 Bridge Paint	Bridge Field Painting – Paint Application	3.13	1.63	2.00	3.13	57 th
11. Miscellaneous Incidental	11.24 Steel	Reinforcing Bars, Deformed Dowel Bars, and Deformed Tie Bars	3.06	2.44	3.06	3.06	58 th
1. Asphalt Construction	1.3 Asphalt Surface Treatment	Mineral Aggregate for Microsurfacing	3.00	1.56	2.06	3.00	59 th
12. Pavement Restoration	12.3 Pavement Jacking and Undersealing	Flow Test	2.94	1.69	2.56	2.94	60 th
13. Bridge Deck Restoration	13.2 Bridge Deck Polymer Chip Seal	Polymer	2.75	1.81	2.44	2.75	61 st
6. PCC Paving Construction	6.1 Materials	Fly Ash	2.50	1.25	2.19	2.50	62 nd
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Moisture Content of Mix (Class Q and HR)	2.38	0.75	1.56	2.38	63 rd
6. PCC Paving Construction	6.1 Materials	Cement	2.38	1.19	2.13	2.38	64 th
12. Pavement Restoration	12.2 Joint and Spall Repair	Fly Ash	2.31	1.50	2.19	2.31	65 th
11. Miscellaneous Incidental	11.18 Pipe	Corrugated Metal	2.19	1.94	2.00	2.19	66 th
1. Asphalt Construction	1.1 Asphalt Concrete, Hot Mix	Bulk Specific Gravity	2.13	0.63	1.56	2.13	67 th
11. Miscellaneous Incidental	11.18 Pipe	HDPE Slip Line Pipe	1.81	1.56	1.69	1.81	68 th
11. Miscellaneous Incidental	11.18 Pipe	Steel Pipe	1.69	1.38	1.44	1.69	69 th
8. Roadway Lighting and Traffic Control	8.1 Materials	Standard Items of Electrical Equipment	1.63	1.25	1.06	1.63	70 th
8. Roadway Lighting and Traffic Control	8.1 Materials	Items Requiring Approval of Catalog Cuts or Shop Drawings	1.31	1.38	1.13	1.38	71 st
8. Roadway Lighting and Traffic Control	8.1 Materials	Items Requiring an Umbrella Certificate for the Material	1.13	1.00	0.88	1.13	72 nd

Appendix J: Construction Inspection Activities Average Expected Values and Ranking

The table below outlines the 35 construction inspection activities ranked in the Task 3 risk assessment. The table is organized by the Task 3 risk ranking, with the highest-risk activities at the top and the lowest at the bottom.

Division	Inspection Activity	Cost Impact EV	Safety Impact EV	Service Interruption Impact EV	Highest Expected Value (HEV)	Task 3 Risk Rank
Structures Construction	Structural Concrete	8.81	8.81	9.81	9.81	1
Incidental Construction	Temporary Traffic Control	4.81	9.31	5.69	9.31	2
Structures Construction	Drilled Shaft Construction	7.69	6.88	8.56	8.56	3
Structures Construction	Timber, Prestressed, and Steel Piles	6.13	6.44	7.44	7.44	4
Structures Construction	Steel Structures	6.31	6.44	6.88	6.88	5
Structures Construction	Bridge Deck Preparation and Resurfacing	6.75	4.88	6.69	6.75	6
Rigid Pavement	PCC Pavement	6.25	4.56	6.19	6.25	7
Structures Construction	Precast and Pretensioned Prestressed Concrete	5.38	5.94	5.50	5.94	8
Structures Construction	Pipe Culverts	4.75	4.63	5.44	5.44	9
Structures Construction	Bridge Deck Polymer Chip Seal	5.44	2.81	4.31	5.44	10
Structures Construction	Reinforcing Steel	4.50	4.31	5.31	5.31	11
Incidental Construction	Steel Beam Guardrail	3.38	5.25	2.81	5.25	12
Structures Construction	Structural Plate Pipe and Structural Plate Pipe Arch Culverts	3.94	4.19	5.13	5.13	13
Incidental Construction	Traffic Signals and Roadway Lighting	3.06	5.13	3.69	5.13	14
Asphalt Construction	Asphalt Concrete - Class Q (New Section)	4.94	3.19	4.19	4.94	15
Structures Construction	Bridge End Backfill	4.81	3.00	4.88	4.88	16
Incidental Construction	Cable Guardrail	2.88	4.75	2.94	4.75	17
Asphalt Construction	Asphalt Concrete - Class S	4.63	3.13	4.13	4.63	18
Earthwork	Roadway and Drainage Excavation and Embankment Construction	4.19	2.69	3.13	4.19	19
Structures Construction	Box, Pipe, and Plate Pipe Culvert Undercutting	4.19	2.44	3.13	4.19	20

Division	Inspection Activity	Cost Impact EV	Safety Impact EV	Service Interruption Impact EV	Highest Expected Value (HEV)	Task 3 Risk Rank
Granular Bases and Surfacing	Granular Bases and Surfacing	4.13	2.69	3.81	4.13	21
Asphalt Construction	Asphalt Surface Treatment	4.13	2.56	3.44	4.13	22
Asphalt Construction	Asphalt Concrete, General	3.94	2.69	3.75	3.94	23
Asphalt Construction	Asphalt Concrete - Class D, E, G	3.75	2.56	3.50	3.75	24
Asphalt Construction	Asphalt Concrete - Class HR	3.75	2.31	3.31	3.75	25
Asphalt Construction	Prime, Tack, Fog, and Flush Seal	3.75	2.44	3.31	3.75	26
Incidental Construction	Drop Inlets	3.13	2.94	3.75	3.75	27
Structures Construction	Bridge Field Painting, Repainting, and Paint Residue Containment	3.63	1.94	2.63	3.63	28
Incidental Construction	Manholes	2.88	3.00	3.63	3.63	29
Earthwork	Roadway Shaping	3.19	1.81	2.75	3.19	30
Granular Bases and Surfacing	Full Depth Reclamation	3.06	1.94	2.63	3.06	31
Structures Construction	Shop Painting	2.94	1.13	1.94	2.94	32
Asphalt Construction	Asphalt Concrete Composite	2.50	1.63	2.50	2.50	33
Rigid Pavement	Rubblize PCC Pavement (New Section)	2.50	1.56	2.44	2.50	34
Rigid Pavement	Cracking and Sealing of PCC Pavement	2.25	1.25	2.06	2.25	35

Appendix K: 189 SDDOT Projects Reviewed for Material Testing from the MS&T

No.	PCN	Region	Area	Letting Date	Location	Description of Work
1	00GP	Rapid City	Rapid City	01/20/2021	I90 EBL & WBL - from Exit 32 (Sturgis) to Exit 40 (Tilford)	Construct Median and Ramp Crossovers
2	006A	Aberdeen	Aberdeen	04/20/2005	SD10 FM US281 E TO SAND LAKE	Asphalt Surface Treatment
3	00HW	Pierre	Pierre	12/17/2008	SD47 from US212 near Lebanon N to the SD20 Junction	Cold Milling Asphalt Concrete & Asphalt Concrete Resurfacing
4	00LX	Pierre	Winner	03/16/2006	from SD391 to Swett	Asphalt Surface Treatment & Asphalt Concrete Crack Sealing
5	00MX	Aberdeen	Aberdeen	03/16/2006	from W of Mina to Near Aberdeen	Asphalt Surface Treatment (Sand Seals & Chip Seals)
6	00X9	Rapid City	Rapid City	02/01/2012	SD44 - (Jackson Blvd.) from Rapid Creek to Mt View Rd in Rapid City; SD44 - Str 1.2 SW of the junction of Mt View Road in Rapid City over Rapid Creek	Urban Grading, Storm Sewer, C&G, Sidewalk, Lighting, Signals, PCC Surfacing, Bridge Deck Overlay & Approach Slabs
7	017J	Pierre	Winner	04/04/2007	US 18 Through the City of Winner	Microsurfacing, Asphalt Surface Treatment & Pavement Marking
8	01DX	Pierre	Winner	03/16/2022	Structure 2.9N of Witten over Cottonwood Creek SN 62-080-201	Structure (92' Prestressed Girder Bridge) & Approach Grading
9	01KD	Rapid City	Belle Fourche	01/16/2008	From Hwy. 85 to Hwy. 79	Asphalt Surface Treatment (Chip Seal)
10	01KN	Rapid City	Belle Fourche	02/19/2020	Structure 4.5N & 2W of Spearfish over the Redwater River SN 41-070-012	Structure (74' Concrete Bulb Tee Bridge)& Approach Grading
11	01TM	Aberdeen	Watertown	04/24/2013	US12 - from the End of the Concrete W of Milbank to Grant St in Milbank	Structures, Grading, PCC Pavement, Curb & Gutter, Storm Sewer, Lighting, and Signals
12	01TX	Pierre	Winner	03/04/2009	from the Nebraska State Line to the Junction of US18	Microsurfacing
13	020U	Rapid City	Belle Fourche	02/17/2016	I90 - Exit 14 (US14A) Spearfish	Interchange Reconstruction - PCC Paving, Structure (183' Long x 264' wide Prestressed Girder Bridge), Lighting, and Signals
14	021G	Rapid City	Rapid City	05/11/2022	I90 EBL - from W of Exit 37 (Pleasant Valley) to Exit 40 (Tilford)	Grading, PCC Surfacing, Replace Str (278' Steel Girder, 2-7x6 CIP, 20x10 CIP, Long Span Arch Ext., 3-8x4 CIP, 9x8 Precast)
15	025Z	Mitchell	Sioux Falls	09/18/2013	SD19 - from the Junction. of SD38 to the Junction of SD34	Shoulder Widening, Grading, and Structures
16	027K	Rapid City	Rapid City	02/05/2020	SD44 (Omaha St) - from Mt. View Rd to the start of the divided lanes near 12th St.	Grading, Structure Widening, Storm Sewer, Curb & Gutter, Sidewalk, Traffic Signals, PCC Surfacing, Lighting
17	02E8	Rapid City	Custer	10/20/2021	Str 4E & 1.8N of Edgemont over abandoned RR line SN 24-162-102	Structure (178' Prestressed Girder) & Approach Grading
18	02EC	Mitchell	Mitchell	12/01/2021	Structure 5 S & 6.6 W of Howard over Rock Creek SN 49-094-180	Structure (4-11x18 CIP RCBC) & Approach Grading
19	02G4	Aberdeen	Watertown	02/17/2010	SD10 in the Watertown Area	Microsurfacing
20	02GF	Pierre	Mobridge	04/28/2010	Hwy 12 in the Mobridge Area	Microsurfacing

No.	PCN	Region	Area	Letting Date	Location	Description of Work
21	02W2	Rapid City	Belle Fourche	05/01/2012	Various routes in the Belle Fourche Area	Asphalt Surface Treatment (Chip Seal)
22	033T	Rapid City	Rapid City	09/07/2011	I90- WBL, from west of the Junction. with US14 to Cactus Flats (Exit 131)	Microsurfacing
23	035F	Rapid City	Rapid City	09/04/2024	I90 E & W - Strs 3.3 E of the Wasta Interchange Over Bull Ck	Replace Structure (2) 394.5' Prestressed Girder Bridges, Approach Grading, Asphalt Surfacing
24	036E	Pierre	Winner	01/16/2019	US83 - from N. of the Mellette/Jones Co. Line to S of Murdo	Grading, Structures (164' Concrete Bridge & 2 Box Culverts), Interim Surfacing
25	038Z	Pierre	Pierre	09/02/2020	SD1806 - from the Lyman/Stanley Co Line N 14.7; Str 11.2 SE of US83 over Antelope Ck	Cold Milling & Asphalt Concrete Resurfacing, Pipe Work, Deck Overlay, Approach Guardrail, Slope and Ditch Channel Grading
26	039L	Pierre	Pierre	01/20/2021	US212 - Through Gettysburg	Urban Grading, PCC Paving, ADA Upgrades, Storm Sewer, Roadway Lighting
27	03JK	Pierre	Winner	04/04/2012	Various Routes in the Winner Area	Microsurfacing
28	03K5	Pierre	Winner	04/17/2013	Various Locations in the Winner Area	Asphalt Surface Treatment (Chip Seal)
29	03TH	Rapid City	Custer	11/03/2021	US18 - from US385 to the Hot Springs City Limits	Urban Reconstruction, PCC Surfacing, Curb & Gutter, Sidewalk, Lighting, Signals
30	03VD	Rapid City	Custer	10/02/2024	US385 - Fm 1.5 N of US16 E to Pactola Dam; US385 - Str 3.6 N of US16 E over Horse Creek	Grading, Interim Surfacing, Replace Str (2-13x13 CIP & 12x12 CIP RCBC)
31	045F	Mitchell	Mitchell	04/03/2013	SD44 from the Charles Mix/Douglas County Line to the North US281 JUNCTION	Microsurfacing
32	047G	Rapid City	Belle Fourche	02/18/2015	SD75 in the Belle Fourche Area	Asphalt Surface Treatment (Chip Seal)
33	04DK	Pierre	Winner	09/21/2022	I90 - Strs, Over 282 Ave 3 E of the Draper Interchange; Over a creek 5.5 W of the US83 N Interchange; Over 286 Ave 4.7 W of the US83 N Interchange	Polymer Chip Seal, LSDC Overlay, Joints, Berm Repair, Replace Approach Slabs, Drop Inlets, Approach Pavement, Guardrail, Curb
34	04DV	Rapid City	Belle Fourche	10/03/2018	US12 - from the ND State Line E to the Perkins/Corson County Line	Cold Milling Asphalt Concrete, Full Depth Reclamation, & Asphalt Concrete Resurfacing
35	04E7	Pierre	Winner	03/25/2020	US83 - from N of White River to N of the Mellette/Jones Co Line	Grading, Structures (319' Prestressed Girder Bridge, 469' Prestressed Girder Bridge & 2 CIP RCBC) & Interim Surfacing
36	04E8	Pierre	Winner	10/20/2021	US83 - from White River to S of Murdo	Asphalt Concrete Surfacing, ADA Upgrades
37	04EM	Pierre	Winner	05/03/2023	SD44 - from US83 to the east of the city limits of Wood	Mill, Asphalt Concrete Resurfacing, Pipe Work
38	04F0	Mitchell	Yankton	10/06/2021	SD52 - from SD37 to SD50	Asphalt Concrete Surfacing, Approach Slab, Guardrail
39	04FC	Rapid City	Custer	12/04/2024	US18 - In Pine Ridge from 2 Blocks N of SD407 to E of Indian Health Rd	Urban Grading, Curb & Gutter, Storm Sewer, Lighting, PCC Surfacing, ADA, Signal

No.	PCN	Region	Area	Letting Date	Location	Description of Work
40	04FD	Pierre	Winner	12/02/2020	US18 - from W of Monroe St to Lincoln St in Winner, US18E&W - from Lincoln St to 3rd St in Winner, & US18 - from 3rd St to 7th St in Winner	Grading, Storm Sewer, Curb & Gutter, Sidewalk, Roadway Lighting, Traffic Signals & Portland Cement Concrete Surfacing, water meter
41	04FK	Aberdeen	Huron	10/03/2018	SD26 - 2.8 mi W of SD45 Over Shaefer Ck	Structure Replacement (106' Prestressed Girder), Scour Protection & Column Repair
42	04FR	Rapid City	Belle Fourche	12/09/2020	SD20 - 4.2 & 5 E of the MT State Line Over the Little Missouri River & Over Valley Creek & 14.8 E of the E US85 Junction Over Sioux Creek	Structure (263' Prestressed Girder, 153' Prestressed Girder & 3-12'x8' CIP or Precast RCBC)& Approach Grading
43	04G5	Mitchell	Yankton	10/04/2023	US81 - from the End of the Divided Lanes to 303rd St N of Yankton	Grading, Replace Structures (2-109' Prestressed Girder Bridges, 9x8 Precast RCBC) & Interim Surfacing
44	04K0	Mitchell	Mitchell	10/07/2020	SD44 - from the E Junction of US281 to SD37 at Parkston	Shoulder Widening, Asphalt Concrete Surfacing of Shoulders, Pipe Work, Extend RCBC & Upgrade Bridge Approach Rail
45	04LJ	Rapid City	Belle Fourche	02/17/2016	From SD79 7S of Newell, E 6 mi. on Valley Township Road to 137 Ave.	Asphalt Surface Treatment (Chip Seal)
46	04LL	Pierre	Winner	02/24/2016	From 310 Ave., 5W of Junction of 296 St./315 Ave., E 11 mi. to US183/321 Ave. (FA 6302)	Maintenance Patching & Asphalt Surface Treatment
47	04PD	Rapid City	Rapid City	01/19/2022	SD44 - from LaCrosse St to Covington St in Rapid City	ADA Curb Ramps, Sidewalk, Signals & Intersection Improvement
48	04V9	Mitchell	Mitchell	11/7/2021	US18 - Str 0.8 N of Pickstown Over Saint Francis Bay; US18 - from Pickstown to Lake Andes	Replace Structure (225' Prestressed Girder Bridge), Approach Grading; Spot Grading, Pipe Work, Interim Surfacing; Intersection
49	04X4	Mitchell	Yankton	02/16/2022	SD46 - from US81 to Irene	Grading, Interim Surfacing, Replace Structure RCBC(2-10x10 CIP, 9x8 CIP, (2) 3-12x12 Precast or CIP, 8x8 CIP & 9x5 Precast or
50	04X5	Aberdeen	Huron	01/19/2022	SD26 - from SD47 to SD45	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work
51	04XK	Mitchell	Sioux Falls	12/07/2022	I-229 Exit 9 (Benson Rd) in Sioux Falls	Modify Interchange, Grading, PCC Surface
52	04XQ	Pierre	Pierre	05/19/2021	US14 - from W of SD1804 to the US83 N Junction (Blunt Junction)	Asphalt Concrete Resurfacing, Pipe Work
53	04XT	Rapid City	Custer	11/18/2020	US18E - from Smithwick Road to the S Junction of US385 on the Original Lanes of the Heartland Expressway	Cold Milling Asphalt Concrete & Asphalt Concrete Resurfacing; Reconstruction of Select Vertical Curves, Asphalt Concrete Surface
54	04WM	Mitchell	Sioux Falls	03/16/2016	Arrowhead Parkway - from Sycamore to East of Veteran's Parkway, including a shared use path extending south on Highline Ave until 18th Street and then west in Sioux Falls	Grading, Storm Sewer, Curb & Gutter & PCCP Surfacing, Shared Use Path
55	04WR	Rapid City	Belle Fourche	04/10/2019	US212 - from the Junction of Maurine Rd/Bixby Rd to the W City Limits of Faith	Asphalt Concrete Resurfacing
56	04XW	Pierre	Pierre	09/07/2022	SD1806 - from SD273 N 11.3 to the Lyman/Stanley Co Line; SD1806 - 6.4 NW of SD271 Over Cedar Ck, 6.7 NW of SD271 Over Straight Ck	Spot Grading, Cold Milling, Asphalt Concrete Resurfacing, Pipe Work, Approach Guardrail, Erosion Repair
57	04X0	Pierre	Winner	11/15/2023	SD44 - from SD63 to the N Junction of US83	Full Depth Reclamation, Asphalt Concrete Surfacing, Gravel Surfacing, Modify Intersection, Pipe Work (Pipe Replacements and 3

No.	PCN	Region	Area	Letting Date	Location	Description of Work
58	054L	Aberdeen	Aberdeen	03/02/2016	SD10 - F the East City Limits in Britton East 11.2 Miles	Microsurfacing
59	054Q	Rapid City	Belle Fourche	04/20/2016	Rapid City Region	Microsurfacing
60	055A	Aberdeen	Aberdeen	03/15/2017	Various Routes in the Aberdeen Area	Asphalt Concrete Surface Treatment
61	055C	Aberdeen	Watertown	02/01/2017	Various Routes in the Watertown Area	Asphalt Concrete Surface Treatment
62	055D	Rapid City	Custer	02/15/2017	Various Routes in the Custer Area	Asphalt Concrete Surface Treatment
63	055E	Rapid City	Belle Fourche	04/05/2017	Various Routes in the Belle Fourche Area	Asphalt Concrete Surface Treatment, Asphalt Concrete Crack Leveling, and Asphalt Concrete Crack Sealing
64	055J	Pierre	Mobridge	04/05/2017	Various Routes in the Mobridge Area	Asphalt Concrete Surface Treatment
65	055K	Pierre	Pierre	03/15/2017	SD34 - from the Meade/Ziebach County Line to Pierre	Asphalt Concrete Surface Treatment
66	055Q	Mitchell	Sioux Falls	02/15/2017	Various Routes in the Sioux Falls Area.	Asphalt Concrete Surface Treatment
67	05DV	Aberdeen	Aberdeen	09/06/2023	US281 - Str 0.2 N of Junction US12 Over BNSF RR	Repair Embankment Settlement, Approach Pavement, Approach Slabs, Zone Painting
68	05E9	Pierre	Winner	12/06/2023	US14 - from Midland to SD34	Cold Milling, Asphalt Concrete Resurfacing, Shoulder Full Depth Reclamation, Pipe Work, Bridge Rail Upgrade
69	05ED	Pierre	Winner	11/06/2019	US183 - from US18 to the White River	Full Depth Reclamation & Asphalt Concrete Resurfacing, Asphalt Concrete Contractor Furnish & Placed Asphalt Mix
70	05EN	Pierre	Pierre	12/15/2021	US212 - from LaPlant to the W Junction of US83	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work & Landslide Repair
71	05F9	Mitchell	Sioux Falls	11/16/2022	I29 N/S - 1 N of Exit 98 (Dell Rapids); 1.2 N Minnehaha Co. Line; 3.8 S of Exit 109 (Colman); 3 S of Exit 109 (Colman)	High Friction Surface Treatment, Polymer Chip Seal, Deck Repair, Curb Repair, Approach Slabs, Replace Joint
72	05FN	Rapid City	Belle Fourche	02/05/2020	US212 - Str 2.3 W of SD79 Over Owl Ck.	Replace Structure (3-12'x12 CIP or Precast RCBC) and Approach Grading
73	05GY	Aberdeen	Watertown	10/05/2022	SD127 - Strs 5.2 E of SD106 over a creek & 5.6 E of SD106 over a creek	Replace Structures (3-9' x 6' CIP or Precast RCBC, 2-10' x 6' CIP or Precast RCBC) & Approach Grading
74	05HT	Aberdeen	Aberdeen	09/07/2022	US12 EBL & WBL - from E of the Aberdeen Airport to E of Bath	Grading, PCC Surfacing, Lighting & Structure (12x12 CIP RCBC)
75	05HU	Aberdeen	Watertown	10/05/2022	US14 E & W - from S of Arlington to E of the S US81 Junction	Grading, Rubblize PCC, Asphalt Concrete Surfacing
76	05J4	Aberdeen	Watertown	12/14/2022	SD15 - from the N Junction of SD20 N to Milbank	Cold Milling, Asphalt Concrete Surfacing, Guardrail, Pipework
77	05JE	Mitchell	Sioux Falls	01/23/2019	26th Street from Cleveland Avenue to 1,050 feet West of Southeastern Avenue in Sioux Falls	Grading, Storm Sewer, Curb & Gutter, PCC & Asphalt Concrete Surfacing, Signals, Lighting, Permanent Signing, Sidewalk

No.	PCN	Region	Area	Letting Date	Location	Description of Work
78	05JN	Mitchell	Mitchell	03/26/2025	SD46 in Wagner	Grading, PCC Surfacing, Storm Sewer, Curb & Gutter, Sidewalk, Lighting, Signals
79	05KE	Aberdeen	Huron	04/06/2016	SD37 N&S from 2 miles South of the SD244 JUNCTION to North of 33rd ST SE in Huron	Microsurfacing
80	05L4	Pierre	Pierre	04/04/2018	Various Routes in the Pierre Area	Asphalt Surface Treatment (Chip Seal)
81	05L7	Aberdeen	Watertown	03/21/2018	Various Routes in the Watertown Area	Asphalt Surface Treatment (Chip Seal)
82	05LL	Pierre	Pierre	07/19/2017	Various Routes in the Pierre Area	Microsurfacing
83	05LM	Mitchell	Mitchell	04/05/2017	US281 - from the Junction of SD258 to the Junction of 243 St	Microsurfacing
84	05T4	Mitchell	Mitchell	12/13/2023	I-90 E & W - From 8 E of Chamberlain to White Lake	Asphalt Concrete Milling & Asphalt Concrete Resurfacing
85	05TQ	Rapid City	Belle Fourche	01/20/2021	SD34 - from Regent St in Sturgis E to E of SD79	Cold Mill Asphalt Concrete, Asphalt Concrete Resurfacing, Pipe Work, Structure Replacement & Approach Grading, Intersection I
86	05TT	Mitchell	Mitchell	09/21/2022	US18 - from Pickstown to Lake Andes	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing
87	05TX	Aberdeen	Huron	12/09/2020	US212 - From Doland to 6 W of Clark	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing & Pipe Work
88	05TY	Pierre	Mobridge	11/20/2024	US12 - from 12 E of McLaughlin to W of Mobridge	Full Depth Reclamation, Asphalt Concrete Surfacing, Pipe Work
89	05U1	Rapid City	Rapid City	12/09/2020	US14 - from E of Wall to Cottonwood; US14 - 3.8 W of the Jackson Co Line Over a Branch of Cottonwood Creek	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work, Replace Str (2-12x6 CIP RCBC) & Approach Grading
90	05U7	Mitchell	Yankton	09/20/2023	SD46 - from US81 to Irene	Asphalt Concrete Surfacing
91	05XC	Pierre	Mobridge	09/20/2023	SD47 - from SD20 to US12	Asphalt Concrete Surfacing
92	05Y3	Rapid City	Custer	02/06/2019	Various Routes in the Custer Area	Asphalt Surface Treatment
93	065L	Mitchell	Yankton	08/16/2023	I-29 - Strs, Exit 1 (Dakota Dunes); Exit 18 (Elk Point); 0.2 N of Exit 18 (Elk Point) over RR	Polymer Chip Seal, Replace Abutments, Berm Repair, Replace Joints, Approach Slabs, Approach Pavement, Approach Guardrail, End
94	065N	Aberdeen	Watertown	12/14/2022	I-29 - Strs 2 S of the Exit 224 (Peever); Exit 232 (Sisseton)	Polymer Chip Seal, Approach Slabs, Joints, End Block Modification, Approach Surfacing, Approach Guardrail
95	0687	Mitchell	Mitchell	11/03/2021	US18 - from Burke to W of SD43	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work
96	068A	Pierre	Mobridge	02/16/2022	US12 - from the Perkins/Corson Co Line to Morristown	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing, Pipe Work
97	068D	Pierre	Mobridge	12/15/2021	US12 & US12 EBL & WBL - from Mobridge E City Limits to S of Selby	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing & Pipework
98	068V	Rapid City	Belle Fourche	01/19/2022	US212 - from SD79 in Newell to the Maurine/Bixby Rd	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work, Guardrail Upgrades

No.	PCN	Region	Area	Letting Date	Location	Description of Work
99	0694	Rapid City	Custer	10/16/2024	US385 - from N of Pactola Dam to 4 N of SD44	Asphalt Concrete Surfacing
100	069F	Aberdeen	Huron	01/19/2022	SD47 - from N of SD26 to the US212 E Junction	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing & Culvert Repairs
101	06CF	Mitchell	Sioux Falls	02/15/2023	I229 - Exit 2 (Western Ave) in Sioux Falls	Ramp Improvement, LSDC Overlay, Approach Slabs, Approach Pavement, Replace Steel Pedestrian Rail
102	06CM	Pierre	Mobridge	01/22/2025	US212 - from Eagle Butte to LaPlant	Cold Milling, Asphalt Concrete Resurfacing, Modify Intersection, Pipe Work, Rumble Stripes & High-Grade Polymer Pavement Mark
102	06CW	Aberdeen	Watertown	03/20/2024	SD21 - from W City Limits of Hayti to US81	Full Depth Reclamation, Asphalt Concrete Surfacing, Pipe Work
103	06D6	Pierre	Mobridge	11/17/2021	SD10 - from Pollock to US83	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work
104	06DL	Mitchell	Yankton	02/15/2023	I29 N & S - from Exit 26 near Vermillion N 10	Asphalt Concrete Resurfacing, PCC Pavement Repair, Box Culvert Extension (2-10x6 RCBC), Pipe Work
105	06DQ	Rapid City	Custer	09/20/2023	US18 W - Str 1.0 S of SD79 N Junction Over the Cheyenne River	Abutment, Berm, Joint Repair, Approach Slabs, Bridge Ends & Approach Pavement
106	06J3	Rapid City	Rapid City	05/02/2018	I-90 EBL & WBL - from W of Exit 67 to W of Exit 84	Microsurfacing
107	06J6	Mitchell	Mitchell	04/06/2022	US81 - from SD38 to the McCook/ Miner Co Line	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing, Pipe Work
108	06J7	Mitchell	Yankton	02/15/2023	SD46 - from Wagner to SD37	Cold Milling, Full Depth Reclamation, Asphalt Concrete Surfacing, Pipe Work, Modify Intersection, Guardrail
109	06K3	Rapid City	Custer	04/01/2020	Various Locations in the Rapid City Region	Intersection Improvements & Lighting
110	06N7	Mitchell	Sioux Falls	2/1/2023	Crooks along West Ave from Main St. to Executive Ave	Shared Use Path
111	06P0	Mitchell	Mitchell	11/02/2022	I-90 EBL & WBL - from Oacoma to 2 E of Chamberlain	Asphalt Concrete Resurfacing of Shoulders, Edge Drains, Repair Str Bridge, Joint & Spall Repair, Pipe Work, Lighting
112	06P9	Mitchell	Sioux Falls	07/17/2024	US81 - from N of NW 9th St in Madison to the Lake/Kingsbury/Brookings Co Line	Cold Milling, Full Depth Reclamation, Asphalt Concrete Surfacing, Pipe Work, Modify Intersection
113	06PD	Mitchell	Mitchell	01/19/2022	SD37 - NBL & SBL, from the W Junction of SD34 to S of SD224	Cold Milling, Rubbilize existing PCC, Edge Drains, Asphalt Concrete Surfacing, Pipe Work
114	06PF	Watertown	Aberdeen	03/06/2024	US212 – From the E City Limits of Clark to the Beginning of the Concrete near Watertown; US212 E & W, EF & WF - From 19th St to 458th Ave in Watertown	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work & Permanent Vehicle Classification System
115	06PJ	Aberdeen	Aberdeen	02/01/2023	US212 - from E of the W SD47 Junction to the Potter/Faulk Co Line	Asphalt Concrete Resurfacing, Pipe Work
116	06QD	Aberdeen	Aberdeen	02/01/2023	SD20 - from W of the Potter/Faulk Co Line to SD45	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing, Pipe Work

No.	PCN	Region	Area	Letting Date	Location	Description of Work
117	06QK	Rapid City	Custer	02/05/2025	US16A - from 2 E of Custer to SD36	Structure's (2-12'x12' CIP RCBC, 2-9'x7' CIP RCBC, 2-8'x7' CIP RCBC) & Approach Grading, Cold Milling, Asphalt Concrete Resurfacing
118	06QM	Aberdeen	Huron	10/19/2022	SD28 - from the Spink/Clark Co Line E 12	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing, Pipe Work
119	06R0	Pierre	Pierre	04/17/2024	SD34 - from Hughes/Hyde Co Line to the SD47 N Junction	Cold Milling, Asphalt Concrete Resurfacing, Full Depth Reclamation
120	06RN	Aberdeen	Huron	11/15/2023	SD26 - from SD45 to the Hand/Spink Co Line	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work (End Sections & Pipe Replacement)
121	06UM	Rapid City	Belle Fourche	10/19/2022	SD34 - from Belle Fourche to Whitewood	Asphalt Concrete Surfacing, Passing Lanes, Intersection Improvements & Pipe Work
122	06WX	Rapid City	Rapid City	02/05/2020	SD445 - Deadwood Ave and Krebs Drive	Grading, Storm Sewer, C&G, PCC Surfacing, Pavement Marking & Signing
123	06Y8	Mitchell	Sioux Falls	01/22/2020	Various Routes in the Sioux Falls Area	Asphalt Surface Treatment
124	06X2	Mitchell	Sioux Falls	04/21/2021	I29 - Exits 78 (26th St), 81 (Maple St.) & 83 (60th St) in Sioux Falls	Approach Slab Replacement, Epoxy Chip Seal, LSDC Overlay, Approach Pavement, PCC Pavement Repair, PCC Ditch Liner Repair & A
125	06YX	Aberdeen	Huron	04/01/2020	Various Locations in the Huron Area	Asphalt Surface Treatment
126	0702	Rapid City	Rapid City	03/03/2021	Various Routes in the Rapid City Area	Asphalt Surface Treatment, Rout & Seal
127	070C	Pierre	Pierre	06/02/2021	Various Routes in the Pierre Area	Pavement Restoration
128	070F	Pierre	Pierre	05/01/2019	Various Routes in the Pierre Region	Microsurfacing
129	0745	Aberdeen	Watertown	03/20/2024	Watertown along Lake Kampeska from Parkview Drive to Marina Drive	Asphalt Concrete Shared Use Path & 8x8 CIP RCBC Extension
130	076A	Mitchell	Sioux Falls	01/19/2022	Structure 9 N of Egan on 478th Ave over the Big Sioux River SN 51-120-044	Structure (245' Prestressed Girder) & Approach Grading
131	07CY	Mitchell	Sioux Falls	05/15/2024	I229 - for Cliff Ave	Temporary Grading, Asphalt Concrete Surfacing, Temporary Structure Installation & Large Block Concrete Retaining Walls, Cross
132	07JR	Rapid City	Belle Fourche	08/05/2020	SD79 - 10 NE of SD168 Over Frog Creek	Structure (2-12'x12' CIP Box Culvert) & Approach Grading
133	07KM	Rapid City	Custer	04/14/2021	Various Routes in the Custer Area	Asphalt Surface Treatment
134	07KN	Aberdeen	Huron	04/14/2021	Various Routes in the Huron Area	2021 Asphalt Surface Treatment
135	07KQ	Pierre	Pierre	03/17/2021	Various Routes in the Pierre & Winner Areas	Asphalt Surface Treatment
136	07KT	Pierre	Winner	03/03/2021	Various Routes in the Winner Area	Asphalt Surface Treatment
137	07KY	Rapid City	Belle Fourche	05/19/2021	Various Routes in the Belle Fourche & Custer Areas	Pavement Restoration, NGCS Grinding, Asphalt Concrete Surfacing, Median Ditch Repair & Weigh-In-Motion Upgrades

No.	PCN	Region	Area	Letting Date	Location	Description of Work
138	07ME	Rapid City	Belle Fourche	11/17/2021	Structure 1 N & 4.3 W of Newell on Orman Rd over a Ck (SN 10-267-330)	Structures (82' Prestressed Girder, 5-12'x11 CIP RCBC, 103' Prestressed Girder, 150' Continuous Concrete) & Approach Grading
139	07Y2	Rapid City	Belle Fourche	12/13/2023	US85 - from Ludlow to the ND State Line	Full Depth Reclamation, Cold Milling, Asphalt Concrete Surfacing, Pipe Work (Repair Joints, 24" CIPP, 36" CIPP, Slip line 66")
140	07Y7	Mitchell	Yankton	10/04/2023	US18 - from SD25 to US81	Cold Milling & Asphalt Concrete Surfacing
141	07YF	Pierre	Winner	11/02/2022	SD53 - from SD44 N 11	Full Depth Reclamation, Otta Seal & Blotter Surfacing
142	07YU	Aberdeen	Huron	01/11/2023	SD45 - from Miller to US212	Cold Milling Asphalt Concrete & Asphalt Concrete Resurfacing
143	080F	Mitchell	Yankton	12/01/2021	SD50, SD50E, SD50W – from 1 W of Tyndall through Tabor	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work
144	081A	Rapid City	Rapid City	02/025/2025	I90 E & W - 3 SE of Exit 23 (Whitewood) over Spring Ck	LSDC Overlay, Approach Slabs, Approach Rail
145	084E	Mitchell	Yankton	09/06/2023	Structure 0.8 N & 4 W of Scotland on 419th Ave over Dawson Creek SN 05-180-002	Structure (2-10x9 CIP RCBC, 3-10x10 CIP RCBC, 3-11x6 CIP RCBC) & Approach Grading
146	088G	Aberdeen	Aberdeen	03/16/2022	Various Routes in the Aberdeen Area	Asphalt Surface Treatment
147	088L	Aberdeen	Huron	02/15/2023	Various Routes in the Huron Area	Asphalt Surface Treatment
148	088M	Mitchell	Mitchell	04/20/2022	Various Locations in the Mitchell Area	Asphalt Surface Treatment
149	088Q	Pierre	Mobridge	04/06/2022	Various Locations in the Mobridge Area	Asphalt Surface Treatment
150	088R	Rapid City	Pierre	04/06/2022	Various Locations in the Pierre Area	Asphalt Surface Treatment
151	088T	Mitchell	Sioux Falls	02/16/2022	Various Locations in the Sioux Falls Area	Asphalt Surface Treatment
152	088V	Pierre	Winner	05/04/2022	Various Locations in the Winner Area	Asphalt Surface Treatment & Rout & Seal
153	089E	Rapid City	Custer	03/01/2023	Various Locations in the Custer Area	Microsurfacing
154	089Q	Pierre	Winner	09/07/2022	Various Locations in the Winner Area	PCC Pavement Grinding, Asphalt Concrete Surfacing of Shoulders
155	08ED	Mitchell	Sioux Falls	03/01/2023	Dell Rapids - along the W side of 474th Ave from W 10th St to W 7th St	PCC Shared Use Path
156	08H9	Pierre	Winner	04/16/2025	US18 - 0.5 E of US183N over Cottonwood Creek, 1.4 W of Winner over Dog Ear Creek, 5 SE of Winner over Creek, 3.9 E of US183N over Big Hollow Creek & 2 SE of Winner over Sand Creek	LSDC Overlay
157	08N5	Aberdeen	Watertown	05/15/2024	Structure 4.5 E & 1 N of Rosholt on 104th St over a Ck SN 55-283-040	Structure (3-12'x8' CIP RCBC) & Approach Grading
158	08P3	Rapid City	Rapid City	03/22/2023	South Rochford Rd from Rochford SW to Deerfield Rd	Grading, Drainage, Base Course, Asphalt Concrete Surfacing
159	08R4	Aberdeen	Aberdeen	03/22/2023	Various Locations in the Aberdeen Area	Asphalt Surface Treatment

No.	PCN	Region	Area	Letting Date	Location	Description of Work
160	08R7	Pierre	Mobridge	04/19/2023	Various Locations in the Mobridge Area	Asphalt Surface Treatment
161	08R8	Pierre	Pierre	03/01/2023	Various Routes in the Pierre Area	Asphalt Surface Treatment
162	08RD	Mitchell	Sioux Falls	02/15/2023	Various Locations in the Sioux Falls Area	Asphalt Surface Treatment, Rout & Seal
163	08RE	Rapid City	Watertown	01/11/2023	Various Locations in the Watertown Area	Asphalt Surface Treatment & Flush Seal
164	08RK	Rapid City	Rapid City	02/01/2023	Various Locations in the Rapid City Area	Microsurfacing & Asphalt Concrete Patching
165	08RL	Pierre	Winner	02/01/2023	Various Locations in the Winner Area	Microsurfacing
166	08XW	Aberdeen	Watertown	10/18/2023	US81 - from Arlington to SD28	Cold Milling, Asphalt Concrete Resurfacing, Shoulder Surfacing
167	08XY	Mitchell	Yankton	10/18/2023	I-29 N - from Exit 2 to the NCL of North Sioux City, I-29 S - from N of Exit 1 to the NCL of North Sioux City	Cold Milling, Asphalt Concrete Resurfacing of Shoulders, Modify NB Off Ramp, Lighting
168	0970	Aberdeen	Huron	04/04/2024	Various Locations in the Huron Area	Asphalt Surface Treatment
169	0971	Mitchell	Mitchell	06/05/2024	Various Locations in the Mitchell Area	Asphalt Surface Treatment
170	0975	Mitchell	Sioux Falls	03/05/2025	Various Locations in the Sioux Falls Area	Asphalt Surface Treatment
171	096U	Aberdeen	Aberdeen	02/07/2024	Various Locations in the Aberdeen Area	Asphalt Surface Treatment & Flush Seal
172	096V	Rapid City	Belle Fourche	03/06/2024	Various Locations in the Belle Fourche Area	Asphalt Surface Treatment
173	09E7	Mitchell	Yankton	02/12/2025	I-29 N & S - From North Sioux City to N of Exit 26 (SD50 - Vermillion); From 3 S of Exit 38 (Volin) to 1 S of Exit 38 (Volin)	Cold Milling, Asphalt Concrete Resurfacing of Shoulders & Ramps & Crossroads, Durable Pavement Marking & Guardrail
174	09L0	Mitchell	Mitchell	04/16/2025	Various Locations in the Mitchell Area	Asphalt Surface Treatment
175	09L6	Aberdeen	Watertown	04/02/2025	Various Routes in the Watertown Area	Asphalt Surface Treatment
176	09QY	Aberdeen	Aberdeen	04/16/2025	US281, US281 N & S - Fm 0.1 S of US12 to 5th Ave NW in Aberdeen	Cold Milling, Asphalt Concrete Resurfacing of Shoulders
177	4437	Mitchell	Sioux Falls	03/20/2013	Cliff Ave - from N 60th Street N to Dike Dr. & I90, Cliff Ave Interchange & Structures 1.3 E of I29, 1.1 & 0.8W of SD115 Over the Big Sioux River, Silver Creek & Railroad; Over RR, 0.9 E of I29, MRM 397.45	Grading, PCC Surfacing, Structures, Bridge Rehabilitation, Curb and Gutter, Traffic Signals, and Lighting
178	5777	Rapid City	Rapid City	04/01/2020	Sheridan Lake Road from the junction of US385 to Alberta Road	Grading, Asphalt Concrete Surfacing, C&G, Structures (20' x 12' Precast RCBC & 9' x 8' Precast RCBC) & Storm Sewer
179	6597	Mitchell	Yankton	07/26/2005	2 E & 2.6 N of Utica Over Beaver Creek	Structure & Approach Grading (110' Comp Prestressed Girder Bridge)
180	6932	Pierre	Winner	04/14/2004	US14 FM MIDLAND W 16.5 MI	Microsurfacing

No.	PCN	Region	Area	Letting Date	Location	Description of Work
181	H021	Rapid City	Rapid City	2/16/2011	Anamosa St from Haines Ave to Midway St in Rapid City	Grading, PCC Pavement, Curb & Gutter, Storm Sewer, Roadway Lighting, and Structures
182	H096	Pierre	Pierre	01/27/2010	9 N & 10.1 W of Presho Over a Creek	Structure and Approach Grading (65' Prestressed Concrete Double Tee)
183	I2M0	Rapid City	Custer	06/04/2012	Begin divided North of Hot Springs to the county line	Microsurfacing (Shoulder Repair)
184	I30T	Rapid City	Rapid City	11/06/2013	From Fall River/Custer co line N	Microsurfacing (Shoulder Repair)
185	I5L0	Rapid City	Custer	04/15/2020	US 16 from the Wyoming border to 1.5 W of Jewel Cave	PCCP repair
186	I5UM	Aberdeen	Aberdeen	05/25/2022	US 12 E, at the BNSF Railroad crossing	Resurface Asphalt Approaches to the bridge
187	I6JL	Aberdeen	Aberdeen	09/02/2021	Replace Culvert on SD25 8.9 Miles North of Webster	Replace Culvert on SD25 North of Webster
188	I7C2	Aberdeen	Watertown	12/08/2023	SD20 through Watertown	PCCP Repair
189	I7XC	Rapid City	Rapid City	06/30/2025	In Box Elder and east of New Underwood	Microsurfacing

Appendix L: 51 SDDOT Projects Reviewed for Construction Inspection Daily Diary Events

No.	PCN	Region	Location	Description of Work
1	01DX	Pierre	Structure 2.9N of Witten over Cottonwood Creek SN 62-080-201	Witten over Cottonwood Creek Structure (92' Prestressed Girder Bridge) & Approach Grading
2	00X9	Rapid City	SD44 - (Jackson Blvd.) from Rapid Creek to Mt View Rd in Rapid City; SD44 - Str 1.2 SW of the junction of Mt View Road in Rapid City over Rapid Creek	Urban Grading, Storm Sewer, C&G, Sidewalk, Lighting, Signals, PCC Surfacing, Bridge Deck Overlay & Approach Slabs
3	021G	Rapid City	I90 EBL - from W of Exit 37 (Pleasant Valley) to Exit 40 (Tilford)	I-90 Grading, PCC Surfacing, Replace Str (278' Steel Girder, 2-7x6 CIP, 20x10 CIP, Long Span Arch Ext., 3-8x4 CIP, 9x8 Precast)
4	035F	Rapid City	I90 E & W - Strs 3.3 E of the Wasta Interchange Over Bull Ck	I-90 Replace Structure ((2) 394.5' Prestressed Girder Bridges), Approach Grading, Asphalt Surfacing
5	036E	Pierre	US83 - from N. of the Mellette/Jones Co. Line to S of Murdo	US83 Grading, Structures (164' Continuous Conc Bridge & 2 Box Culverts), Interim Surfacing
6	038Z	Pierre	SD1806 - from the Lyman/Stanley Co Line N 14.7; Str 11.2 SE of US83 over Antelope Ck	Cold Milling & Asphalt Concrete Resurfacing, Pipe Work, Deck Overlay, Approach Guardrail, Slope and Ditch Channel Grading
7	04DK	Pierre	I90 - Strs, Over 282 Ave 3 E of the Draper Interchange; Over a creek 5.5 W of the US83 N Interchange; Over 286 Ave 4.7 W of the US83 N Interchange	I-90 Polymer Chip Seal, LSDC Overlay, Joints, Berm Repair, Replace Approach Slabs, Drop Inlets, Approach Pavement, Guardrail, Curb
8	04F0	Mitchell	SD52 - from SD37 to SD50	SD52 Asphalt Concrete Surfacing, Approach Slab, Guardrail
9	04FC	Rapid City	US18 - In Pine Ridge from 2 Blocks N of SD407 to E of Indian Health Rd	US18 Urban Grading, Curb & Gutter, Storm Sewer, Lighting, PCC Surfacing, ADA, Signal
10	04PD	Rapid City	SD44 - from LaCrosse St to Covington St in Rapid City	SD44 ADA Curb Ramps, Sidewalk, Signals & Intersection Improvement
11	04X5	Aberdeen	SD26 - from SD47 to SD45	SD26 Cold Milling, Asphalt Concrete Resurfacing, Pipe Work
12	04XK	Mitchell	I-229 Exit 9 (Benson Rd) in Sioux Falls	I-229 Modify Interchange, Grading, PCC Surfacing
13	04XT	Rapid City	US18E - from Smithwick Road to the S Junction of US385 on the Original Lanes of the Heartland Expressway	US18 Cold Milling Asphalt Concrete & Asphalt Concrete Resurfacing; Reconstruction of Select Vertical Curves, Asphalt Concrete Surfacing
14	05TQ	Rapid City	SD34 - from Regent St in Sturgis E to E of SD79	Cold Mill Asphalt Concrete, Asphalt Concrete Resurfacing, Pipe Work, Structure Replacement & Approach Grading, Intersection I
15	05F9	Mitchell	I29 N/S - 1 N of Exit 98 (Dell Rapids); 1.2 N Minnehaha Co. Line; 3.8 S of Exit 109 (Colman); 3 S of Exit 109 (Colman)	I-29 High Friction Surface Treatment, Polymer Chip Seal, Deck Repair, Curb Repair, Approach Slabs, Replace Joint

No.	PCN	Region	Location	Description of Work
16	05GY	Aberdeen	SD127 - Strs 5.2 E of SD106 over a creek & 5.6 E of SD106 over a creek	SD127 Replace Structures (3-9' x 6' CIP or Precast RCBC, 2-10' x 6' CIP or Precast RCBC) & Approach Grading
17	05J4	Aberdeen	SD15 - from the N Junction of SD20 N to Milbank	SD15 Cold Milling, Asphalt Concrete Surfacing, Guardrail, Pipe work
18	05TX	Aberdeen	US212 - From Doland to 6 W of Clark	US212 Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing & Pipe Work
19	065D	Mitchell	I90 - 470th Ave Str over I90, 2.1 W of I29	Bridge Deck Overlay, Asphalt Concrete Resurfacing of Approaches
20	065L	Mitchell	I-29 - Strs, Exit 1 (Dakota Dunes); Exit 18 (Elk Point); 0.2 N of Exit 18 (Elk Point) over RR	I-29 Polymer Chip Seal, Replace Abutments, Berm Repair, Replace Joints, Approach Slabs, Approach Pavement, Approach Guardrail, End
21	065N	Aberdeen	I-29 - Strs 2 S of the Exit 224 (Peever); Exit 232 (Sisseton)	I-29 Polymer Chip Seal, Approach Slabs, Joints, End Block Modification, Approach Surfacing, Approach Guardrail
22	068V	Rapid City	US212 - from SD79 in Newell to the Maurine/Bixby Rd	US212 Cold Milling, Asphalt Concrete Resurfacing, Pipe Work, Guardrail Upgrades
23	069F	Aberdeen	SD47 - from N of SD26 to the US212 E Junction	SD47 Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing & Culvert Repairs
24	06CF	Mitchell	I229 - Exit 2 (Western Ave) in Sioux Falls	I-229 Ramp Improvement, LSDC Overlay, Approach Slabs, Approach Pavement, Replace Steel Pedestrian Rail
25	06DQ	Rapid City	US18 W - Str 1.0 S of SD79 N Junction Over the Cheyenne River	Abutment, Berm, Joint Repair, Approach Slabs, Bridge Ends & Approach Pavement
26	06K3	Rapid City	Various Locations in the Rapid City Region	Intersection Improvements & Lighting (Various Locations)
27	06MM	Mitchell	I229 Exit 9 (Benson Rd) in Sioux Falls	Modify interchange, grading PCC surfacing
28	06N3	Rapid City	US18 - In Pine Ridge, from 2 Blocks N of SD407 to E of Indian Health Rd	Urban Grading, Curb & Gutter, Storm Sewer, Lighting, PCC Surfacing, ADA, Signal
29	06N7	Mitchell	Crooks along West Ave from Main St. to Executive Ave	Along West Ave Shared Use Path
30	06QM	Aberdeen	SD28 - from the Spink/Clark Co Line E 12	SD28 Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing, Pipe Work
31	06RN	Aberdeen	SD26 - from SD45 to the Hand/Spink Co Line	SD26 Cold Milling, Asphalt Concrete Resurfacing, Pipe Work (End Sections & Pipe Replacement)
32	06TQ	Mitchell	I29 N/S - 1 N of Exit 98 (Dell Rapids); 1.2 N Minnehaha Co. Line; 3.8 S of Exit 109 (Colman); 3 S of Exit 109 (Colman)	High Friction Surface Treatment, Polymer Chip Seal, Deck Repair, Curb Repair, Approach Slabs, Replace Joint
33	06UM	Rapid City	SD34 - from Belle Fourche to Whitewood	Asphalt Concrete Surfacing, Passing Lanes, Intersection Improvements & Pipe Work
34	06X2	Mitchell	I29 - Exits 78 (26th St), 81 (Maple St.) & 83 (60th St) in Sioux Falls	I-29 Approach Slab Replacement, Epoxy Chip Seal, LSDC Overlay, Approach Pavement, PCC Pavement Repair, PCC Ditch Liner Repair
35	0745	Aberdeen	Watertown along Lake Kampeska from Parkview Drive to Marina Drive	Parkview Drive to Marina Drive Asphalt Concrete Shared Use Path & 8x8 CIP RCBC Extension

No.	PCN	Region	Location	Description of Work
36	076A	Mitchell	Structure 9 N of Egan on 478th Ave over the Big Sioux River SN 51-120-044	478th Ave over Big Sioux River Structure (245' Prestressed Girder) & Approach Grading
37	07KM	Rapid City	Various Routes in the Custer Area	Asphalt Surface Treatment (Various Routes)
38	07KY	Rapid City	Various Routes in the Belle Fourche & Custer Areas	Pavement Restoration, NGCS Grinding, Asphalt Concrete Surfacing, Median Ditch Repair & Weigh In Motion Upgrades (Various Routes)
39	07ME	Rapid City	Structure 1 N & 4.3 W of Newell on Orman Rd over a Ck (SN 10-267-330)	Norman Rd over a creek Cold Mill Asphalt Concrete, Asphalt Concrete Resurfacing, Pipe Work, Structure Replacement & Approach Grading, Intersection I
40	07VR	Rapid City	I90 EBL - From W of Exit 37 (Pleasant Valley) to Exit 40 (Tilford)	Grading, PCC Surfacing, Replace Str (278' Steel Girder, 2-7x6 CIP, 20x10 CIP, Long Span Arch Ext., 3-8x4 CIP, 9x8 Precast)
41	07Y7	Mitchell	US18 - from SD25 to US81	US18 Cold Milling & Asphalt Concrete Surfacing
42	07YU	Aberdeen	SD45 - from Miller to US212	SD45 Cold Milling Asphalt Concrete and Asphalt Concrete Resurfacing
43	07YV	Aberdeen	SD45 - From Miller to US212	Cold Milling Asphalt Concrete & Asphalt Concrete Resurfacing
44	088V	Pierre	Various Locations in the Winner Area	Asphalt Surface Treatment & Rout & Seal (Various Locations)
45	08ED	Mitchell	Dell Rapids - along the W side of 474th Ave from W 10th St to W 7th St	W side of 474th Ave PCC Shared Use Path
46	0818	Mitchell	I229 - Exit 2 (Western Ave) in Sioux Falls	Ramp Improvement, LSDC Overlay, Approach Slabs, Approach Pavement, Replace Steel Pedestrian Rail
47	08N5	Aberdeen	Structure 4.5 E & 1 N of Rosholt on 104th St over a Ck SN 55-283-040	104th Street Structure (3-12'x8' CIP RCBC) & Approach Grading
48	08QM	Mitchell	I229 Exit 9 (Benson Rd) in Sioux Falls	Modify Interchange, Grading, PCC Surfacing
49	08QQ	Rapid City	I90 EBL - From W of Exit 37 (Pleasant Valley) to Exit 40 (Tilford)	Grading, PCC Surfacing, Replace Str (278' Steel Girder, 2-7x6 CIP, 20x10 CIP, Long Span Arch Ext., 3-8x4 CIP, 9x8 Precast)
50	08R0	Mitchell	Various Routes in the Sioux Falls Area	Rout and Seal (Various Routes)
51	08XW	Aberdeen	US81 - from Arlington to SD28	US281 Cold Milling, Asphalt Concrete Resurfacing, Shoulder Surfacing

Appendix M: 83 SDDOT Projects Reviewed for Field Personnel Staffing

No.	PCN	No. of Field Techs	3420 Quantity (Total Hours)	3420 Salary	3420 Benefits	Start Date	Finish Date	Region	Location	Description of Work	Classification
1	01KN	6	615.5	\$13,841.40	\$2,116.67	07/22/20	03/15/21	Rapid City	Structure 4.5N & 2W of Spearfish over the Redwater River SN 41-070-012	Structure (74' Concrete Bulb Tee Bridge)& Approach Grading	Bridge / New Structure
2	02EC	13	126.0	\$2,996.43	\$1,523.20	12/20/21	08/30/22	Mitchell	Structure 5 S & 6.6 W of Howard over Rock Creek SN 49-094-180	Structure (4-11x18 CIP RCBC) & Approach Grading	Bridge / New Structure
3	02E8	10	2,652.4	\$65,837.05	\$38,086.34	11/30/21	08/09/23	Rapid City	Str 4E & 1.8N of Edgemont over abandoned RR line SN 24-162-102	Structure (178' Prestressed Girder) & Approach Grading	Bridge / New Structure
4	08N5	5	337.5	\$9,356.62	\$3,854.96	07/30/24	11/13/24	Aberdeen	Structure 4.5 E & 1 N of Rosholt on 104th St over a Ck SN 55-283-040	Structure (3-12'x8' CIP RCBC) & Approach Grading	Bridge / New Structure
5	07ME	11	1,146.1	\$27,987.72	\$17,302.34	02/22/22	08/06/24	Rapid City	Structure 1 N & 4.3 W of Newell on Orman Rd over a Creek (SN 10-267-330)	Structures (82' Prestressed Girder, 5-12'x11 CIP RCBC, 103' Prestressed Girder, 150' Continuous Concrete) & Approach Grading	Bridge / New Structure
6	07JR	8	307.9	\$7,063.21	\$3,619.74	08/03/21	06/07/22	Rapid City	SD79 - 10 NE of SD168 Over Frog Creek	Structure (2-12'x12' CIP Box Culvert) & Approach Grading	Bridge / New Structure
7	08RE	4	242.8	\$6,243.07	\$2,069.51	06/01/23	06/26/23	Rapid City	Various Locations in the Watertown Area	Asphalt Surface Treatment & Flush Seal	Surface Treatment / Seal
8	065L	15	1,218.3	\$34,384.25	\$12,146.69	09/14/23	05/14/25	Mitchell	I-29 - Strs, Exit 1 (Dakota Dunes); Exit 18 (Elk Point); 0.2 N of Exit 18 (Elk Point) over RR	Polymer Chip Seal, Replace Abutments, Berm Repair, Replace Joints, Approach Slabs, Approach Pavement, Approach Guardrail, End	Bridge Preservation
9	08XY	15	1,006.5	\$27,792.65	\$9,952.66	05/23/24	04/08/25	Mitchell	I-29 N - from Exit 2 to the NCL of North Sioux City, I-29 S - from N of Exit 1 to the NCL of North Sioux City	Cold Milling, Asphalt Concrete Resurfacing of Shoulders, Modify NB Off Ramp, Lighting	Mill & AC Overlay
10	06DL	16	2,368.3	\$76,212.59	\$32,473.61	03/21/23	04/10/24	Mitchell	I-29 N & S - from Exit 26 near Vermillion N 10	Asphalt Concrete Resurfacing, PCC Pavement Repair, Box Culvert Extension (2-10x6 RCBC), Pipe Work	AC Surfacing
11	06X2	20	4,458.0	\$113,779.81	\$68,074.70	05/19/21	07/02/24	Mitchell	I29 - Exits 78 (26th St), 81 (Maple St.) & 83 (60th St) in Sioux Falls	Approach Slab Replacement, Epoxy Chip Seal, LSDC Overlay, Approach Pavement, PCC Pavement Repair, PCC Ditch Liner Repair & A	Bridge Preservation
12	00GP	4	892.4	\$18,958.29	\$11,564.55	02/12/21	09/03/21	Rapid City	I-90 EBL & WBL - from Exit 32 (Sturgis) to Exit 40 (Tilford)	Construct Median and Ramp Crossovers	Grading / Reconstruction
13	021G	27	11,130.8	\$304,189.70	\$157,232.38	5/12/2022	05/01/25	Rapid City	I-90 EBL - from W of Exit 37 (Pleasant Valley) to Exit 40 (Tilford)	Grading, PCC Surfacing, Replace Str (278' Steel Girder, 2-7x6 CIP, 20x10 CIP, Long Span Arch Ext., 3-8x4 CIP, 9x8 Precast)	Bridge / New Structure

No.	PCN	No. of Field Techs	3420 Quantity (Total Hours)	3420 Salary	3420 Benefits	Start Date	Finish Date	Region	Location	Description of Work	Classification
14	06P0	17	5,904.8	\$169,163.04	\$73,470.61	12/13/22	07/01/24	Mitchell	I-90 EBL & WBL - from Oacoma to 2 E of Chamberlain	Asphalt Concrete Resurfacing of Shoulders, Edge Drains, Repair Str Bridge, Joint & Spall Repair, Pipe Work, Lighting	Bridge Preservation
15	06CF	12	1,304.0	\$38,733.79	\$19,417.07	07/10/23	03/08/24	Mitchell	I-229 - Exit 2 (Western Ave) in Sioux Falls	Ramp Improvement, LSDC Overlay, Approach Slabs, Approach Pavement, Replace Steel Pedestrian Rail	Bridge Preservation
16	07CY	12	523.5	\$14,306.12	\$6,120.58	06/25/24	03/25/25	Mitchell	I-229 - for Cliff Ave	Temporary Grading, Asphalt Concrete Surfacing, Temporary Structure Installation & Large Block Concrete Retaining Walls, Cross	AC Surfacing
17	088V	7	1,404.5	\$36,187.02	\$18,173.74	05/23/22	05/03/23	Pierre	Various Locations in the Winner Area	Asphalt Surface Treatment & Rout & Seal	Surface Treatment / Seal
18	04XK	25	8,439.8	\$241,974.43	\$107,121.37	03/16/23	02/02/26	Mitchell	I-229 Exit 9 (Benson Rd) in Sioux Falls	Modify Interchange, Grading, PCC Surface	Grading / Reconstruction
19	065N	5	668.0	\$17,023.40	\$7,596.94	05/30/23	01/18/24	Aberdeen	I-29 - Strs 2 S of the Exit 224 (Peever); Exit 232 (Sisseton)	Polymer Chip Seal, Approach Slabs, Joints, End Block Modification, Approach Surfacing, Approach Guardrail	Bridge Preservation
20	035F	15	2,192.6	\$60,412.23	\$26,934.00	02/26/25	01/08/26	Rapid City	I-90 E & W - Strs 3.3 E of the Wasta Interchange Over Bull Ck	Replace Structure (2) 394.5' Prestressed Girder Bridges, Approach Grading, Asphalt Surfacing	Bridge / New Structure
21	04DK	13	1,463.5	\$40,256.92	\$20,437.12	04/12/23	10/03/23	Pierre	I-90 - Strs, Over 282 Ave 3 E of the Draper Interchange; Over a creek 5.5 W of the US83 N Interchange; Over 286 Ave 4.7 W of the US83 N Interchange	Polymer Chip Seal, LSDC Overlay, Joints, Berm Repair, Replace Approach Slabs, Drop Inlets, Approach Pavement, Guardrail, Curb	Bridge Preservation
22	05T4	16	3,969.9	\$122,583.15	\$46,890.01	02/13/24	09/23/25	Mitchell	I-90 E & W - From 8 E of Chamberlain to White Lake	Asphalt Concrete Milling & Asphalt Concrete Resurfacing	Mill & AC Overlay
23	08R4	4	558.0	\$15,947.44	\$8,068.77	06/21/23	09/01/23	Aberdeen	Various Locations in the Aberdeen Area	Asphalt Surface Treatment	Surface Treatment / Seal
24	096U	2	100.0	\$2,560.22	\$1,054.80	05/13/24	06/07/24	Aberdeen	Various Locations in the Aberdeen Area	Asphalt Surface Treatment & Flush Seal	Surface Treatment / Seal
25	05HT	17	437.5	\$13,492.51	\$6,788.91	11/30/22	05/20/24	Aberdeen	US12 EBL & WBL - from E of the Aberdeen Airport to E of Bath	Grading, PCC Surfacing, Lighting & Structure (12x12 CIP RCBC)	Grading / Reconstruction
26	068A	7	433.5	\$10,993.60	\$7,101.91	06/21/22	11/08/22	Pierre	US12 - from the Perkins/Corson Co Line to Morristown	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing, Pipe Work	Mill & AC Overlay
27	068D	7	1,340.50	\$34,303.50	\$22,160.14	05/03/22	10/27/22	Pierre	US12 & US12 EBL & WBL - from Mobridge E City Limits to S of Selby	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing & Pipework	Mill & AC Overlay
28	07KN	5	325.50	\$9,362.21	\$6,021.34	05/24/22	01/17/23	Aberdeen	Various Routes in the Huron Area	2021 Asphalt Surface Treatment	Surface Treatment / Seal

No.	PCN	No. of Field Techs	3420 Quantity (Total Hours)	3420 Salary	3420 Benefits	Start Date	Finish Date	Region	Location	Description of Work	Classification
29	04XQ	10	460.50	\$10,857.23	\$5,459.42	06/24/21	10/08/24	Pierre	US14 - from W of SD1804 to the US83 N Junction (Blunt Junction)	Asphalt Concrete Resurfacing, Pipe Work	AC Surfacing
30	05U1	8	1,522.80	\$37,501.95	\$19,970.42	03/22/21	08/24/21	Rapid City	US14 - from E of Wall to Cottonwood; US14 - 3.8 W of the Jackson Co Line Over a Branch of Cottonwood Creek	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work, Replace Str (2-12x6 CIP RCBC) & Approach Grading.	Bridge / New Structure
31	05HU	12	2,818.00	\$77,742.84	\$36,973.40	03/15/23	12/27/23	Aberdeen	US14 E & W - from S of Arlington to E of the S US81 Junction	Grading, Rubbilize PCC, Asphalt Concrete Surfacing	Grading / Reconstruction
32	03TH	24	17,820.90	\$481,124.72	\$255,312.83	12/01/21	12/30/25	Rapid City	US18 - from US385 to the Hot Springs City Limits	Urban Reconstruction, PCC Surfacing, Curb & Gutter, Sidewalk, Lighting, Signals	Urban Reconstruction
33	04FD	18	5,770.00	\$129,664.92	\$75,313.97	01/29/21	11/15/22	Pierre	US18 - from W of Monroe St to Lincoln St in Winner, US18E&W - from Lincoln St to 3rd St in Winner, & US18 - from 3rd St to 7th St in Winner	Grading, Storm Sewer, Curb & Gutter, Sidewalk, Roadway Lighting, Traffic Signals & Portland Cement Concrete Surfacing, water meter	Urban Reconstruction
34	04XT	13	5,252.90	\$129,879.56	\$74,007.30	11/30/20	07/25/22	Rapid City	US18E - from Smithwick Road to the S Junction of US385 on the Original Lanes of the Heartland Expressway	Cold Milling Asphalt Concrete & Asphalt Concrete Resurfacing; Reconstruction of Select Vertical Curves, Asphalt Concrete Surface	Grading / Reconstruction
35	04V9	21	4,212.10	\$121,762.67	\$64,308.19	12/21/21	01/31/25	Mitchell	US18 - Str 0.8 N of Pickstown Over Saint Francis Bay; US18 - from Pickstown to Lake Andes	Replace Structure (225' Prestressed Girder Bridge), Approach Grading; Spot Grading, Pipe Work, Interim Surfacing; Intersection	Bridge / New Structure
36	06DQ	7	693.30	\$16,665.95	\$6,814.74	02/06/24	01/21/25	Rapid City	US18 W - Str 1.0 S of SD79 N Junction Over the Cheyenne River	Abutment, Berm, Joint Repair, Approach Slabs, Bridge Ends & Approach Pavement	Bridge Preservation
37	05TT	8	1,021.00	\$30,776.50	\$15,596.58	05/01/23	04/26/24	Mitchell	US18 - from Pickstown to Lake Andes	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing	Mill & AC Overlay
38	07Y7	13	1,087.00	\$31,771.06	\$11,846.78	03/12/24	02/27/25	Mitchell	US18 - from SD25 to US81	Cold Milling & Asphalt Concrete Surfacing	Mill & AC Overlay
39	088M	14	1,533.00	\$36,211.19	\$17,722.41	05/19/22	01/23/23	Mitchell	Various Locations in the Mitchell Area	Asphalt Surface Treatment	Surface Treatment / Seal
40	05TQ	13	1,026.20	\$24,147.72	\$14,372.03	03/19/21	12/13/21	Rapid City	SD34 - from Regent St in Sturgis E to E of SD79	Cold Mill Asphalt Concrete, Asphalt Concrete Resurfacing, Pipe Work, Structure Replacement & Approach Grading, Intersection I	Bridge / New Structure
41	06PD	25	3,348.50	\$91,992.99	\$54,638.99	02/03/22	04/20/23	Mitchell	SD37 - NBL & SBL, from the W Junction of SD34 to S of SD224	Cold Milling, Rubbilize existing PCC, Edge Drains, Asphalt Concrete Surfacing, Pipe Work	Grading / Reconstruction

No.	PCN	No. of Field Techs	3420 Quantity (Total Hours)	3420 Salary	3420 Benefits	Start Date	Finish Date	Region	Location	Description of Work	Classification
42	027K	22	10,469.60	\$245,057.61	\$140,162.97	02/05/20	08/28/24	Rapid City	SD44 (Omaha St) - from Mt. View Rd to the start of the divided lanes near 12th St.	Grading, Structure Widening, Storm Sewer, Curb & Gutter, Sidewalk, Traffic Signals, PCC Surfacing, Lighting	Urban Reconstruction
43	04PD	17	3,654.70	\$82,861.80	\$47,348.66	02/22/22	08/23/23	Rapid City	SD44 - from LaCrosse St to Covington St in Rapid City	ADA Curb Ramps, Sidewalk, Signals & Intersection Improvement	Urban Reconstruction
44	080F	19	2,023.30	\$47,725.83	\$26,367.46	12/20/21	12/07/22	Mitchell	SD50, SD50E, SD50W – from 1 W of Tyndall through Tabor	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work	Mill & AC Overlay
45	06J6	12	1,102.30	\$31,205.83	\$18,670.17	09/12/22	11/25/25	Mitchell	US81 - from SD38 to the McCook/ Miner Co Line	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing, Pipe Work	Mill & AC Overlay
46	08XW	7	2,442.30	\$63,658.44	\$24,255.18	03/13/24	01/13/25	Aberdeen	US81 - from Arlington to SD28	Cold Milling, Asphalt Concrete Resurfacing, Shoulder Surfacing	Mill & AC Overlay
47	05FN	10	1,603.70	\$37,745.87	\$12,963.28	02/25/20	05/10/22	Rapid City	US212 - Str 2.3 W of SD79 Over Owl Ck.	Replace Structure (3-12'x12 CIP or Precast RCBC) and Approach Grading.	Bridge / New Structure
48	05TX	12	994.80	\$23,511.70	\$14,148.00	07/07/21	11/15/21	Aberdeen	US212 - From Doland to 6 W of Clark	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing & Pipe Work	Mill & AC Overlay
49	068V	16	4,465.90	\$119,144.01	\$66,639.41	01/25/22	04/24/24	Rapid City	US212 - from SD79 in Newell to the Maurine/Bixby Rd	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work, Guardrail Upgrades	Mill & AC Overlay
50	06PJ	8	1,018.50	\$32,662.10	\$16,578.74	10/06/23	06/18/24	Aberdeen	US212 - from E of the W SD47 Junction to the Potter/Faulk Co Line	Asphalt Concrete Resurfacing, Pipe Work	AC Surfacing
51	05DV	8	1,454.90	\$38,551.90	\$15,082.54	04/16/24	01/13/25	Aberdeen	US281 - Str 0.2 N of Junction US12 Over BNSF RR	Repair Embankment Settlement, Approach Pavement, Approach Slabs, Zone Painting	Bridge Preservation
52	08R0	3	307.00	\$7,833.00	\$4,010.50	05/23/23	09/12/23	Pierre	Various Routes in the Pierre Area	Pavement Restoration	Pavement Restoration / Grinding
53	070C	5	124.40	\$2,701.07	\$1,558.22	07/26/21	03/27/23	Pierre	Various Routes in the Pierre Area	Pavement Restoration	Pavement Restoration / Grinding
54	08R8	6	395.80	\$10,875.53	\$3,187.21	05/26/23	07/13/23	Pierre	Various Routes in the Pierre Area	Asphalt Surface Treatment	Surface Treatment / Seal
55	08R7	6	272.70	\$8,358.67	\$3,194.70	06/01/23	07/25/23	Pierre	Various Locations in the Mobridge Area	Asphalt Surface Treatment	Surface Treatment / Seal
56	089Q	8	874.00	\$21,983.50	\$11,071.53	04/11/23	09/21/23	Pierre	Various Locations in the Winner Area	PCC Pavement Grinding, Asphalt Concrete Surfacing of Shoulders	Pavement Restoration / Grinding
57	08RL	5	201.50	\$6,699.32	\$3,430.03	08/15/23	09/20/23	Pierre	Various Locations in the Winner Area	Microsurfacing	Surface Treatment / Seal
58	07KY	19	1,038.70	\$24,616.87	\$7,280.04	08/26/21	06/24/22	Rapid City	Various Routes in the Belle Fourche & Custer Areas	Pavement Restoration, NGCS Grinding, Asphalt Concrete Surfacing, Median Ditch Repair & Weigh-In-Motion Upgrades	Pavement Restoration / Grinding

No.	PCN	No. of Field Techs	3420 Quantity (Total Hours)	3420 Salary	3420 Benefits	Start Date	Finish Date	Region	Location	Description of Work	Classification
59	096V	7	1,083.50	\$33,400.64	\$13,761.11	04/19/24	09/11/24	Rapid City	Various Locations in the Belle Fourche Area	Asphalt Surface Treatment	Surface Treatment / Seal
60	06J7	16	2,337.20	\$64,504.79	\$28,242.15	03/28/23	09/08/23	Mitchell	SD46 - from Wagner to SD37	Cold Milling, Full Depth Reclamation, Asphalt Concrete Surfacing, Pipe Work, Modify Intersection, Guardrail	Mill & AC Overlay
61	0694	12	1,278.20	\$37,553.70	\$17,768.84	01/23/25	07/09/25	Rapid City	US385 - from N of Pactola Dam to 4 N of SD44	Asphalt Concrete Surfacing	AC Surfacing
62	06D6	10	898.50	\$21,520.30	\$13,045.12	05/05/22	04/27/23	Pierre	SD10 - from Pollock to US83	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work	Mill & AC Overlay
63	06YX	3	156.70	\$3,659.18	\$1,775.61	07/23/20	08/26/20	Aberdeen	Various Locations in the Huron Area	Asphalt Surface Treatment	Surface Treatment / Seal
64	088L	5	142.10	\$3,973.28	\$1,584.82	04/25/23	08/14/23	Aberdeen	Various Routes in the Huron Area	Asphalt Surface Treatment	Surface Treatment / Seal
65	04FR	16	4,475.40	\$104,252.80	\$58,714.25	01/22/21	06/02/23	Rapid City	SD20 - 4.2 & 5 E of the MT State Line Over the Little Missouri River & Over Valley Creek & 14.8 E of the E US85 Junction Over Sioux Creek	Structure (263' Prestressed Girder, 153' Prestressed Girder & 3-12'x8' CIP or Precast RCBC)& Approach Grading	Bridge / New Structure
66	06QD	12	2,289.70	\$71,428.35	\$35,962.85	08/03/23	12/06/24	Aberdeen	SD20 - from W of the Potter/Faulk Co Line to SD45	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing, Pipe Work	Mill & AC Overlay
67	05XC	7	1,115.00	\$35,929.06	\$14,802.80	05/01/24	10/31/24	Pierre	SD47 - from SD20 to US12	Asphalt Concrete Surfacing	AC Surfacing
68	069F	13	1,504.50	\$42,012.44	\$27,140.05	04/13/22	11/18/22	Aberdeen	SD47 - from N of SD26 to the US212 E Junction	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing & Culvert Repairs	Mill & AC Overlay
69	06WX	6	814.90	\$19,279.16	\$11,376.85	07/29/20	05/11/23	Rapid City	SD445 - Deadwood Ave and Krebs Drive	Grading, Storm Sewer, C&G, PCC Surfacing, Pavement Marking & Signing	Urban Reconstruction
70	088R	11	419.50	\$9,657.45	\$3,808.79	04/25/22	12/02/22	Rapid City	Various Locations in the Pierre Area	Asphalt Surface Treatment	Surface Treatment / Seal
71	088Q	8	642.50	\$15,394.17	\$6,951.19	05/26/22	08/23/22	Pierre	Various Locations in the Mobridge Area	Asphalt Surface Treatment	Surface Treatment / Seal
72	07KM	12	1,007.70	\$21,659.75	\$11,201.62	05/18/21	07/22/22	Rapid City	Various Routes in the Custer Area	Asphalt Surface Treatment	Surface Treatment / Seal
73	05J4	11	1,455.00	\$38,986.35	\$17,874.08	03/23/23	07/31/23	Aberdeen	SD15 - from the N Junction of SD20 N to Milbank	Cold Milling, Asphalt Concrete Surfacing, Guardrail, Pipework	Mill & AC Overlay
74	04X5	14	2,247.50	\$65,634.81	\$42,392.53	03/24/22	03/02/23	Aberdeen	SD26 - from SD47 to SD45	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work	Mill & AC Overlay
75	06RN	13	1,556.30	\$39,462.21	\$13,304.60	12/14/23	06/21/24	Aberdeen	SD26 - from SD45 to the Hand/Spink Co Line	Cold Milling, Asphalt Concrete Resurfacing, Pipe Work (End Sections & Pipe Replacement)	Mill & AC Overlay
76	06QM	14	1,002.40	\$26,088.15	\$11,209.65	12/06/22	09/29/23	Aberdeen	SD28 - from the Spink/Clark Co Line E 12	Cold Milling Asphalt Concrete, Asphalt Concrete Resurfacing, Pipe Work	Mill & AC Overlay

No.	PCN	No. of Field Techs	3420 Quantity (Total Hours)	3420 Salary	3420 Benefits	Start Date	Finish Date	Region	Location	Description of Work	Classification
77	07YU	12	1,902.80	\$57,076.27	\$26,278.39	04/12/23	11/20/23	Aberdeen	SD45 - from Miller to US212	Cold Milling Asphalt Concrete & Asphalt Concrete Resurfacing	Mill & AC Overlay
78	04F0	13	1,640.40	\$41,450.70	\$23,215.62	12/21/21	03/02/23	Mitchell	SD52 - from SD37 to SD50	Asphalt Concrete Surfacing, Approach Slab, Guardrail	Bridge Preservation
79	05GY	9	787.20	\$23,307.71	\$11,871.24	06/08/23	04/02/24	Aberdeen	SD127 - Strs 5.2 E of SD106 over a creek & 5.6 E of SD106 over a creek	Replace Structures (3-9' x 6' CIP or Precast RCBC, 2-10' x 6' CIP or Precast RCBC) & Approach Grading	Bridge / New Structure
80	05U7	13	1,105.50	\$33,977.04	\$13,801.00	03/28/24	05/06/25	Mitchell	SD46 - from US81 to Irene	Asphalt Concrete Surfacing	AC Surfacing
81	038Z	17	2,970.10	\$71,116.01	\$41,365.84	12/10/20	01/04/23	Pierre	SD1806 - from the Lyman/Stanley Co Line N 14.7; Str 11.2 SE of US83 over Antelope Ck	Cold Milling & Asphalt Concrete Resurfacing, Pipe Work, Deck Overlay, Approach Guardrail, Slope and Ditch Channel Grading	Mill & AC Overlay
82	06UM	13	2,440.80	\$72,329.22	\$36,856.38	11/15/22	04/25/24	Rapid City	SD34 - from Belle Fourche to Whitewood	Asphalt Concrete Surfacing, Passing Lanes, Intersection Improvements & Pipe Work	AC Surfacing
83	04K0	22	8,630.10	\$228,891.22	\$137,669.94	11/16/20	12/19/24	Mitchell	SD44 - from the E Junction of US281 to SD37 at Parkston	Shoulder Widening, Asphalt Concrete Surfacing of Shoulders, Pipe Work, Extend RCBC & Upgrade Bridge Approach Rail	AC Surfacing