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# ALDOT Research Project 931-071

Final Report

# DEVELOPMENT OF A WORKER SAFETY ASSESSMENT, RISK IDENTIFICATION, AND CONTROL PROGRAM FOR ALDOT

Prepared by
Wesley C. Zech
Jason T. Kirby
Lana Khalil Marji

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## ABSTRACT

This research examines the safety challenges faced by Transportation Maintenance Technicians (TMTs) at the Alabama Department of Transportation (ALDOT). By analyzing extensive injury data from 2009 to 2024, along with insights from surveys and interactions with ALDOT personnel, this effort highlights significant trends and relationships among injury characteristics such as nature, cause, source, and affected body parts. The findings reveal considerable costs and productivity losses associated with common injury types that warrant the need for targeted interventions.

By reviewing successful safety programs across various state Departments of Transportation (DOTs), the study identifies opportunities to enhance safety within ALDOT. This effort proposes a step-by-step job hazard analysis (JHA) approach tailored specifically for TMTs, complete with customized JHA forms ready for immediate use by ALDOT. Additionally, the research presents improved and revised First Report of Injury (FROI) forms to standardize reporting and enhance future injury analysis.

These measures are expected to reduce injury frequency and severity, manage associated costs, and foster a proactive safety culture within ALDOT. The study acknowledges limitations, such as absence of work hours data needed to calculate injury rates, and deficiencies in injury data categorization, suggesting areas for future research. Ultimately, the findings serve as a foundation for future safety improvements and continued research to address evolving risks in ALDOT's transportation maintenance operations.

Keywords: Transportation Maintenance, Worker Safety, Injury Analysis, Safety Culture, Job Hazard Analysis.

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| | |
|---|---|
| ALDOT | Alabama Department of Transportation |
| ANSI | American National Standards Institute |
| ATSSA | American Traffic Safety Services Association |
| BLS | Bureau of Labor Statistics |
| CDC | Centers for Disease Control and Prevention |
| DOT | Department of Transportation |
| FROI | First Report of Injury |
| GACC | Geographic Area Coordination Centers |
| GFO | Guidelines for Operation |
| HCM | Human Capital Management |
| INDOT | Indiana Department of Transportation |
| JHA | Job Hazard Analysis |
| MDOT | Mississippi Department of Transportation |
| MSHA | Mine Safety and Health Administration |
| MUTCD | Manual on Uniform Traffic Control Devices |
| NIOSH | National Institute for Occupational Safety and Health |
| NSC | National Safety Council |
| OSHA | Occupational Safety and Health Administration |
| PPE | Personal Protective Equipment |
| SEICTF | State Employee Injury Compensation Trust Fund |
| TDOT | Tennessee Department of Transportation |
| TTC | Temporary Traffic Control |
| TxDOT | Texas Department of Transportation |
| UAB | University of Alabama at Birmingham |
| WIRP | Workplace Incident Reporting Platform |

# CHAPTER 1: INTRODUCTION

The safety of transportation maintenance workers remains a main concern for state Departments of Transportation (DOTs) across the United States. A study by the University of Delaware found that transportation maintenance was one of the most dangerous occupations and is significantly riskier than others (UDEL, 2020), 68% of work related fatalities, during 2011-2018, were either construction laborers, highway maintenance workers, construction equipment operators, heavy and tractor trailer drivers, first-line supervisors of construction, or extraction workers (CDC, 2022).

Recognizing the significant risks faced by their workforce, the Alabama Department of Transportation (ALDOT) collaborated with the University of Alabama at Birmingham (UAB) to conduct an investigation of worker safety data to identify risks, trends, and recommendations for reducing the occurrence of injuries and illnesses. As part of risk identification, analyzing ALDOT's worker injury records is a critical step in determining probable risks and assigning resources to safety aspects that may decrease the frequency and severity of work-related injuries. ALDOT's need to properly assess both the extent and distribution of occupational hazards comes from the necessity to protect ALDOT's personnel and monetary resources. Results of the analyses are of crucial value for identifying the problem and evaluating success, as well as for developing work-related injury prevention and treatment programs.

## 1.1 Objectives

The purpose of the research is to use historical injury data to assist ALDOT in identifying high hazard accident types that lead to fatalities, injuries, and illnesses amongst ALDOT personnel. The specific objectives of this research are as follows:

- Examine and analyze ALDOT's injury reporting procedures and accrued injury records to identify trends and identify contributing factors leading to worker injuries;
- Develop a prioritized ranking of high hazard accident types;
- Report findings in practical and valuable way for ALDOT to consider as they implement an organization wide safety program;
- Recommend future courses of action that may lead to improvements in worker safety and health by reducing the frequency and severity of worker injuries, and illnesses.

## 1.2 Methodology and Organization of Dissertation

The research methodology is divided into main tasks that were performed to satisfy the aforementioned objectives. A brief description of each chapter is provided in this section.

Chapter 1 introduces the focus of the research, enhancing worker safety for Transportation Maintenance Technicians (TMTs) within ALDOT. It outlines the study's objectives, the research methodology, and expected outcomes. The chapter also describes ALDOT's current risk management and injury reporting processes, identifying potential areas for improvement in data collection and analysis.

Chapter 2 presents an in-depth analysis of ALDOT’s worker injury data from 2009 to 2024. It covers data preparation, trends in injury characteristics (e.g., nature, cause, source, body part affected), and the cost associated with various types of injuries. Additionally, it provides a spatial analysis of injuries to identify high-risk locations and includes limitations of the dataset.

Chapter 3, State-of-the-Practice Survey of DOTs’ Safety Efforts is a published paper (Marji et al.,2023) that details a survey of U.S DOTs to gather insights into their safety practices, programs, and injury prevention efforts. The survey compares ALDOT's approach to peer DOTs, examining areas such as training, incident reporting, and hazard control, with recommendations for adopting best practices.

Chapter 4, Safety Culture and Worker Perception Survey, is another published paper that focuses on a survey conducted with ALDOT TMTs to gauge their perceptions of workplace safety, including management commitment, resources, and safety culture Marji et al., 2024). The survey results reveal TMTs’ firsthand experiences with hazards and their perspectives on areas for improvement within ALDOT’s safety programs.

Chapter 5 provides an overview of a step-by-step Job Hazard Analysis (JHA) approach specifically for TMTs. It provides customized JHA forms for common TMT tasks, detailing specific hazards and control measures, which ALDOT can use to systematically assess and mitigate workplace risks.

To enhance record keeping and standardize injury reporting at ALDOT, Chapter 6 proposes enhancements to ALDOT’s injury reporting, including a revised First Report of Injury (FROI) form. These changes aim to standardize data collection, improve record accuracy, and support more effective injury analysis and prevention strategies.

Chapter 7 presents a draft outline for a recommended safety manual tailored for ALDOT TMTs, drawing from state DOT manuals and industry best practices. The manual includes guidance and suggested training on key safety topics such as temporary traffic control, personal protective equipment (PPE), JHA, and incident reporting.

Chapter 8 summarizes the key findings and recommendations from the research. It discusses limitations, such as data gaps and reporting inconsistencies, and suggests directions for future research to support ongoing improvements in ALDOT’s safety programs.

## 1.3 Expected Outcomes

Outcomes of this effort’s recommendations are expected to: (1) lessen the effects of workplace injuries experienced by ALDOT personnel, (2) reduce expenses related to injuries including significant reductions in workers' compensation premiums, (3) increase workers productivity by decreasing the number of days away from work or job restriction, and (4) increase worker engagement by demonstrating an active initiative for improving the safety culture at ALDOT.

## 1.4 ALDOT's Risk Management Plan and Current Recordkeeping Process

Retaining records of work-related injuries is an essential part of any organization's risk management plan as it helps in: (1) avoiding work-related injuries and illnesses in the future, (2) recognizing trends and common hazards that allows for implementing effective safety and health programs, and (3) raising employee awareness to follow safety practices and report hazards in the workplace.

This section discusses ALDOT's recordkeeping process to better understand the current procedures followed to record and report fatalities, injuries, and illness of ALDOT's personnel.

### *1.4.1 Risk management plan.*

Risk management comes from the necessity to prepare for the likelihood of an incident occurring and having strategies for dealing with the consequences. ALDOT adheres to the programs and practices stated by Alabama Department of Finance, Division of Risk Management (DORM). The main services of DORM include implementing suitable and reliable coverage for exposure to loss at minimal expense, ensuring that claims are compensated equitably and in a timely manner, and promoting health and safety in the workplace (DORM, n.d.).

According to DORM, the tools of risk management are (1) Avoidance, which implies taking a course of action that removes the risk completely, (2) Retention, such as self-insuring instead of purchasing insurance from a third party, (3) Transferring the risk, usually through purchasing insurance from a third party, (4) Risk and loss reduction whether in probability or severity, (5) Prioritizing safety environments and programs, and (6) Securing equipment, materials, jobsites, and valuable records (DORM, n.d.).

DORM administrates the State Employee Injury Compensation Trust Fund (SEICTF) adopted by ALDOT, which offers indemnity and medical benefits for work-related injuries. Indemnity benefits include "lost wages, compensation for permanent partial disability, permanent total disability, payments to dependents, and payment towards burial expenses in the event of fatal injury" (DORM, n.d.).

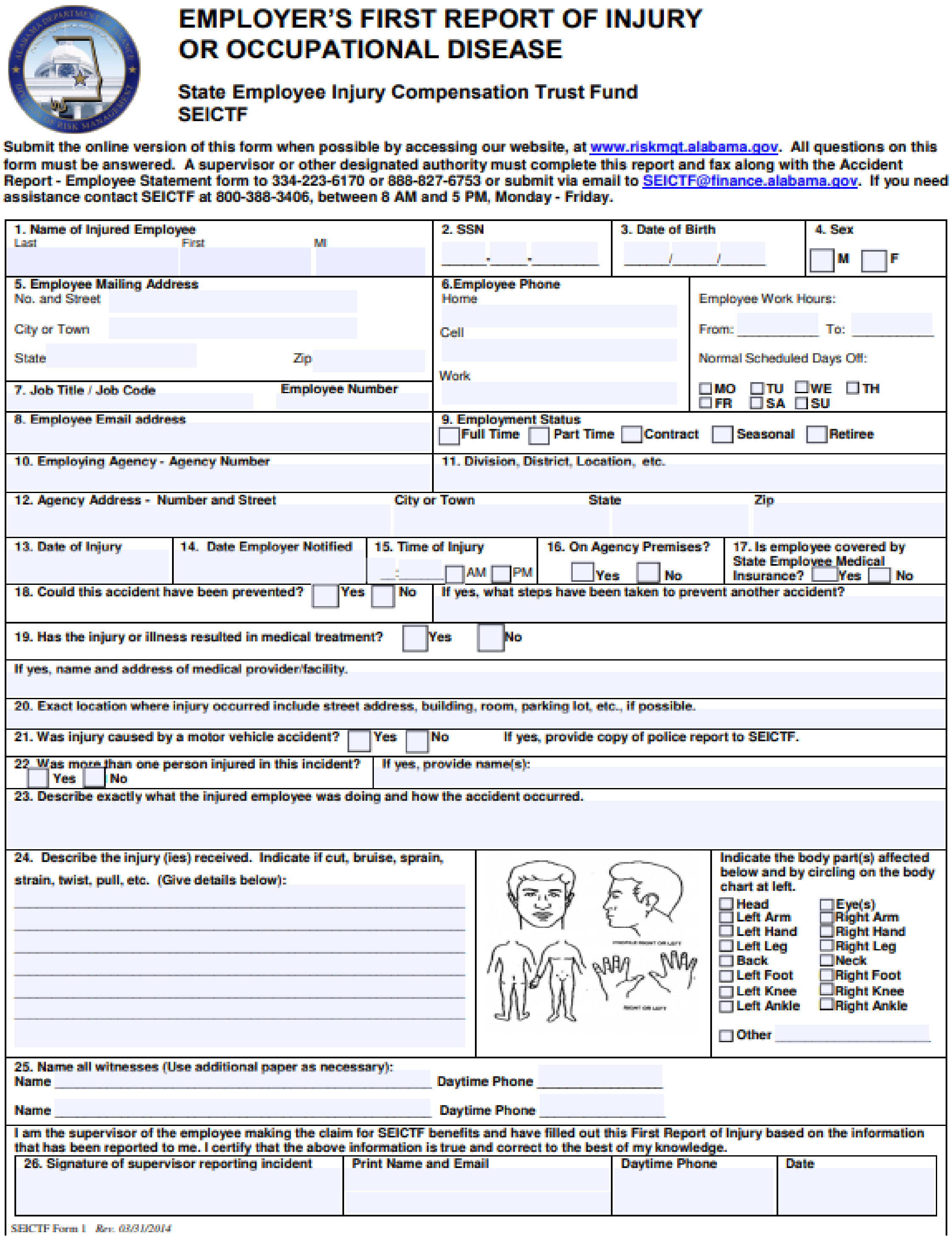
The main benefits of SEICTF are summarized as follows:

1. <u>Medical Costs</u>: coverage includes co-payment and deductibles as well as all essential medical fees.
2. <u>Lost Time</u>: employees can choose between two options: (1) receive two-thirds compensation of the worker's income, which is not taxed and is bounded by a minimum and maximum weekly rate, and (2) the employee can choose to use accumulated paid annual or sick leave instead of option one where they receive their full income with two-thirds of the amount not subject to tax.
3. <u>Permanent Disability</u>: the compensation designated depends on the extent of disability, employment, or income loss, as a result of the injury.

4. Death: compensation payments are provided to entitled dependents for up to 500 weeks, with the amount of two-thirds of worker's income, which is not taxable and bounded by a minimum and maximum weekly rate. SEICTF also provides up to $5,000 of memorial service expenses.

### *1.4.2 Accident reporting procedures*

When an ALDOT worker is injured, he/she informs the supervisor as soon as possible, and completes the "Accident Report/Employees Statement" form. The supervisor then completes the "Employer's First Report of Injury" and the "Authorization for Initial Treatment and Pharmacy" forms in case medical care is needed. These forms should be finalized within 24 hours of the injury report. The main information collected in the First Report of Injury (FROI) include but are not limited to (1) Date of Birth, (2) Gender, (3) Job Title and Code, (4) Employment Status, (5) Date and Time of Injury, (6) Possible Preventative Action, (7) Exact Location of Injury Occurrence, (8) weather the Injury is Motor Vehicle Related, (9) Accident Description, and (10) Part of Body Affected as shown in Figure 1-1



**EMPLOYER'S FIRST REPORT OF INJURY OR OCCUPATIONAL DISEASE**

**State Employee Injury Compensation Trust Fund**
**SEICTF**

**Submit the online version of this form when possible by accessing our website, at www.riskmgt.alabama.gov. All questions on this form must be answered. A supervisor or other designated authority must complete this report and fax along with the Accident Report - Employee Statement form to 334-223-6170 or 888-827-6753 or submit via email to SEICTF@finance.alabama.gov. If you need assistance contact SEICTF at 800-388-3406, between 8 AM and 5 PM, Monday - Friday.**

**1. Name of Injured Employee** Last First MI

**2. SSN** ____-____-________

**3. Date of Birth** ____/____/____

**4. Sex** ☐ **M** ☐ **F**

**5. Employee Mailing Address**
No. and Street
City or Town
State Zip

**6.Employee Phone**
Home
Cell
Work

Employee Work Hours:
From: __________ To: __________
Normal Scheduled Days Off:
☐ **MO** ☐ **TU** ☐ **WE** ☐ **TH**
☐ **FR** ☐ **SA** ☐ **SU**

**7. Job Title / Job Code** **Employee Number**

**8. Employee Email address**

**9. Employment Status**
☐ **Full Time** ☐ **Part Time** ☐ **Contract** ☐ **Seasonal** ☐ **Retiree**

**10. Employing Agency - Agency Number**

**11. Division, District, Location, etc.**

**12. Agency Address - Number and Street** **City or Town** **State** **Zip**

**13. Date of Injury**

**14. Date Employer Notified**

**15. Time of Injury** __:______ ☐ AM ☐ PM

**16. On Agency Premises?** ☐ **Yes** ☐ **No**

**17. Is employee covered by State Employee Medical Insurance?** ☐ **Yes** ☐ **No**

**18. Could this accident have been prevented?** ☐ **Yes** ☐ **No** **If yes, what steps have been taken to prevent another accident?**

**19. Has the injury or illness resulted in medical treatment?** ☐ **Yes** ☐ **No**

**If yes, name and address of medical provider/facility.**

**20. Exact location where injury occurred include street address, building, room, parking lot, etc., if possible.**

**21. Was injury caused by a motor vehicle accident?** ☐ **Yes** ☐ **No** **If yes, provide copy of police report to SEICTF.**

**22. Was more than one person injured in this incident?** ☐ **Yes** ☐ **No** **If yes, provide name(s):**

**23. Describe exactly what the injured employee was doing and how the accident occurred.**

**24. Describe the injury (ies) received. Indicate if cut, bruise, sprain, strain, twist, pull, etc. (Give details below):**

**Indicate the body part(s) affected below and by circling on the body chart at left.**
☐ **Head** ☐ **Eye(s)**
☐ **Left Arm** ☐ **Right Arm**
☐ **Left Hand** ☐ **Right Hand**
☐ **Left Leg** ☐ **Right Leg**
☐ **Back** ☐ **Neck**
☐ **Left Foot** ☐ **Right Foot**
☐ **Left Knee** ☐ **Right Knee**
☐ **Left Ankle** ☐ **Right Ankle**
☐ **Other** ____________________

**25. Name all witnesses (Use additional paper as necessary):**
**Name** ________________________________ **Daytime Phone** ______________
**Name** ________________________________ **Daytime Phone** ______________

**I am the supervisor of the employee making the claim for SEICTF benefits and have filled out this First Report of Injury based on the information that has been reported to me. I certify that the above information is true and correct to the best of my knowledge.**

| **26. Signature of supervisor reporting incident** | **Print Name and Email** | **Daytime Phone** | **Date** |
|---|---|---|---|
| | | | |

SEICTF Form 1 *Rev. 03/31/2014*

**Figure 1-1 ALDOT Employer's First Report of Injury.**

In case of an emergency, the employee must obtain instant care at the closest medical center and inform their supervisor as soon as possible. The next business day, the worker must follow up with a preferred provider. When the employee seeks medical care, he/she needs to provide the Authorization for Initial Treatment and Pharmacy form to the health provider, to avoid having to pay any copayment or deductibles. Afterwards the health provider will complete their section of the form, and the employee will send the form back to the supervisor to be sent to SEICTF.

In case the employee does not wish to pursue medical treatment, the supervisor should note this on the Employer's First Report of Injury under Section 19. The supervisor may advise the employee to seek medical care if the injury is considered to be a hazard to the employee's own safety, co-workers, and/or others. If the employee continues to reject medical attention, the supervisor can require the employee to take leave and obtain a medical discharge from a healthcare provider before being authorized to return to work.

## 1.5 Summary

This chapter sets out the research objectives, methodology, and specific tasks undertaken in this research. It also aimed to gain familiarity with ALDOT's recordkeeping process and risk management plan to identify the information collected when an injury occurs and assess the recording procedure. This information helps identify potential gaps in data collection that could affect ALDOT's ability to accurately assess workplace hazards and implement preventative measures.

# CHAPTER 2: ALDOT WORKER INJURY ANALYSIS

ALDOT worker injury records from 2009 through 2024 were received by the research team as an excel file with 5,780 injury records. The dataset contained multiple data fields that were used to describe each record of injury including: Employee Number, Injury Date, Job Code, Job Description, Injury Description, Cause/Nature/Source/Site Descriptions, Department Names, and Sub Department Names.

Upon review of the injury dataset, it was obvious that data fields were inconsistent or contained erroneous information that needed to be corrected through a data preparation process. As an example, some 'Job Descriptions' were inconsistent throughout the years from 2009-2019, and some were not found in the most recent ALDOT 2020 Merit System Employment Guide. Additionally, the 'Injury Description' fields were incomplete, 'Causes, Natures, and Sources were duplicated, sometimes with different spellings. Location records were also inconsistent. Hence the need for correcting incomplete, duplicated, and improperly formatted injury records.

## 2.1 Data Preparation

This section describes the data preparation process of the ALDOT injury dataset to enhance and prepare it for analysis. The data preparation process focused on: (1) aligning Job Descriptions and Job Codes from various years, (2) using the Injury Date to extract the month, day, and year, (3) standardizing the Nature/Cause/Source/Site Descriptions, (4) assigning median days away from work, (5) assigning workers compensation values, and (6) using Department Names and Sub-department Names to extract geographical attributes for the purpose of spatial analysis. The following sections describe the approach and methods used for the preparation of the dataset.

### *2.1.1 Job Description*

In the injury dataset supplied by ALDOT, it was discovered that several Job Descriptions were assigned the same Job Code. The original Job Codes and Job Descriptions are listed in Table 2-1.

**Table 2-1 Different Job Description with Similar Job Codes**

| Job Code (original) | Job Description (original) | Number of Records |
|---|---|---|
| 20118 | Engineering Assistant Sr | 44 |
| 20118 | Engineering Assistant III | 35 |
| 20430 | Grad Civil Engineer | 33 |
| 20430 | Civil Engineering Graduate | 13 |
| 90244 | Transportation Maintenance Tech | 593 |
| 90244 | Transport Maintenance Tech I | 298 |
| 90246 | Transport Maintenance Tech Sr | 152 |
| 90246 | Transport Maintenance Tech III | 148 |
| 90247[1] | Transportation Maintenance Tech II | 140 |
| 90247[1] | Transport Maintenance Tech II | 502 |

Note: 1. Job Code and Description 90247 – Transportation Maintenance Technician II does not exist in the 2022-2023 Merit System Employment.

To provide consistency within the dataset, Job Descriptions with the same Job Code were modified based upon the ALDOT Job Descriptions provided in the 2022-2023 Merit System Employment Guide (SPD, 2022), as shown in Table 2-2. By aligning the Job Codes with the appropriate Job Descriptions, a year-by-year analysis can be performed to determine which Job Descriptions experience the highest number of injuries.

**Table 2-2 Updated Job Codes and Job Descriptions**

| Job Code and Description (Original) | Job Code and Description (Modified) | Number of Records (Modified) |
|---|---|---|
| **90242 -Hwy Maint. Tech II**<br>**90245 - Hwy Maint. Tech II/III** | 90247 - Transport Maint Tech II (TMT II)[1] | 1344 (27.6%) |
| **90243 - Hwy Maint. Tech III** | 90246 - Transport Maint Tech III (TMT III) | 352 (7.2%) |
| **20116 - Engineering Assistant** | 20111 - Engineering Assistant I (EA I) | 228 (4.7%) |
| **90436 - Heavy Equipment Mechanic** | 90445 - Equipment Mechanic | 188 (3.9%) |
| **20115 - Engineering Assistant II / III** | 20114 - Engineering Assistant II (EA II) | 146 (3%) |
| **20118 – Engineering Assistant Sr.** | 20118 – Engineering Assistant III (EA III) | 88 (1.8%) |

Note: 1. Job Code and Description 90247 – Transportation Maintenance Technician II does not exist in the 2022-2023 Merit System.

### *2.1.2 Injury Date Modification*

Based on the date assigned to each injury record in the injury dataset, three new columns were generated showing the month, day, and year of the injury occurrence to identify the trend of occurrence and possible missing records. A sample of these columns is shown in Table 2-3.

**Table 2-3 Sample of Month, Day, and Year of Injuries Modifications**

| Injury Date (original) | Month | Day | Year |
|---|---|---|---|
| 9/7/2009 | September | Monday | 2009 |
| 1/21/2010 | January | Thursday | 2010 |
| 08/12/2020 | August | Wednesday | 2020 |
| 04/04/2024 | April | Thursday | 2024 |
| 7/2/2013 | July | Tuesday | 2013 |
| 9/25/2014 | September | Thursday | 2014 |

By generating the month, day, and year form the original injury date, future analysis can be performed to identify trends based upon day of the week, month of the year, and year over year.

### *2.1.3 Injury Characteristics*

This section discusses the injury characteristics described by Nature, Cause, Source and Body Part, in terms of definitions and the procedure that was used to allocate costs associated with injuries. Information published by the U.S. Bureau of Labor Statistics (BLS) and the National Safety Council (NSC) were used in conjunction with the ALDOT's records to get an estimate of direct and indirect cost.

The original ALDOT dataset contained four different data fields to describe the characteristics of each injury. These fields reported (1) Nature Description, (2) Cause Description, (3) Source Description, and (4) Site Description.

The Center for Disease Control (CDC) defines the Nature of Injury as the "the principal physical characteristic(s) of the injury or illness"(CDC, 2020). It is a way to classify injuries by characterizing the damage inflicted. For example, a "Sprain" means that one or more ligaments is stretched or torn (NIH, 2015), while a "contusion" is the medical term for a bruise, which is a region of injured tissue or skin where blood capillaries have been ruptured without breaking the skin (Merriam-Webster, n.d.).

The Cause Description in the ALDOT data identifies the object, substance, bodily motion, or exposure which directly produced or inflicted the injury. According to ALDOT's classification, Source Description mainly describes "the manner in which the injury was produced or inflicted" by the Cause Description. Site Description is used to identify the Part of Body that was directly affected by the injury and will be referred to as Part of Body.

### *2.1.4 Estimation of Injury Cost*

The costs of worker injuries can be divided into direct and indirect costs. Direct costs include workers' compensation, medical and legal fees. Indirect costs are associated with injury investigation, and costs associated with days away from work. Costs associated with absenteeism rely heavily on the number of days lost. Some of these indirect costs include training substitute workers, loss of productivity and efficiency, paid time-off, and lower employee morale. According to OSHA's "Safety Pays" program, indirect costs are always higher than direct cost with a ratio that ranges from 1:1.1 to 1:4.5 (OSHA, n.d.).

*Median days away from work.* One of the most critical safety metrics defined by OSHA is the Days Away, Restricted, or Transferred (DART) Rate. Aside from the direct and indirect costs sustained, the DART rate can be used to evaluate the safety environment in the workplace. U.S BLS provides the median number of days away from work per claim by Event or Exposure, Nature, and Body Part. Because several of the Nature, Cause, and Source descriptions in ALDOT's data were not comparable to the Nature and Events categories provided by BLS, the "Part of Body" affected by the injuries was chosen to assign a median number of Days Away From Work. This assignment was based on records associated with claim type "I," which stands for Indemnity—claims where the employee has lost more than three days of work. BLS provides the median number of days away from work by Body Part which was aligned with ALDOT records as shown in Table 2-4 column 1 (BLS, 2024).

*Worker's compensation.* The NSC provides the average total incurred costs per claim by Cause of Injury, Nature, and Body Part. The Part of Body affected by the injuries was chosen for the assignment of an average cost per injury, which was aligned with ALDOT records as shown in Table 2-4 column 2 (NSC, 2024).

**Table 2-4 Assigned Injury Cost By Body Part (Median No. of Days Away from Work & Average Cost per Claim)**

| Body Part (ALDOT) | Median Days Away from Work (BLS) | Average Cost per Claim (NSC) |
|---|---|---|
| Abdomen | 20 | N/A |
| Ankle | 9 | $30,720 |
| Arm | 14 | $49,838 |
| Back | 7 | $35,439 |
| Buttock | 8 | N/A |
| Chest | 6 | $20,386 |
| Elbow(s) | 16 | $1,273 |
| Eye(s) | 3 | N/A |
| Face | 2 | $33,635 |
| Finger(s) | 5 | $1,321 |
| Foot | 8 | $4,906 |
| Groin | 15 | N/A |
| Hand(s) | 5 | $1,153 |
| Head | 3 | $94,285 |
| Hip | 17 | $60,155 |
| Internal Organs | 14 | $20,356 |
| Knee(s) | 15 | $35,332 |
| Leg(s) | 14 | $4,427 |

| | | |
|---|---|---|
| Multi Body Parts | 10 | $62,257 |
| Neck | 6 | $65,659 |
| No Injury | 0 | N/A |
| Nose | 6 | N/A |
| Ribs | 6 | $10,191 |
| Shoulder | 25 | $49,838 |
| Thigh(s) | 9 | $60,155 |
| Toe | 7 | N/A |
| Trunk | 9 | $39,328 |
| Unknown/Not Reported | N/A | N/A |
| Wrist | 18 | $887 |

### *2.1.5 Geocoding the Records*

ALDOT data included a column for the Department Name and the Sub-department Name of the recorded injuries. This information was used for geocoding the injuries by ALDOT region, area, county, and city based on ALDOT's organizational structure and field offices (Table 2-5). This allowed for spatially displaying the locations with high injuries and identifying patterns or hot spots on a map.

**Table 2-5 Sample of Extracted Location Information**

| Sub Name (original) | Dept. Name (original) | Region | Area | County | City |
|---|---|---|---|---|---|
| District 51 - Fayette/ Lamar | West Central Region (Div 5) | West Central | Fayette | Lamar | Fayette |
| District 5 - Gadsden | North Region – Guntersville (Div 1) | North | Guntersville | Etowah | Gadsden |
| District 62 - Union Springs | SE Region– Montgomery (Div 6) | Southeast | Montgomery | Bullock | Union Springs |
| District 2 - Oneonta | East Central Region – Hoover (Div 3) | East Central | Birmingham | St. Clair | Oneonta |
| District 71 - Dothan | SE Region – Troy (Div 7) | Southeast | Troy | Houston | Dothan |

### *2.1.6 Summary*

This section discusses the data preparation process for the Alabama Department of Transportation (ALDOT) worker safety injury records, which contained 5,780 records from 2009 to 2024. The original data exhibited inconsistencies and erroneous information, particularly in fields such as Job Descriptions, Injury Descriptions, and Location records. To enhance the dataset for analysis, several steps were undertaken, including aligning Job Descriptions and Job Codes across different years, extracting and standardizing date components from the Injury Date, and standardizing Nature, Cause, Source, and Site Descriptions. Additionally, median days away from work were assigned based on injury records, workers' compensation values were allocated, and geographical attributes were extracted for spatial analysis using Department and Sub-department

Names. The section emphasizes the necessity of these modifications to ensure accurate data analysis and effectively identify trends in workplace injuries.

The following sections (2.2, 2.3, 2.4, 2.5, and 2.6) demonstrate the descriptive statistical analysis of ALDOT injury records (i.e., frequency and severity). It is important to note that to assess safety issues at ALDOT, fatality, injury, and illness rates should be compared against benchmarks (i.e., nationwide or statewide rate), or against industry rates covered by ALDOT. Typically, these rates are calculated using total number of hours worked by all employees during a certain year.

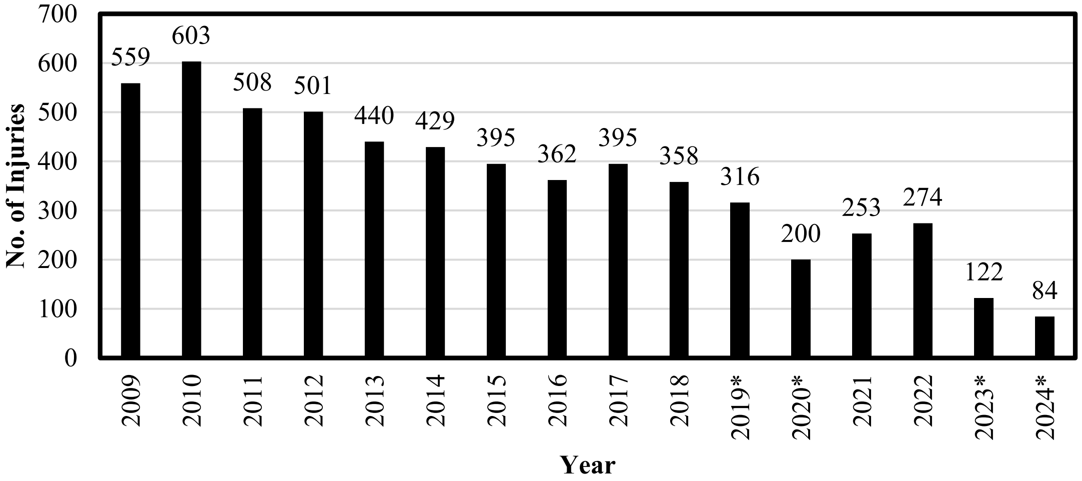
Due to dataset limitations, the number of hours worked by ALDOT employees was not provided, therefore fatalities, injury, and illness rates could not be calculated as part of this analysis. However, the injury records were used to compare Injury Characteristics, Job Descriptions, and Regions within ALDOT to provide further insight into worker safety. Section 2.5; Estimation of Injury Cost, outlines the costs allocated to the injuries, by year, per Body Part affected, based on assumptions discussed.

## 2.2 Exploring Time Trends

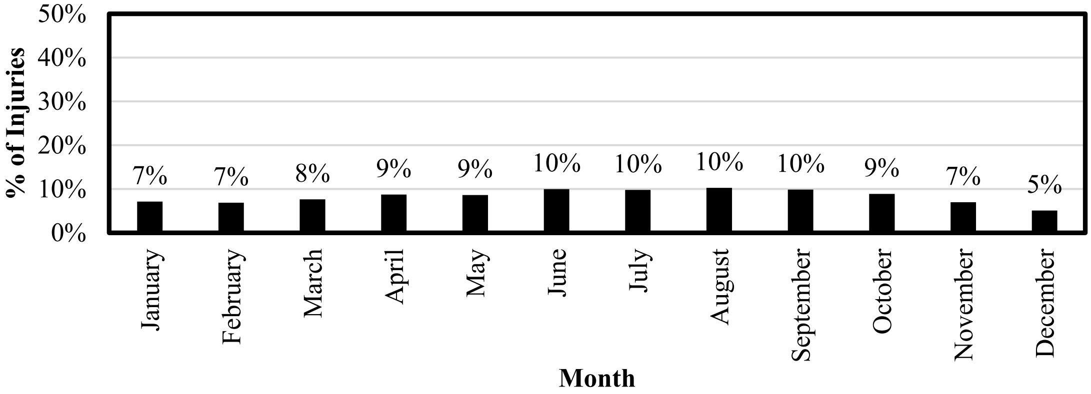
The first step in data mining was to explore time trends by plotting the injury records per year, month, and day as shown in Figure 2-1, to unveil any upward or downward trends and attempt to develop a forecasting model. Plotting the injuries by year indicated that earlier years (i.e., 2009-2019) had a considerably higher number of injuries (Figure 2-1 (a)). The graph shows a clear downward trend in overall injury numbers. However, this observation is misleading since it is simply the frequency of injuries per year and does not take into consideration the number of hours worked in each year, which would be required to develop an actual injury rate. Moreover, the years 2019, 2020, 2023, and 2024 only contain partial data that are missing months of injury records (3 months missing in 2019, 4 months missing in 2020, 7 months missing in 2023, and 8 months missing in 2024) .

Figure 2-1 (b) illustrates injuries by month of the year, which shows the highest number of injuries occur during the summer months (i.e., June, July, August, and September). This observation is in concurrence with a study by BLS explaining that higher number of injuries occur throughout the summer when construction activity is at its peak. Moreover, the number of injuries is considerably less near the end of the calendar year (BLS, 2013).

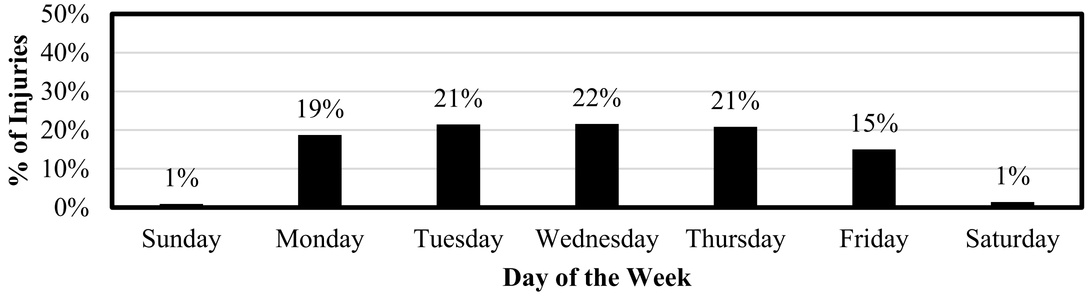
According to the assigned day for all injuries shown in Figure 2-1 (c), it is noticed that midweek (i.e., Tuesday, Wednesday, and Thursday) was when most injuries occurred.



(a) per Year



(b) Month of the Year



(c) Day of the Week

**Figure 2-1 Number of Injuries per Year, Month, and Day of the Week.**

Notes: 1. Covid illness related records were omitted to remove the anomaly in injury records and improve the accuracy and reliability of work-related injury analysis.

2. '*' Indicates years with partial data.

3. Average number of injuries per month and day were calculated excluding years with partial data.

The number of injuries were plotted by month for each individual year to detect any deviations year to year. This revealed that the data for 2019, 2020, 2023, and 2024 was incomplete, as 3, 4, 7, and 8 months of records were missing for these years, respectively. This finding might explains the reduced number of injuries reported in these years compared to other years.

## 2.3 Exploring Job Descriptions

The number of injuries was first analyzed by Occupational Group. As seen in Figure 2-2, Maintenance and Operations accounted for 84% of all injuries during 2009 to 2024, followed by Engineering, Science and Allied with 11% of all injuries, and Clerical, Administrative, Fiscal and Information Technology Group with 5% of all injuries. Meanwhile, Services and Public Safety, Corrections and Inspection only recorded six injuries during the 16-year period, both accounting for less than 0.1% of all injuries.

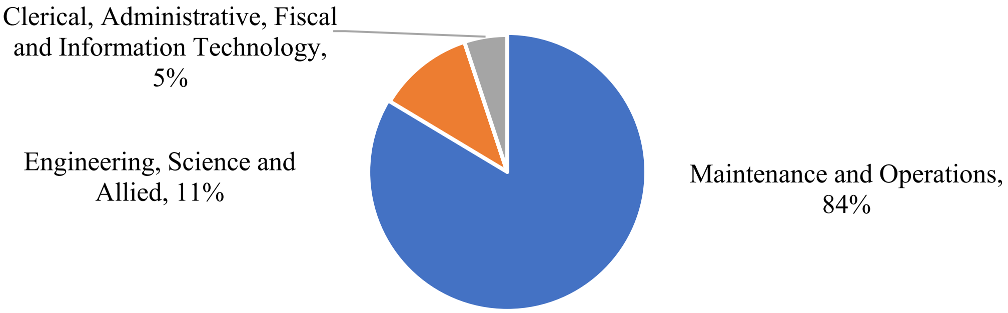


**Figure 2-2 Percent of Injuries by Occupational Group.**

Transportation Maintenance Technicians (TMTs), Transportation Workers (TWs), along with Engineering Assistants (EAs) sustained the highest percentage of all injuries. Based on the Job Descriptions, it was concluded that the top 3 Job Descriptions with highest number of injuries representing 75% of total injuries include TMTs (54%), TWs (12%), and EAs (9%). All other Job Descriptions with less than 5% of all injuries were aggregated into one category entitled "Others", as shown in Figure 2-3.

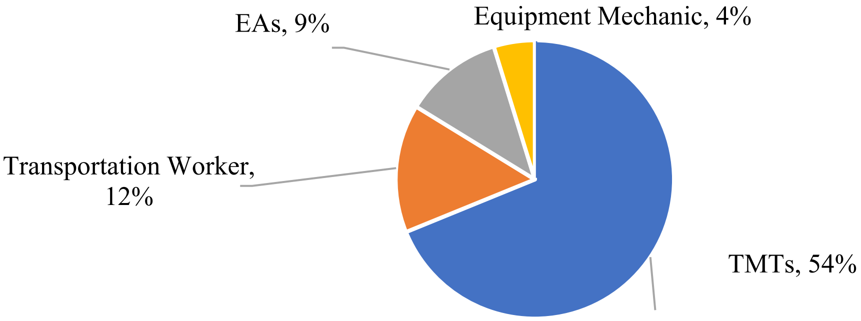


**Figure 2-3 Job Descriptions with Highest Number of Injuries.**

When injuries per Job Description were plotted for each year individually it was found that TMTs recorded the highest percentage of injuries in every single year and accounted for an average of 60% of all injuries per year as shown in Figure 2-4. The trend of TMT injuries raises concern as the graph shows a general increase of TMT-related injury percentage.

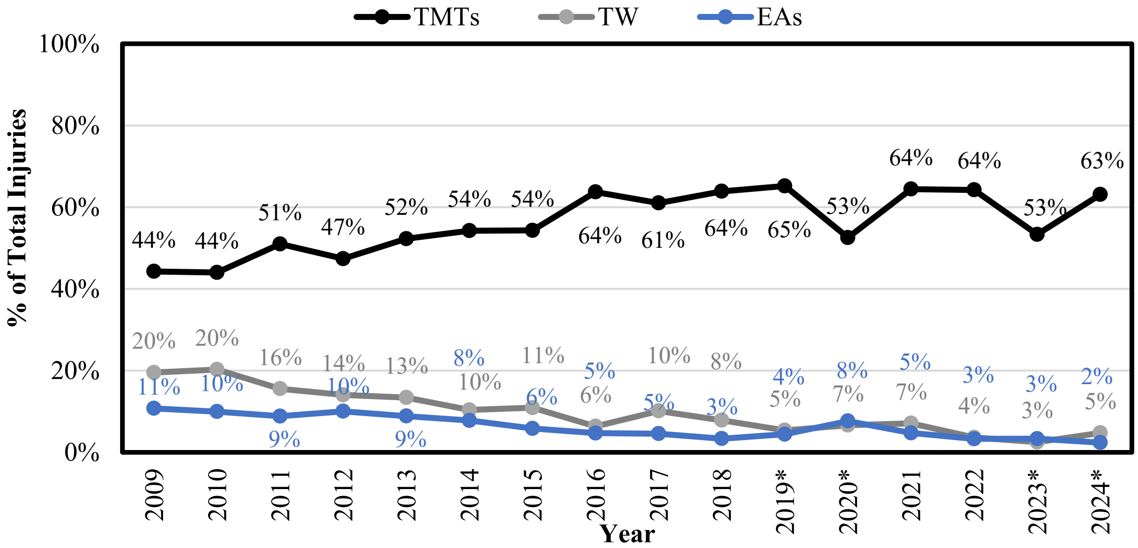


**Figure 2-4 Job Descriptions with Highest Percent of Injuries per Year.**

Note: 1. '*' Indicates years with partial data.

The abovementioned Job Descriptions are not only a concern for non-fatal work injuries, but also for catastrophic and fatal injuries. ALDOT experienced eight injuries resulting in death during the 2009-2024 time period. Four of these cases were TMTs, two were EAs, and one was TW. The one remaining case was a Transportation Manager. Since TMTs consistently recorded the highest percentage of injuries each year, accounting for an average of 60% of all reported injuries annually, the remainder of the analysis will focus exclusively on TMT-related injuries. This will include an in-depth examination of the Nature, Cause, Source, and Body Part affected, as well as the associated costs of injuries within this Job Description. By concentrating on TMT injuries, specific patterns and areas can be identified for targeted improvements in safety practices.

## 2.4 Exploring TMT-Injury Characteristics

In this section, the details of injury characteristics sustained by ALDOT TMTs will be presented by an analysis of the Nature, Source, Cause and Body Part affected by injuries reported over the period between 2019-2024. Understanding these characteristics allows for identifying prevalent injury types, assessing their impact on TMTs, and developing targeted interventions to enhance workplace safety. This analysis will also explore the estimated associated costs of these injuries that resulted in 3 or more days away from work. It is important to note that some injuries that resulted in less than 3 days away or resulted in job restriction or transfer are not included due to data limitations, hence the estimated median days away from work could be underreported.

### *2.4.1 Nature Description*

The Nature of injury is the main physical symptom(s) of the injury or illness (CDC, 2020), where ALDOT categorizes the Nature Description based on what is the result of the injury. It is one of the main tools to categorize injuries based on the type of damage inflicted on the body, to assess the severity of the injury.

The top five highest occurring Nature Descriptions representing 66% of all TMT injuries are: Sprain/Strain (26%), Contusion (16%), Injury (11%), Multiple Injury (9%), and Cut/Laceration (6%). All remaining Nature Descriptions were aggregated into one category entitled "Others" representing 32% of the total number of injuries as shown in Figure 2-5**.** Some of the Nature Descriptions included within the category "Others" are shown in Figure 2-6**.**

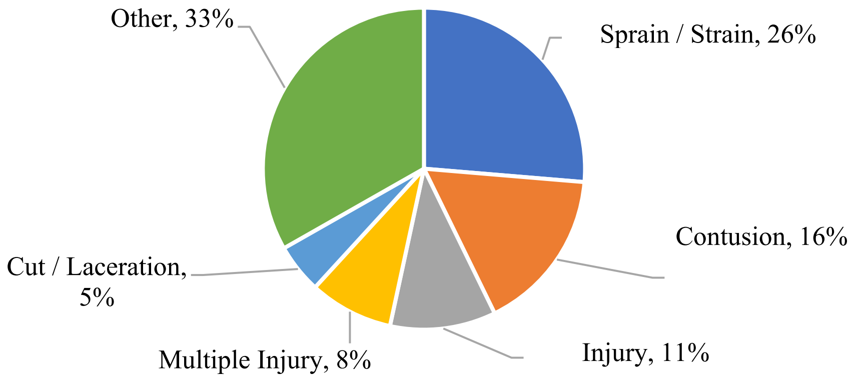


**Figure 2-5 Nature Descriptions with Highest Percent of TMT Injuries.**

Some high frequency Nature Descriptions present a level of ambiguity, in the sense that they do not describe the principal physical characteristic(s) of the injury, per the definition of Nature Description. These Nature Descriptions represent 29% of all TMT injury records and include: Injury (11%), Multiple Injury (9%), Unknown/Not Reported (5%), and No Injury (4%). Figure 2-6 shows the percentages of Nature Descriptions with the ambiguous descriptions shown in black.

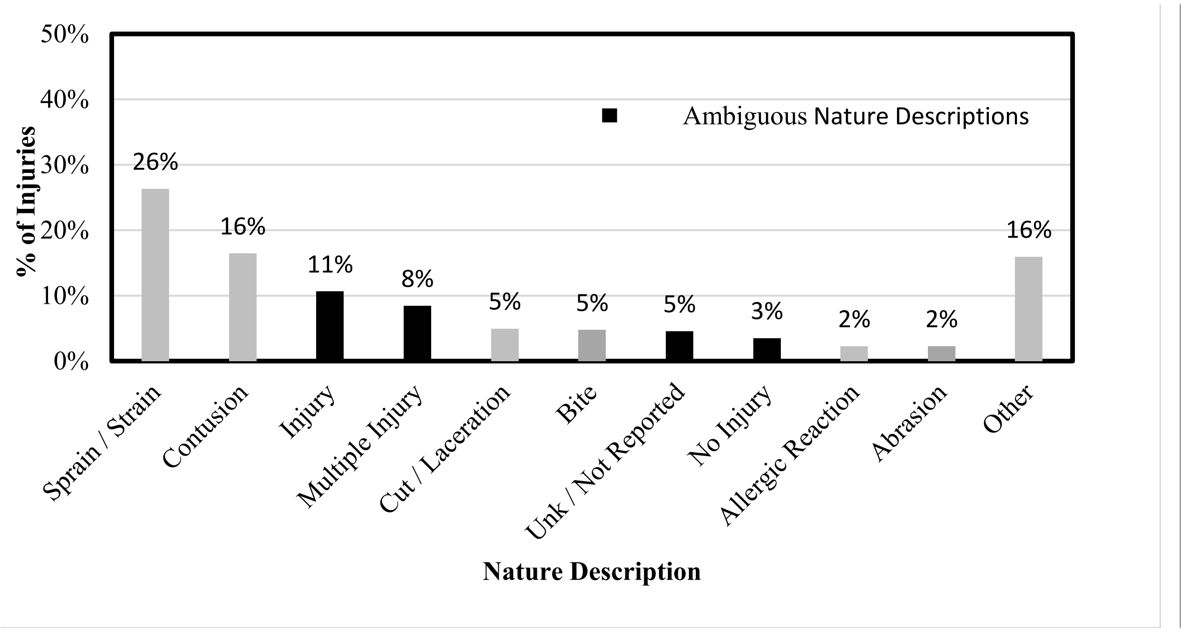
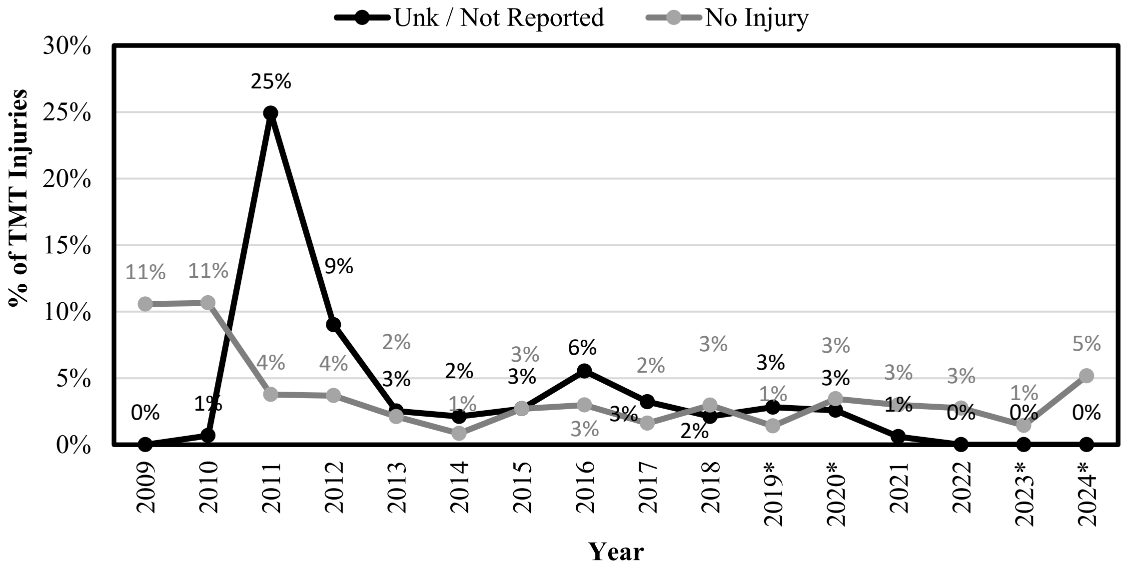
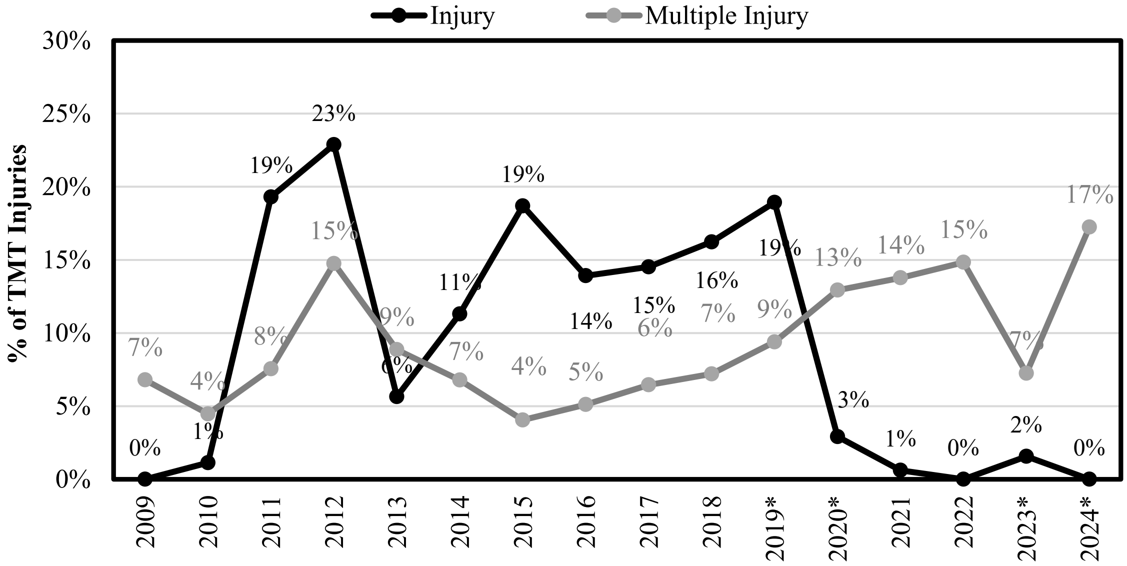


**Figure 2-6 Percent of TMT Injuries by Nature Descriptions.**

When investigating ambiguous Nature Descriptions, it was found that the number of "No Injury" records was higher in earlier years (i.e., 2009 and 2010), while Unknown/Not Reported accounted for 25% of TMT injuries in 2011 as shown in Figure 2-7a. No injury records exhibited a significant drop in year 2020-2024. This may explain why the number of injury records in earlier years was higher compared to other years. It can also suggest changes in reporting practices and improved categorization of injuries. However Multiple Injuries shown an upward trend starting in 2016 as shown in Figure 2-7(b).



(a) Percent of Unk/Not reported, and No Injury Records by Year



(b) Percent of Injury, and Multiple Injury by Year

**Figure 2-7 Percent of Ambiguous Nature Description by Year.**

Note: 1. '*' Indicates years with partial data.

Sprains/Strain, Contusion, and Cut/Laceration Nature Descriptions were plotted by year as shown in Figure 2-8. Sprain/ Strain injuries show significant variability over the years, ranging from a low of 12% of all TMT injuries in 2011 to a high of 40% in 2024. Notable increases are observed in 2021 (29%), 2022 (36%), 2023 (35%), and 2024 (40%), indicating a rising trend in recent years. This could suggest a growing concern, or underlying issues related to musculoskeletal injuries within TMT workers. Contusions fluctuated more drastically, starting at 9% in 2009, peaking at 42% in 2023, and decreasing to 24% in 2024. Between 2009 and 2023, the percentage steadily increased, with spikes in 2015 (23%) and 2019 (22%), followed by a sharp increase in 2023. Cuts/Lacerations show a relatively stable trend, with percentages staying mostly below 10% throughout the years. The highest occurrence was 10% in 2022, while most other years remained between 3% and 6%.

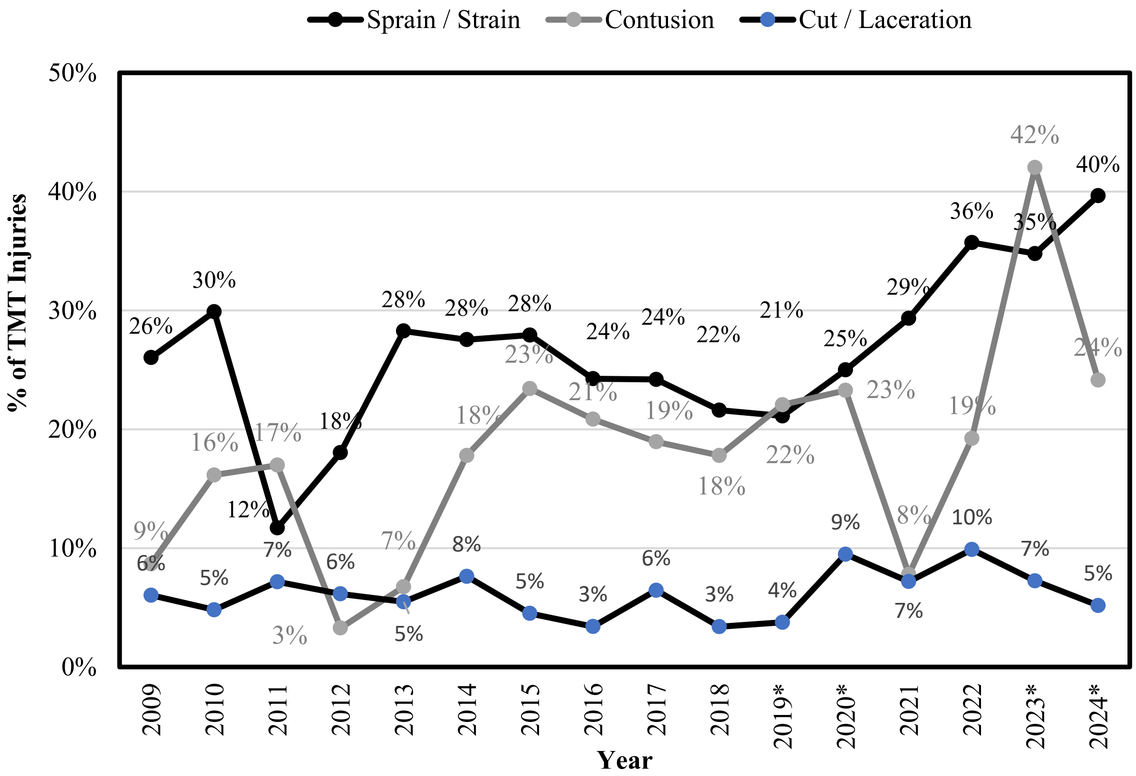


**Figure 2-8 Number of Selected Nature Description Injuries by Year.**

Note: 1. '*' Indicates years with partial data.

The dataset included the claim type for injury records starting in the year 2020 until 2024. Claim types can be N, M, or I. "N" means record only (notification of incident/injury but employee does not need medical treatment), "M" claims are medical only (medical treatment only and no loss time out of work), while claim "I" stands for Indemnity in which the employee has lost more than 3 days out of work. For this research, only claim "I" injuries will be analyzed and used to calculate median number of days away from work and total cost incurred.

Figure 2-9 shows the number of TMT injuries under claim *I* by nature of injury along with the percentage of these records within the Nature Description category for the period 2020 - 2024. This data provides insights into the severity of different Nature Descriptions. Sprains and Strains are the most common injuries resulting in 3 or more days away from work, with 82 *I* claim, while 41% of all Sprains and Strains result in significant time away from work. Multiple Injuries and Contusions follow, with 31 and 18 *I* claims respectively. While Contusions have a lower percentage (17%) of cases resulting in lost days, multiple injuries have a higher impact, with 38% resulting in days lost. Fractures though less frequent, have 67% cases resulting in three or more days away from work, indicating their obvious severity. Cumulative Trauma, Death, and Amputation, though rare, have a 100% impact. Other injuries such as Crushing, Inflammation, Burns, and Puncture may also contribute to time away from work, with varying percentages. Cut/Laceration injuries result in 16% of cases with lost days, Crushing injuries result in 50% of cases leading to absences, while inflammation and burns account for 29% and 25% respectively.

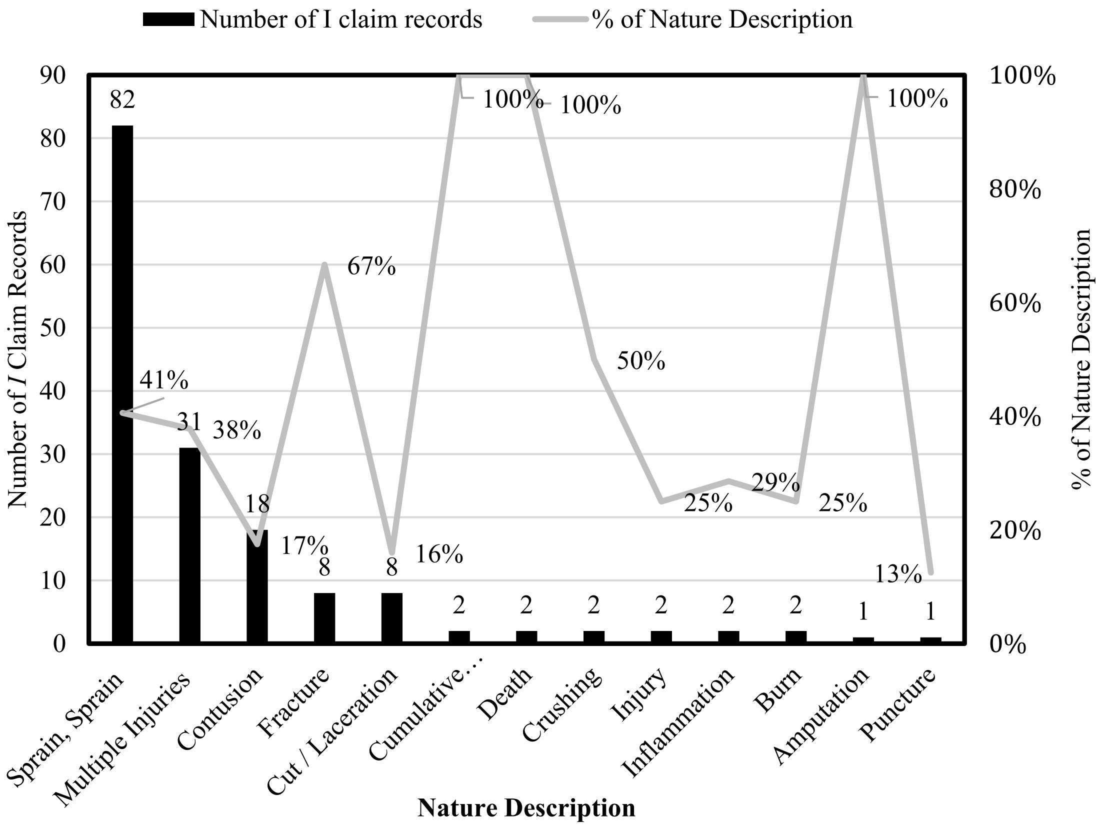
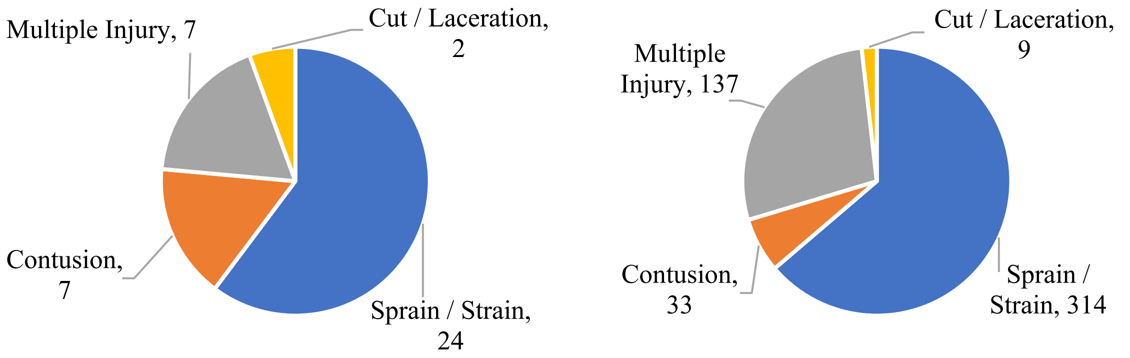


**Figure 2-9 No. of TMT Injuries Resulting in 3 or More Days Away and Percent by Nature Descriptions.**

Assuming these percentages of injuries by nature that result in time away from work, we can estimate the annual average number of *I* claims for each injury nature. To do this, we would first calculate the average number of each injury nature across all years (excluding years with partial data). Then, multiply this average by the calculated percentage of nature that lead to time away from work based on Figure 2-9. This approach will provide an estimate of the annual average number of *I* claims for each injury type, reflecting how often they result in lost work time. These number are shown in Figure 2-10 (a).

Based on this information and referring to BLS Table R67, which lists the median number of days away from work by nature of injury or illness (BLS, 2022) the annual average median number of days lost due to Strains/Sprains for ALDOT TMTs is 314, Contusions account for a median of 33, Multiple injuries account for 137, and 9 days for Cuts/Lacerations as shown in Figure 2-10 (b).



(a) Average Number of TMT I-Claim injuries per Year by Nature

(b) Average Number of Days lost by TMT injury per year by Nature

**Figure 2-10 Average Number of Days Lost per Year by Common Nature Descriptions.**

### *2.4.2 Cause Description*

The Cause Description identifies the object, substance, bodily motion, or exposure that directly produced or inflicted the injury. Cause of injury is crucial for developing preventative strategies targeting specific Causes and specific Job Descriptions exposed to these Causes.

The highest occurring Cause Descriptions representing 56% of all TMT injuries are: Object Handled (20%), Motor Vehicle (11%), Surface (10%), Climbing/Descending (7%), Lifting (7%). Other Cause Descriptions were aggregated into one category named "Others" representing 44% of the total number of injuries as shown in Figure 2-11**.**

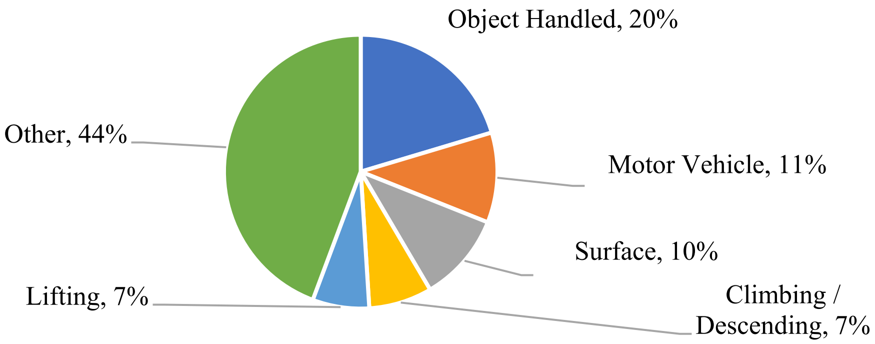


**Figure 2-11 Cause Descriptions with Highest Percent of TMT Injuries.**

Some of the Cause Descriptions included in the category "Others" are shown in Figure 2-12**.**

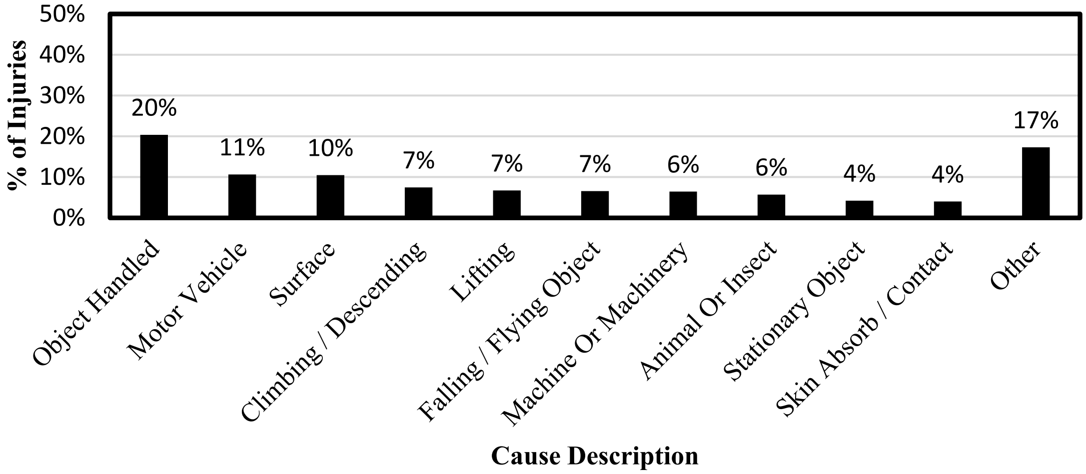


**Figure 2-12 Percent of TMT Injuries by Cause Description.**

To investigate the trends of frequent Causes, Object Handled, Motor Vehicle, and Surface injuries were plotted by year (Figure 2-13).

Object Handled accounted for a significant portion of injuries (25% in 2011), then gradually decreased to 7% in 2024. The percentage of injuries caused by Surface remained relatively stable, with a mode of 11%. While Motor Vehicle related injuries maintained a relatively consistent percentage, accounting for 6% - 15% of total injuries from 2009 to 2022, an increase occurred in 2024, where Motor Vehicle injuries percentage increased to 26%. This is particularly alarming since Motor Vehicle injuries result in the most severe injuries sustained by workers. It is important to note that five out of the eight fatal injury cases during the 16-year period were caused by a Motor Vehicle, whereas the other three causes were Machine or Machinery, and Unknown where the worker was found dead in the vehicle.

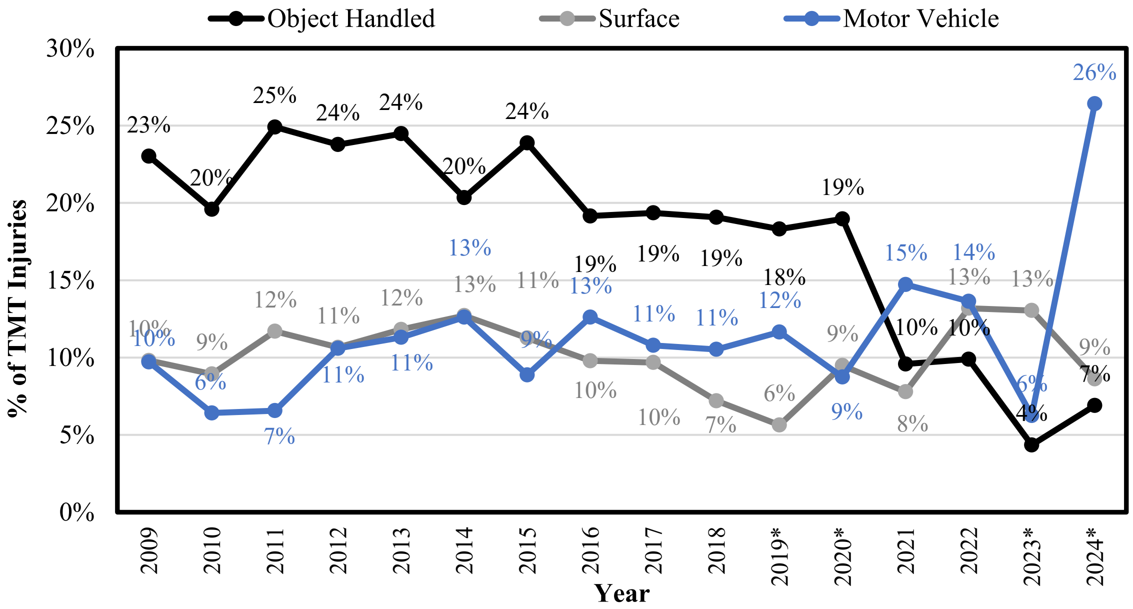


**Figure 2-13 Number of Selected Cause Description Injuries by Year.**

Note: 1. '*' Indicates years with partial data.

To get a broader understanding of the events leading to an injury, the relationship between Nature and Cause Descriptions was explored using Pearson's r to test the null hypothesis. Null hypothesis testing is a conventional method to decide between two analyses of a statistical relationship in a sample. One analysis is known as the null hypothesis. It indicates that there is no correlation between two variables (i.e., Nature Description and Cause Description). The other analysis is called the alternative hypothesis, which means that there is a relationship between the variables and that the relationship in the sample signifies the relationship in the population. To test the null hypothesis, we need to find the p-value. The p-value is the probability that the null hypothesis is true. To find the p-value, we need to find first the area that corresponds to the z-score using the formula shown in Eq. 2-1 below:

$$z = \frac{\bar{x} - \mu}{\mathrm{SD}/\sqrt{\mathrm{n}}} \qquad \text{Eq. 2-1}$$

where,

$\bar{x}$ = sample mean
μ = null hypothesis mean
SD = standard deviation
n = sample size

The z-score is a measure of the number of standard deviations a data point is away from the mean. By finding the size of the rejection area we can determine the p-value and compare it with the confidence interval. A low p-value (small area of rejection) implies that the null hypothesis is unlikely to be true and precedes to the rejection of the null hypothesis, meaning there is a significant relationship between the two variables. In this report, a 99% confidence interval was used, meaning there is less than 1% probability that the assumption of accepting or rejecting the null hypothesis (based on the p-value) is wrong.

Nature and Cause Descriptions were found to be significantly correlated when testing the null hypothesis between them, several significant correlations at 0.01 level were found (p-value < 0.01) the correlations were analyzed using Pearson's r and are summarized in Table 2-6.

**Table 2-6 Correlation Between Nature and Cause Description**

| | | **Cause Description** |
|---|---|---|
| **Nature Description** | **Pearson Correlation** | .102(1) |
| | **p-value** | .000 |
| | **n** | 5780 |

Note: 1. Correlation is significant at the 0.01 level (2-tailed).

The significant correlation is explained by the association of Sprains/Strains, Contusions, Bites, and Lacerations, with certain Cause Descriptions, as shown in Table 2-7 below. Lifting was the leading Cause of Sprain/Strain injuries, while Object Handled was the leading Cause for Contusion and Laceration Natures of Injuries.

**Table 2-7 Percent of Cause Descriptions by Nature of Injury**

| **Cause Description** | **Percent of Nature Injuries** |
|---|---|
| **Sprain/Strain** | |
| **Lifting** | **19%** |
| **Surface** | **17%** |
| **Climbing/Descending** | **13%** |
| **Object Handled** | **12%** |
| **Motor Vehicle** | **10%** |
| **Other** | **29%** |
| **Contusion** | |
| **Object Handled** | **31%** |
| **Surface** | **14%** |
| **Other** | **55%** |
| **Bite** | |
| **Insect or Animal** | **97%** |
| **Other** | **3%** |
| **Laceration** | |
| **Object Handled** | **44%** |
| **Other** | **56%** |

### *2.4.3 Source Description*

Source Description mainly describes "the objects, substances, equipment, and other factors that were responsible for the injury"(BLS, 2023). The highest occurring Source Descriptions representing 66% of all TMT related injuries are Struck By (21%), Fall/Slip/Trip (19%), Bodily Motion (12%), External Contact (7%), and Vehicle Collision (6%). All remaining injuries based upon

Source Descriptions were aggregated into one category named “Others” representing 34% of the total number of TMT injuries as shown in Figure 2-14.

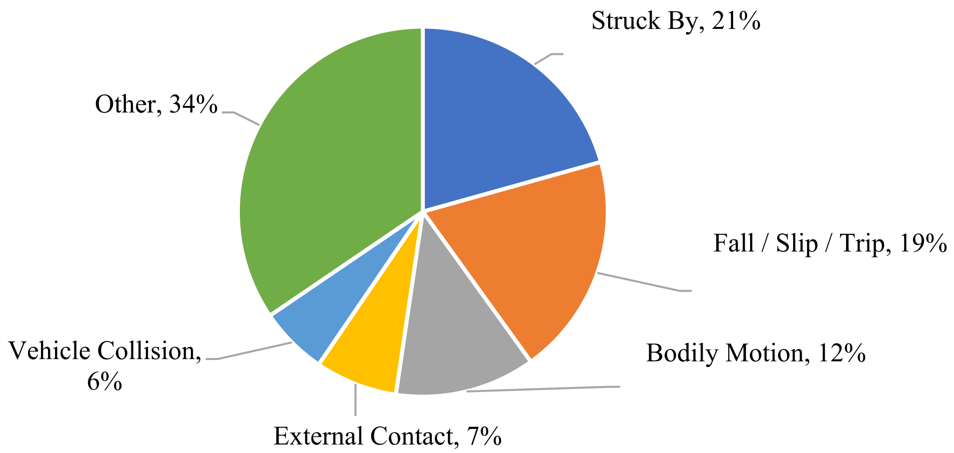


**Figure 2-14 Source Descriptions with Highest Percent of Injuries.**

Some of the Other Source Descriptions included in the category “Others” in Figure 2-14 are shown in Figure 2-15.

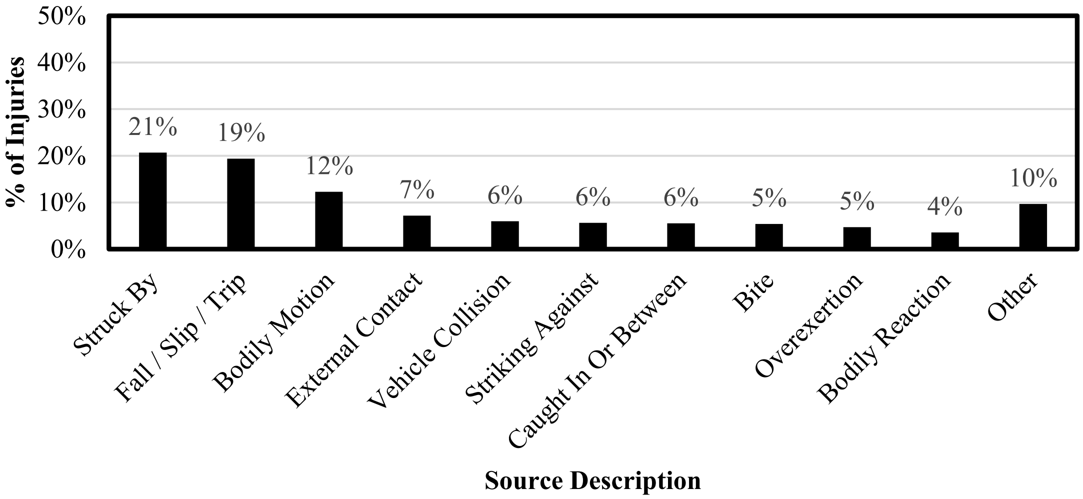


**Figure 2-15 Percent of Injuries Source Description.**

The relationship between Source and Cause Description was investigated, as well as the relationship between Source and Nature Descriptions using Pearson’s r test. Logical significant correlations were found between the Source and Cause at 0.01 level (Table 2-8), which served as an additional description of the event leading to the injury.

## Table 2-8 Correlation Between Source and Cause Description

| | | Cause Description |
|---|---|---|
| Source Description | Pearson Correlation | .205[1] |
| | p-value | .000 |
| | n | 5780 |

Note: 1. Correlation is significant at the 0.01 level (2-tailed).

The significance of the correlation is explained by the following associations: (1) Fall/Slip/Trip with Surface and Climbing/Descending, (2) Struck by with Object Handled, (3) Bite with Animal or Insect, (4) Overexertion and Bodily Motion with Lifting, (5) Vehicle Collision with Motor Vehicle. Similarly, records of frequent Nature Descriptions were found significantly correlated to certain Sources of injuries as shown in Table 2-9.

## Table 2-9 Correlation Between Certain Natures and Source Description

| | | Source Description |
|---|---|---|
| (Sprain/Strain, Contusion, Laceration) | Pearson Correlation | -.284[1] |
| | p-value | .000 |
| | n | 5780 |

Note: 1. Correlation is significant at the 0.01 level (2-tailed).

Significant relationships between Nature and Source of injury are shown in Table 2-10.

## Table 2-10 Percent of Source Descriptions by Nature of Injury

| Source Description | Percent of Nature Injuries |
|---|---|
| **Sprain / Strain** | |
| Bodily Motion | 30% |
| Fall/Slip/Trip | 28% |
| Overexertion | 13% |
| Other | 29% |
| **Contusion** | |
| Struck By | 42% |
| Fall/Slip/Trip | 24% |
| Other | 34% |
| **Laceration** | |
| Struck By | 53% |
| Striking Against | 28% |
| Other | 19% |

Although these correlations seem logical, it is a crucial step to determine the leading events causing these injuries sustained by ALDOT employees.

### *2.4.4 Part of Body*

Part of Body is used to identify the body part that was directly affected by the injury. Top five body parts affected presented 53% of all injuries, and included: Multi Body Parts (19%), Back

(12%), Knee(s) (8%), Finger(s) (8%), and Arm (6%). Injuries sustained to the Shoulder, Hand, and Leg accounted for 15% of TMT injuries, with each sharing an equal percentage (Figure 2-16).

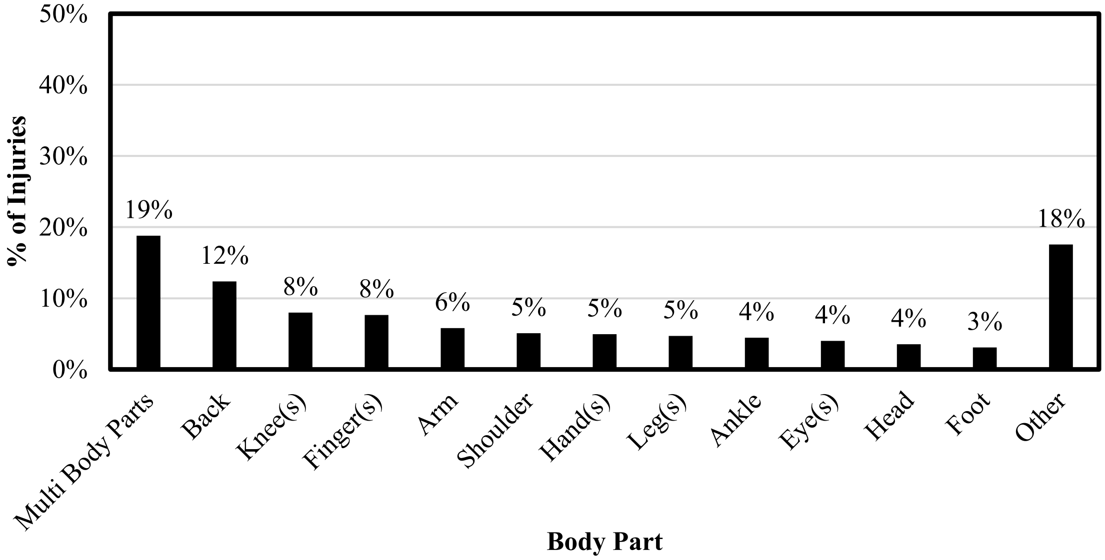


**Figure 2-16 Percent of Injuries By Part of Body.**

The relationships between Part of Body and Cause, Source, and Nature Descriptions were found significant at the 0.01 level as shown in Table 2-11.

**Table 2-11 Correlation Between Body Part and Injury Characteristics**

| | | (Sprain/Strain, Contusion, Laceration) | Cause Description | Source Description |
|---|---|---|---|---|
| **Part of Body** | **Pearson Correlation** | -.187[(1)] | -.075[(1)] | -.074[(1)] |
| | **Sig. (2-tailed)** | .000 | .000 | .000 |
| | **n** | 5780 | 5780 | 5780 |

Note: 1. Correlation is significant at the 0.01 level (2-tailed).

When exploring the relationship between the Part of the Body and other Injury Characteristics, it was found that 73% of all Back injuries were a result of Sprain/Strain, and 59% of all Shoulder injuries were also a result of Sprain/Strain. 35% of all Multi Body Part injuries were a result of Fall/Slip/Trip. These percentages are shown in Table 2-12.

**Table 2-12 Significant Correlations Between Body Part Affected and Other Injury Characteristics**

| Injury Characteristic | Percent of Body part Injury |
|---|---|
| **Back** | |
| Nature Description: Sprain/Strain | 73% |
| All Other Natures | 27% |
| Cause Description: Lifting | 47% |
| All Other Causes | 53% |
| **Knee** | |
| Nature Description: Sprain/Strain | 39% |
| Nature Description: Contusion | 27% |
| All Other Natures | 34% |
| **Shoulder** | |
| Nature Description: Sprain/Strain | 59% |
| All Other Natures | 41% |
| **Multi Body Parts** | |
| Source Description: Fall/Slip/Trip | 35% |
| All Other Sources | 65% |
| **Ankle** | |
| Source Description: Fall/Slip/Trip | 70% |
| All Other Sources | 30% |
| Cause Description: Surface | 43% |
| All Other Sources | 57% |

## 2.5 Estimation of Injury Cost

The cost of injury can be divided into direct and indirect costs. Due to data limitations of the ALDOT dataset, median days away and worker's compensation discussed in this section are based on aligned Body Part, with BLS tables that provides estimated median number of days away from work by Body Part, as well as total incurred cost by Body Part provided by the National Safety Council. The monetary value of indirect costs will not be calculated but will be expressed by Median Days Away from Work. The Analysis will be provided based on an annual average, as the cost of injuries per year provides better understanding of the impact of TMT injuries on ALDOT training substitute workers costs, loss of productivity and efficiency, and paid time-off, and worker's compensation costs based on a yearly budget.

### *2.5.1 Median days away from work*

Records that contain information about days away from work in ALDOT data are limited to the years 2020 through 2024. These records are used to estimate the percentage of Body Part injuries that result in 3 or more days away from work with the corresponding Body Part category. Figure 2-17 highlights the percentage of TMT injuries by Body Part that result in three or more days away from work. It shows that Wrist and Shoulder injuries are the most likely to result in significant time off. Back and Lower Body injuries also result in considerable time away from work. Injuries to the Head and Arms seem less likely to result in extended time off, possibly indicating a lower incidence of severe injuries to these areas.

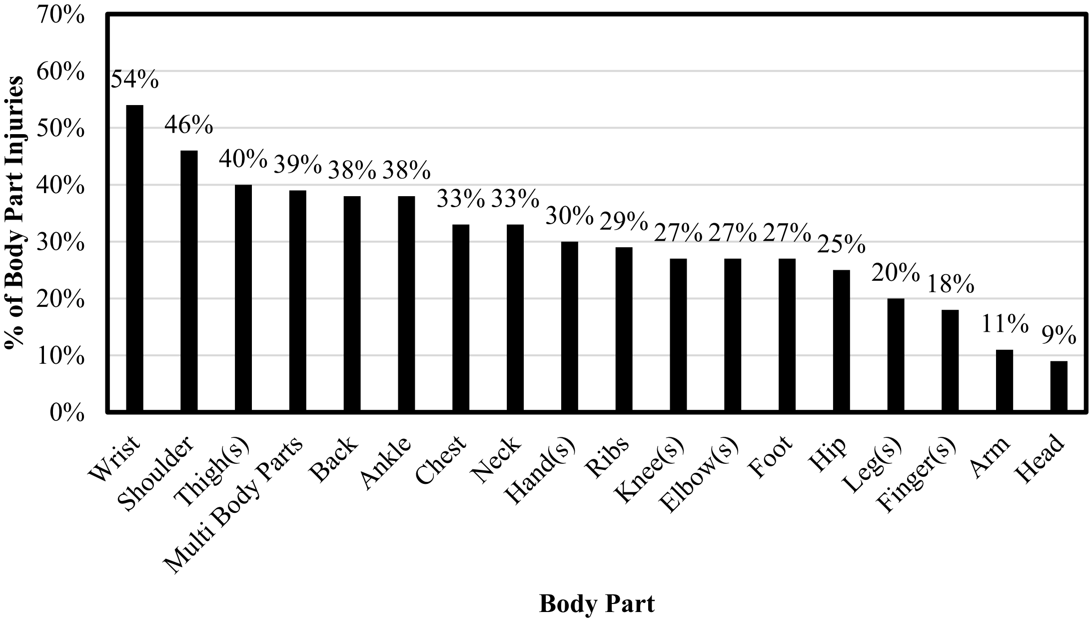


**Figure 2-17 Percent of TMT Injuries resulting in 3 or More days Away Within Body Part Category.**

Using this information, along with the average number of TMT injuries per year (excluding years with partial data), we can estimate the annual cost of injuries by Body Part. By applying the percentage of injuries that result in three or more days away from work for each Body Part, we can calculate the number of injuries that lead to significant time off. Once we have the number of injuries per Body Part resulting in I-claims, we can multiply it by the associated median number away from work as well as cost of treating and compensating for those injuries, allowing us to estimate the direct and a portion of indirect costs per year for TMT injuries by Body Part. This approach helps in identifying the costliest injury types by associating other the Body Part affected to its injury characteristics.

Figure 2-18 presents the estimated number of days away from work per year for TMT injuries based on the affected Body Part. The total estimated annual number of days lost by TMTs is 670 days. Injuries involving Multiple Body Parts result in the most significant time away from work, with an average of 164 days lost annually. This is followed by injuries to the Shoulder (132 days), Knees (76 days), and Back (75 days), all of which lead to considerable time off. Other body parts with notable time away include the Wrist (47 days), Ankle (34 days), and Legs (30 days). Injuries to the Arm (21 days), Elbows (17 days), Hands (17 days), and Fingers (16 days) also contribute to time lost but to a lesser extent. Foot, Neck, Chest, Hip, Thighs, Ribs, and Head injuries, cause fewer days away, ranging from 2 to 15 days annually.

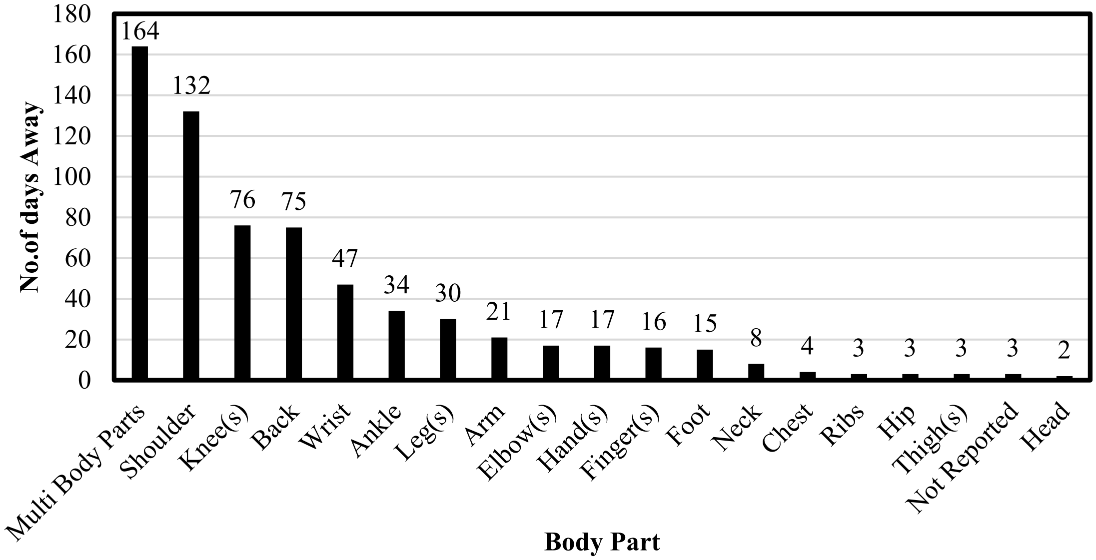


**Figure 2-18 Number of TMT Days Away from Work by Body Part per Year.**

### *2.5.2 Worker's compensation*

Total cost of Worker's Compensation was assigned only to I-claim TMT injuries based on average total incurred costs per claim by Body Part, provided by the NSC (NSC, 2024). Cases of death occurred within the 16-year period of ALDOT injury records are excluded. The estimated ALDOT average total direct cost per year for the 16-year period (2009 - 2024) is $1.59 million. Inclusion of indirect costs would be higher.

Injuries affecting Multiple Body Parts are the costliest, with an annual expense of $560 M, reflecting the severity and complexity of these cases. Back injuries rank second, costing approximately $213K per year, followed by Head injuries ($189K), Arm and shoulder injuries approximately cost $150K for each category, followed by Knee injuries ($106K). Other significant costs were associated with Ankle injuries at $92K and Neck injuries at $66K. The lower extremities, such as Hips and Thighs, account for smaller but costs, at $3K each. Figure 2-19 details direct costs associated with TMT injuries by body part.

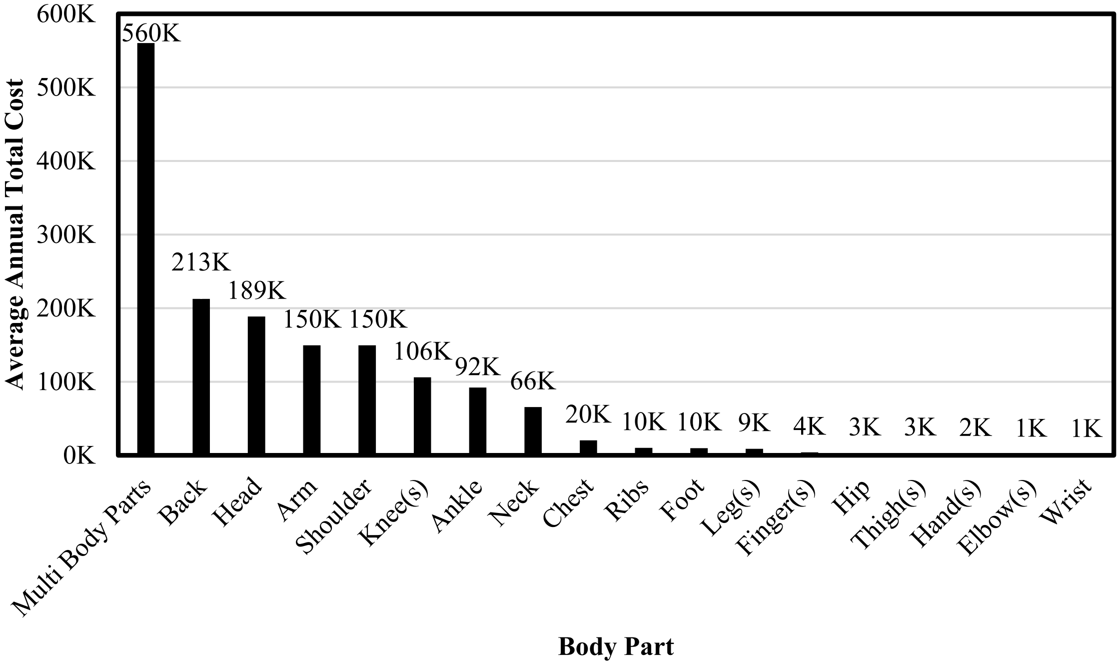


**Figure 2-19 Annual Worker's Compensation Cost of TMT Injuries by Body Part.**

Note: 1. These numbers are based on the national average total incurred costs per claim and might be overestimated

*Cost of injuries and correlations with injury characteristics.* Assigning cost to TMT injuries based on Body Part reveals how the affected Body Part can have a varying impact on the number of days away from work and the corresponding direct costs. Injuries affecting Multiple Body Parts, Shoulder, Knee, and Back take longer to recover from resulting in more days away from work, they also incur the highest costs. Understanding the Causes, Natures, and Sources associated with different Body Part injuries provides valuable insights into the impact of specific injuries on TMT productivity and ALDOT expenses.

Multi-Body Part Injuries, with the longest time away from work as well as highest incurred cost were found to be significantly correlated with Falls/Trips/Slips (35% of all Multi Body Part injuries). These injuries require more recovery time and are associated with medical fees, resulting in high direct cost and number of days away from work.

59% of Shoulder Injuries are due to Sprain/Strains and result in considerable number of days away from work, along with the high direct cost, which can be attributed to the frequent use of the shoulder in physical tasks.

Back injuries, primarily Sprains/Strains (73%), are commonly caused by Lifting (47%). These injuries result in substantial recovery time and rank 2nd in highest direct cost. Knee injuries are sustained by a mix of Sprains/Strains (39%) and Contusions (27%), which are often caused by Lifting or Bending activities. The nature of these injuries results in relatively moderate direct and indirect cost, as the Knee is critical for mobility.

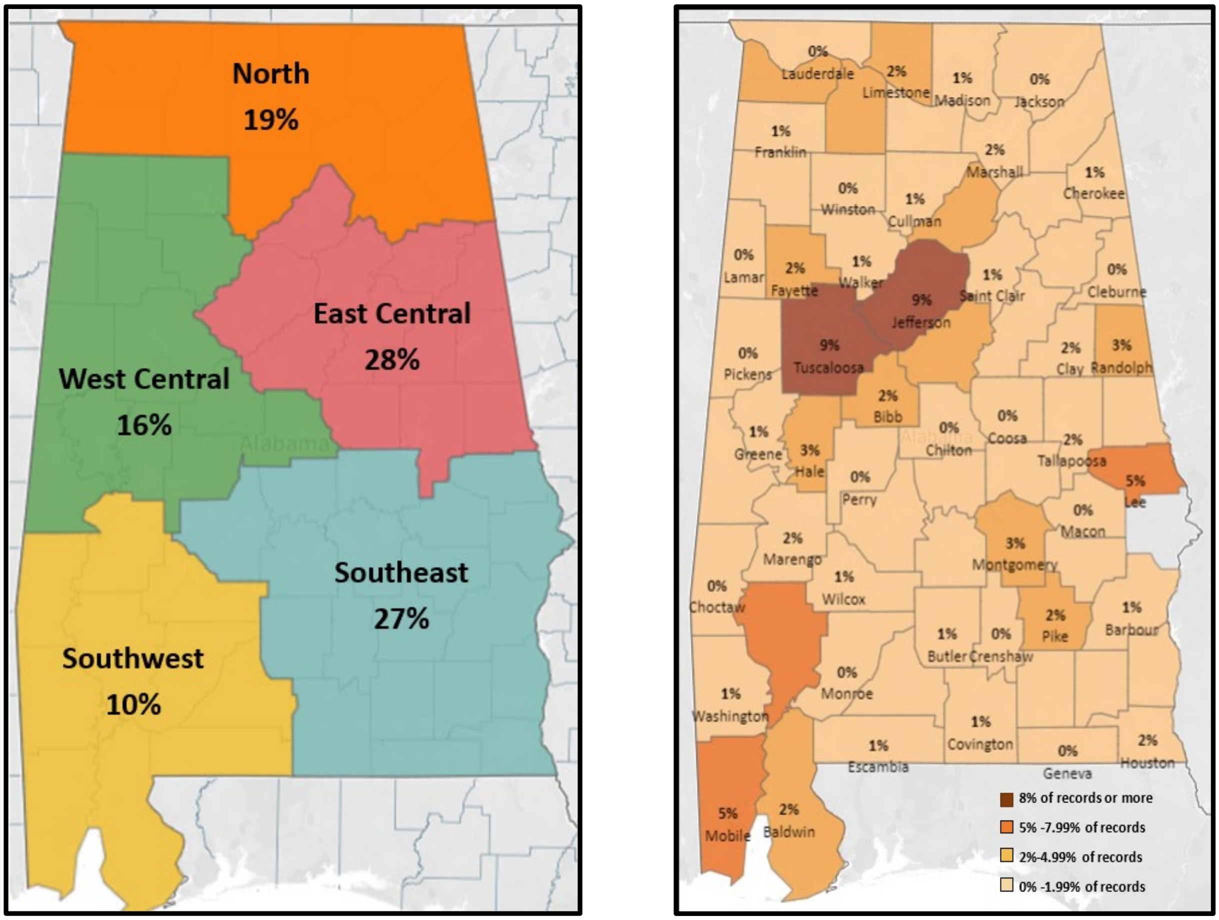
While wrist injuries have a lower median number of days away and direct cost, they still contribute to significant time off, as the wrist is essential for handling tools and objects, leading to limited function when injured.  Falls, Slips, or Trips account for 70% of Ankle injuries, and require moderate recovery period.  These types of injuries often limit mobility, resulting in days away and high medical fees.

## 2.6 Mapping the Injuries

The dataset included information about the Department Name and the Sub-department Name for 89% of the injuries.  These records were mapped and geographically presented to help identify hotspots and prioritize implementation of prevention measures.

526 records (9.1%) out of 5,780 records were not assigned any geographical attribute. These records had the following Department Names: (1) Air Transportation Bureau, (2) DOT, (3) DOT-Maintenance, and (4) Transportation Department.  These records were not considered in the analysis to identify patterns or hotspots of worker injuries.

East Central Region had the highest number of injuries followed by Southeast and North Regions.  The Southwest Region had the lowest number of injuries as shown in Figure 2-20(a). The counties with the highest number of injuries included Jefferson (9% of TMT injuries), Tuscaloosa (9%), Mobile (5%), Lee (5%), and Clarke (4%) as shown in Figure 2-20(b).



(a) by ALDOT Region (b) by Alabama County

**Figure 2-20 Percent of TMT Injuries by Region and County.**

Note: 1. 526 records are omitted due to missing location information.

## 2.7 Limitations of the Dataset

The ALDOT worker safety dataset had several limitations that are crucial to consider for accurate analysis and risk assessment. These limitations included but are not limited to the following:

### *2.7.1 Sequence of events*

Sequence of events describes the occurrence of the injury sustained by a worker. An example of sequence of events would be a worker suffering from overexertion, carrying a container with flammable gas, trips causing the container to fall, which cause an explosion or fire. The dataset consisted of two fields for describing the sequence of events, however Injury Description fields provided minimal descriptions due to a limited number of characters in a cell within Excel or were missing entirely.

### *2.7.2 Coding of Falls*

The Injury Source description included the Source "Fall/Slip/Trip" is missing further coding of falls, such as, fall to lower level, fall on same level, or fall downstairs in addition the height of the fall (e.g., less than 6 feet or greater than 6 feet). Moreover, coding of the Source/Cause descriptions in the dataset was missing additional important descriptive coding (i.e., fell from a ladder, fell from scaffold, collapsing structure, etc.) and any contributing elements (i.e., wind, fluids, ice, etc.) (BLS, 2013).

### *2.7.3 Severity of injuries.*

Work related injuries differ broadly in severity. The severity of a recordable injury can be assessed by: (1) medical care beyond first aid, with no time away from work or restricted activities, (2) DART rate, (3) hospitalization records, and (4) instant or deferred fatality (BLS, 2013). None of these assessments were available in the ALDOT dataset.

### *2.7.4 Number of Hours Worked*

Fatality, injury, and illness rates should be compared against benchmarks to be able to assess the safety environment. The ALDOT dataset lacked the number of hours worked for all employees or for a certain Job Description, therefore fatality and injury rates could not be computed.

### *2.7.5 Further Coding to Several Nature Descriptions*

Some Nature Descriptions in the original ALDOT dataset are vague and do not provide sufficient information for analysis. These Natures include: (1) Injury, (2) Multiple Injuries, and (3) No Injury. These descriptions do not provide a sequence of events, or the type of injury sustained to perform an analysis, provide recommendations, and determine countermeasures.

### *2.7.6 Other Dataset Issues*

During the data preparation process, the following is a list of issues that were discovered within the provided dataset: (1) Records were missing in October, November, and December of the year 2019; January, March, April, May of the year 2020; Only January, February, July, October, December records for 2023; and only January, March, April, and June records for the year 2024, (2) Worker's compensation policy, legal and medical fees to determine direct cost incurred by injuries were not available for analysis, and (3) Other factors that can contribute to injuries, like age, years of experience, time of day, race, or gender were not available.

## 2.8 Conclusion

ALDOT's worker injury data reveals that TMTs consistently account for the highest percentage of injuries, making up an average of 60% of all reported injuries annually across the 2009-

2024 period.  This high injury rate signifies a need for dedicated attention to this group, as the physical nature of their work exposes them to a variety of hazards, including those related to Sprains and Strains, Manual Handling, Motor Vehicle incidents, and Surface-related Falls.

Key characteristics of TMTs' injuries include Sprain and Strain injuries, which primarily affect the back, shoulder, and knees, representing 26% of all TMT injuries.  41% of Sprain / Strain injuries result in 3 or more days away from work, and are mainly associated with Lifting, Bodily Motion, Fall/Slip/Trip and Overexertion.  Contusions and Cuts/Lacerations follow where 17% and 16% of these injuries result in days away from work, respectively.  These injuries are associated with Struck by, Fall/Slip/Trip, and Object Handled incidents.

Object Handled, Motor Vehicle, and Surface (Falls/Slips/Trips) are the primary causes of TMT injuries.  Notably, Motor Vehicle-related injuries have undergone a dramatic increase in 2024, rising to 26%.  These injuries are particularly severe, often resulting in longer recovery times and greater costs.

The financial burden of TMT injuries can be assessed by indirect costs such as lost productivity, training replacement workers, and reduced workforce efficiency, as well as direct costs of medical and compensation expenses.  The high costs associated with certain types of injuries such as Sprain/Strain and Contusions highlight the need for targeted interventions to reduce both injury rates and costs.

Injuries to Multiple Body Parts, as well as to the Shoulder, Back, and Knees, result in the longest recovery times, with median days away from work for Multi-Body Part injuries reaching 164 days annually.  These injuries affect the workers' quality of life and incur high costs due to the extended periods of absenteeism and associated medical and compensation expenses.  TMT related injuries affecting Multiple Body Parts are the most expensive, with an annual cost of $560K.  Back injuries cost ALDOT approximately $213K annually.  Shoulder and knee injuries contribute to approximately $150K and $106K respectively each year.

The most common Nature Description of Multiple Body Part injuries is Strains/Sprains. These injuries often arise from Falls, Slips, and Trips, which account for 35% of Multi-Body Part injuries, while Surface conditions and Motor Vehicles are primary Sources.  Shoulder injuries mainly involve Sprains/Strains, with 59% of cases falling under this category.  These injuries typically result from repetitive motion or acute trauma during physical tasks such as Pushing, Pulling, or Lifting leading to strain injuries.  Bodily Motion during manual handling of objects is another significant cause of Shoulder injuries.

The majority (73%) of Back injuries are Sprains and Strains, reflecting the physical nature of TMT work.  Back injuries commonly result from Lifting heavy objects (47%), and Bodily Motion, particularly twisting or bending during tasks.  Vehicle collisions and Falls are significant sources of Back injuries, especially when a worker is Struck by or involved in a Motor Vehicle incident. Knee injuries are also primarily Sprains and Strains (39%), in addition to Contusions making up 27% of cases.  Climbing and Descending from vehicles or structures, such as stepping out of trucks, is a leading Cause of Knee injuries.  Falls, Slips, and Trips contribute significantly, often on wet or uneven surfaces.  These specific injury patterns are important to understand, in order for ALDOT to implement targeted interventions aimed at reducing the frequency and severity of injuries.

Mapping the injuries by region and county can also aid in prioritizing locations where safety measures should be highlighted.

Rates were not calculated as part of this analysis since information about the number of hours worked by ALDOT employees was not provided.  However, injury records were used to compare and relate Injury Characteristics, and Regions to provide informed conclusions and future recommendations.

The next two chapters of this dissertation include two papers, each shedding light on different safety aspects as it related to TMTs.  The first paper surveys the safety efforts of state Departments of Transportation (DOTs) nationwide, offering a broad overview of the strategies designed to reduce worker injuries.  The second paper focuses on ALDOT TMTs to gain insights pertaining to their safety perspectives.  The two papers identify how safety is viewed and implemented across different levels and set the stage for further identification of specific safety needs and improvement opportunities within ALDOT.

# CHAPTER 3: STATE-OF-THE-PRACTICE SURVEY: UNITED STATES DEPARTMENTS OF TRANSPORTATION WORKER INJURIES AND SAFETY PROGRAM EFFORTS

## ABSTRACT

The State-of-the-Practice Survey on United States Departments of Transportation (DOTs) Worker Injuries and Safety Program Efforts is a comprehensive report that provides valuable insights into the safety programs of state DOTs. The survey was conducted using a web-based questionnaire that was distributed to all 50 state DOTs and received a response rate of 44% (22 states). The survey consisted of 40 questions that were designed to gather information about the safety programs of state DOTs, including their training and education efforts, injury analysis practices, and safety efforts. The survey responses were analyzed using descriptive statistics and a thematic analysis approach. The results highlighted contrasts in safety efforts across responding DOTs, with various methods of injury documentation, data collection, and the implementation of safety-related policies and procedures. The report offers recommendations for reducing worker injuries and illnesses, including the need for standardized injury documentation and data collection practices, the provision of regular and updated training to address new hazards that may arise due to changes in job tasks or procedures, the allocation of adequate funding and resources to support safety programs, and the development of a return-to-work program to facilitate the prompt return of injured workers. Additionally, ergonomic assessments and training should be provided to prevent musculoskeletal injuries. The report concludes that state DOTs can benefit from sharing best practices and collaborating on safety initiatives in order to improve worker safety and reduce the incidence of injuries and illnesses. The findings of this survey may be beneficial to any DOT implementing worker safety best practices within their respective agency. The limitations of the study include a lack of inferential statistical analysis due to the restricted statistical power of the sample size

Keywords: transportation; worker safety; state-of-the-practice; injury reporting; near misses; policies; procedures; and training

## 3.1 Introduction

Departments of transportation (DOTs) are the main governmental entities accountable for the development, construction, maintenance, and operation of interstates and roadways within their respective state (OSHA, 2016). Since construction, maintenance, and traffic control operations expose roadway workers to different hazards (some potentially fatal), state DOTs have an obligation to improve and advocate for the safety of their employees.

While all state DOTs are responsible for administrating and maintaining their state roadway systems, individual organizations can have different approaches to their organization's safety programs. The primary purpose of these efforts is to prevent work-related fatalities, injuries, and/or illnesses. Additional considerations include the desire to limit negative financial implications incidents can create for employees, their families, and organizations alike. Safety programs should employ proactive strategies to control and improve worker safety at the workplace

(U.S. DOT, n.d.). Aspects such as organizational size, availability of funds, and organizational structure can differ broadly from one state to another and may influence implementation. Regardless, state DOTs should mirror best practices that have shown to be effective in reducing harmful worker outcomes.

The Alabama Department of Transportation (ALDOT) began implementing a revised Worker Safety Program in 2020. To determine the state-of-the-practice (SOTP), ALDOT collaborated with the University of Alabama at Birmingham (UAB) to conduct a SOTP survey of state DOTs nationwide to review realistic practices, policies, and programs. The aims of the SOTP Survey on U.S. DOT Worker Injuries and Safety Program Efforts were to identify risks and trends and provide recommendations for reducing the occurrence of worker injuries and illnesses. The survey aimed to gather information about the safety programs of state DOTs, including their training and education efforts, injury analysis practices, and effective safety initiatives. The survey results were intended to highlight contrasts in safety efforts across responding DOTs and provide insights into best practices for improving worker safety. By dissemination of findings, the goal of the survey is to help state DOTs implement effective safety programs and reduce the incidence of worker injuries and illnesses.

## 3.2 Literature Review

DOTs across the United States provide jobs for almost 55,000 employees (U.S. DOT, 2021). However, the number of employees per state varies greatly; related to the lane miles of the state highways, number of bridge structures, population, passenger trips per year, etc. This creates discrepancies to the extent of coverage required from a worker safety standpoint. Regardless of agency size, the construction/maintenance occupational group represents the majority of DOTs workforce. Moreover, these workers experience the highest number of injuries/illnesses. These transportation workers routinely deal with hazards related to conducting work in sites adjacent to traffic, working with heavy equipment, transporting heavy materials, and are often exposed to extreme weather conditions (Al-Shabbani et al., 2017). Critical hazards causing concern in highway construction/maintenance operations were identified in a study by Hancher et al. and included: (1) runovers, backovers and rollovers of heavy machinery, (2) falls, (3) vegetation trimming and cutting, (4) crane operation, (5) short term/quick patching, (6) electric work activities, (7) lack of using proper personal protective equipment (PPE), (7) visibility and hearing, (8) trenching, shoring, and excavation, and (9) debris removal on highways (Hancher et al., 2007). These hazards should be properly and frequently addressed in maintenance worker training programs.

To reduce risks in the workplace, different control measures can have varying levels of hierarchy. The hierarchy of controls are as follows: (1) avoiding or reducing the hazard impact, (2) engineering controls, (3) administrative controls, and (4) PPE. Engineering controls include removal or minimizing the risk, design/redesign of work areas, equipment, or processes to eliminate, minimize, enclose or isolate the hazard(s). Administrative controls include written guidelines for operation and safe work practices, exposure period constraints, supervising the usage of hazardous materials, alarms, signs, and warnings, teamwork, and training (Roughton & Crutchfield, 2015).

Research conducted for the Iowa Department of Transportation to mitigate risks associated with highway maintenance operations proposed several strategies to decrease the frequency and severity of injuries. Strategies included revising existing guidelines and manuals, exploring new technologies for training and information sharing, focusing on worker and equipment visibility, holding meetings to discuss best practices, minimizing the number of workers and vehicles in high-risk environments, and emphasizing the importance of appropriate placement of temporary traffic controls. These strategies aim to improve the safety performance of transportation maintenance workers (Strong & Shane, 2012).

The intent of a safety program according to the Occupational Safety and Health Administration (OSHA) is to protect the workers from existing hazards and any possible risks in the workplace. An efficient safety program can considerably decrease the rate of injuries as it allows organizations to create a safe workplace and promote cooperation and employee involvement (Occupational Safety and Health Administration (OSHA), 2021). Safety programs are based on gathering information from different sources such as current injury records, assessment of hazards, investigating repetitive tasks, and identifying indirect factors leading to injuries. By interpreting this information, effective measures can be taken to lessen the effects of workplace injuries (Wiatrowski, 2013).

The Nevada DOT, for example, developed a workers' compensation system able to explore injury trends based on different characteristics. This system allows addressing recurring injuries, associated tasks, and can integrate controls to be shared with employees. Other features of Nevada DOT Safety Management System include crash investigation and tracking employee training. The positive outcomes since the implementation of their safety program can be observed when examining work-related injury records from 2011 to 2020. In 2011, Nevada DOT recorded 145 work-related injuries compared to 75 injuries in 2019 and 55 in the year 2020 (G. B. Dadi et al., 2022). Another case study conducted on Tennessee DOT (TDOT), which ranks in the top five highway systems in the United States (TDOT, 2021), discusses how the agency was able to improve communication, enhance the management and analysis of safety data and trends, as well as implement corrective measures using Tableau software, a dashboard reporting tool. This electronic system allows for prioritizing and allocating resources regarding urgencies and priorities. TDOT assessed that workers' compensation and property damage cost savings were around $1M in 2019 alone (G. B. Dadi et al., 2022).

The survey questions were developed based on a review of existing literature on worker safety programs and input from subject matter experts in the field. The variables investigated in the survey were determined and chosen based on the aims of the survey and to collect data on a range of variables related to worker safety, including:

1. Agency demographics
2. Injury documentation and data collection practices
3. Training and education efforts
4. Common injury natures, sources, causes
5. Injury and fatality rates

6. Near-miss incident reporting and analysis
7. Ergonomic assessments and training
8. Funding and resource allocation for safety programs

These variables were analyzed individually and collectively to unveil any correlations or causations, such as the size of DOT and funding, injury rate and percent of employees who frequently work in construction and/or maintenance operations, as well as injury documentation process and near-miss reporting.

Reviewing realistic practices, policies, and programs used by peer DOTs can educate decision makers about the hazards of their work environments / tasks and significantly improve the implementation of their safety programs.

## 3.3 Materials and Methods

The research survey was developed using Qualtrics and targeted respondents who were identified as responsible for their respective state DOTs safety program. The survey can be found on Qualtrics website using the following link:
https://uab.co1.qualtrics.com/jfe/form/SV_cCvniASQhmvD9Ai.

The survey comprised forty questions divided into six categories: (1) Agency Demographics, (2) Injury Reporting and Documentation, (3) Injury Trends, (4) Data Collection, (5) Training, and (6) Safety Related Policies and Procedures. Question types included multiple choice, Likert scale (i.e., 5-point), text entry, file upload, and matrix table format questions. Responses to Likert scale and multiple-choice questions were examined using descriptive statistics to recognize patterns and trends. Responses to open-ended (i.e., subjective) questions were qualitatively analyzed using a thematic analysis approach that provides content driven interpretation of data. The thematic method was used to detect, investigate, and report patterns. This was accomplished by gathering and organizing the survey responses in an excel spreadsheet that is easy to manage and visualize. Responses from the same organizations were examined to ensure consistencies, notes were taken and initial observations about recurring responses were noted. The next step was creating different charts and visualizations for each question's responses to identify patterns and generate initial insights until data saturation was reached and no new themes or insights were captured from the data. Finally, descriptions for each insight were documented and a narrative describing these insights was created.

The nationwide survey of state DOTs worker injury and safety efforts was deployed over a four-week period (July 5th to July 31st, 2022), with follow-up reminders sent weekly to non-responders. Ultimately, the survey response rate was 44% (22 of 50 US States). This response rate is considered above average in organizational research (Baruch & Holtom, 2008).

For content validity, the authors met with a panel of safety experts from Alabama Department of Transportation (ALDOT) and reviewed each question in the survey to guarantee relevance and comprehensiveness, as well as to collect feedback and make necessary modifications to ensure that the questions are not confusing and adequately cover the goals of the survey.

Respondents' job titles differed and included titles such as Safety Coordinator, Chief of Occupational Safety and Health, Safety Program Manager, Occupational Safety and Health Branch Manager, etc.  73% of respondents' job titles included the word safety. 36% included Director or Administrator, 32% included Manager or Coordinator, and 32% included Health.  A justification for the validity of survey responses was achieved based on the responding individual's job titles that demonstrate a knowledge, awareness, and access to the agency's current safety efforts, practices, issues, and information.

Different respondents from the same organization were asked to complete the survey.  In total, 23% of responding agencies submitted two or more responses from different safety personnel.  These responses were assessed for similarities individually as well as collectively and were all found to maintain consistency and ensure reliability.

Participating DOTs are shown in Figure 3-1 and classified by the respective state's governing OSHA plan (i.e., State or Federal).  State Plans are still overseen by the Federal regulatory agency OSHA and must be as stringent with regards to safeguarding the work environment.

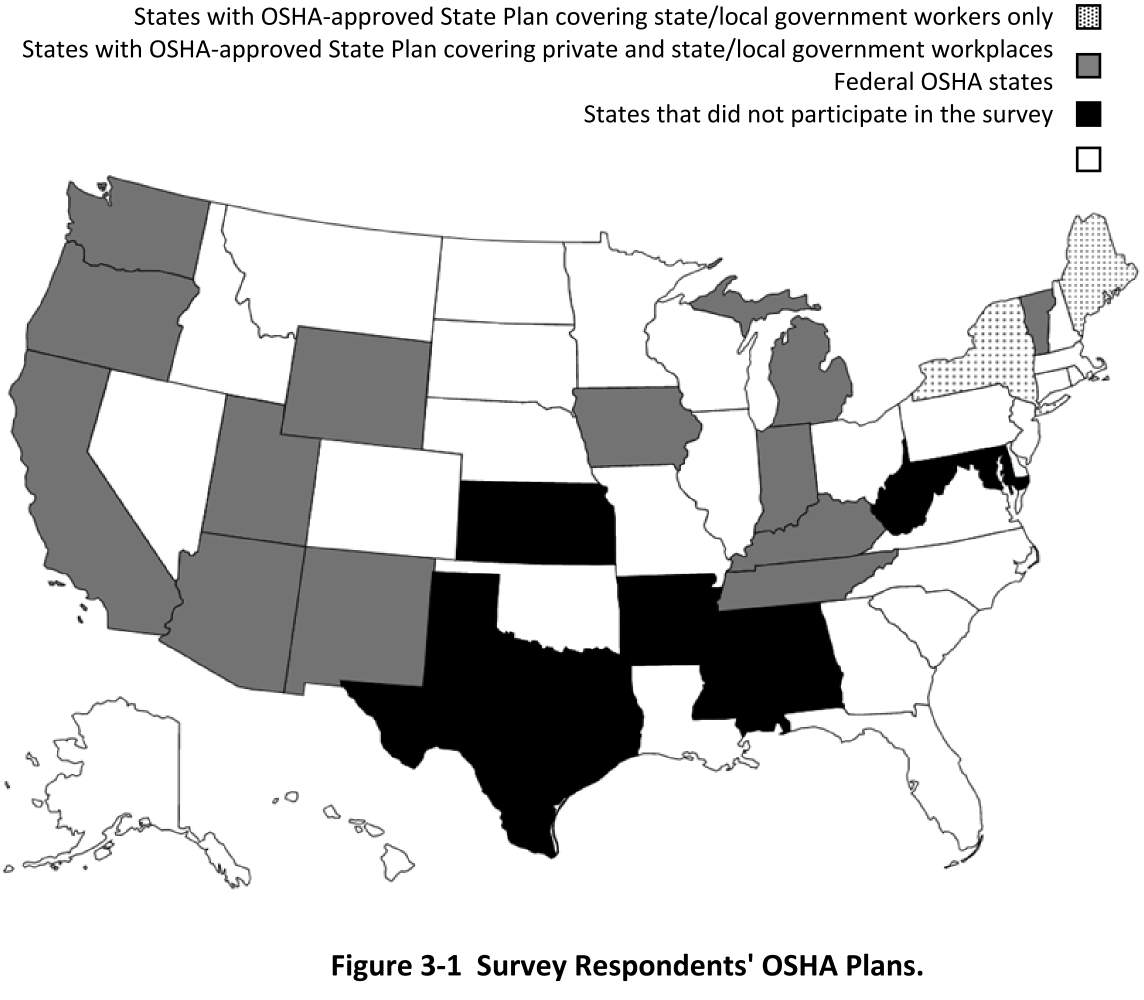


**Figure 3-1  Survey Respondents' OSHA Plans.**

## 3.4 Results

The following section includes the results of the survey and is divided into the following sections: (3.1) Agency Demographics, (3.2) Injury Reporting and Recordkeeping, (3.3) Injury Trends, (3.4) Data Collection, (3.5) Training, and (3.6) Safety Program Funding, Related Topics, and Procedures. Descriptive statistics were used to analyze the responses to Likert scale and multiple-choice questions and to recognize patterns and trends in the data. Visualization tools, while not a statistical technique per se, were used for conveying survey findings effectively. Charts and graphs can help present survey results in a visually appealing and comprehensible manner.

### *3.4.1 Agency Demographics*

The survey instrument collected contact information for each agency and responding individual(s). Respondents job titles differed and included: Safety Coordinator, Chief of Occupational Safety and Health, Safety Program Manager, Occupational Safety and Health Branch Manager, etc. 73% of respondents' job titles included the word safety. 36% included Director or Administrator, 32% included Manager or Coordinator, and 32% included Health. A viable justification for the validity of survey responses was supported by the responding individual's job titles that demonstrate a knowledge, awareness, and access to the agency's current safety efforts, practices, issues, and information.

Further survey questions inquired about the size of the agency regarding the number of employees and the percentage of workers who frequently work in construction and/or maintenance operations. Figure 3-2 shows that no responding agency operates with less than 500 employees, while most agencies range between 2,000-4,000 employees (41%).

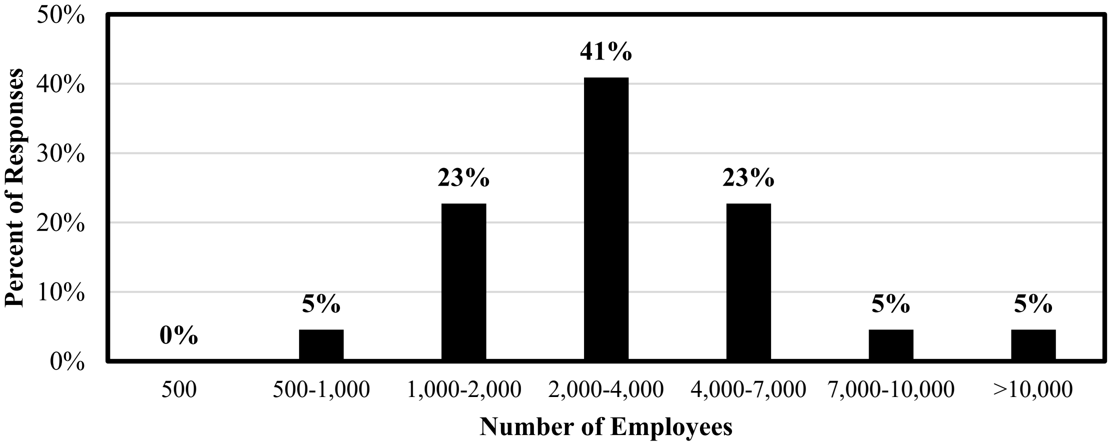


**Figure 3-2 Number of Employees according to the Percent of Responses.**

Figure 3-3 shows the percentage of employees who frequently work in construction/maintenance operations.

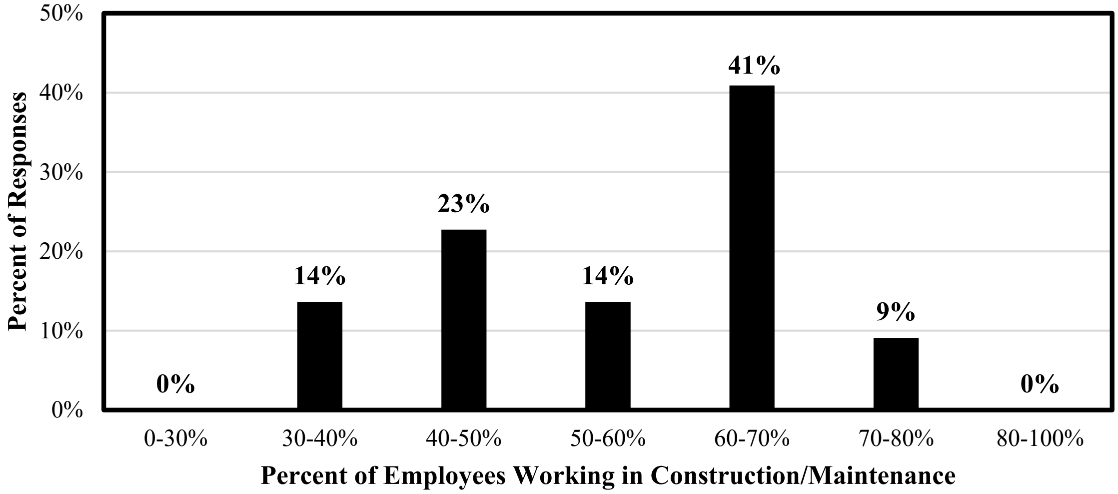


**Figure 3-3 Percent of Employees Frequently Working in Construction/Maintenance.**

In total, 60% of respondents reported that more than half of their employees work in construction/maintenance operations, which highlights the necessity for DOTs to prioritize worker safety given the inherent hazards associated with these operations.

### *3.4.2 Injury Reporting and Recordkeeping*

The survey examined procedures implemented when incidents, fatalities, or injuries occurred to gain a better understanding of national practices. Survey respondents were asked to provide their method of reporting and documenting incidents along with an indication of the importance of each action on a Likert scale.

Figure 3-4 illustrates that the majority of responding DOTs have consistent practices for reporting and recording injuries. An exception was notifying OSHA offices (federal or state), which is dependent on whether a DOT has an OSHA-approved State Plan that covers state and local government workers. Other reported actions by survey respondents included the dissemination of weekly statewide reports for sharing lessons learned and creating discussion opportunities, as well as investigating preventable and lost-time accidents in greater depth. Figure 3-4 also establishes completing ‘Worker Injury Claim’ and the ‘First Report of Injury (FROI)’ forms are considered among the most important reporting and recordkeeping efforts. Once established, a claims process for the affected worker can begin (i.e., receiving medical treatment and/or compensation).

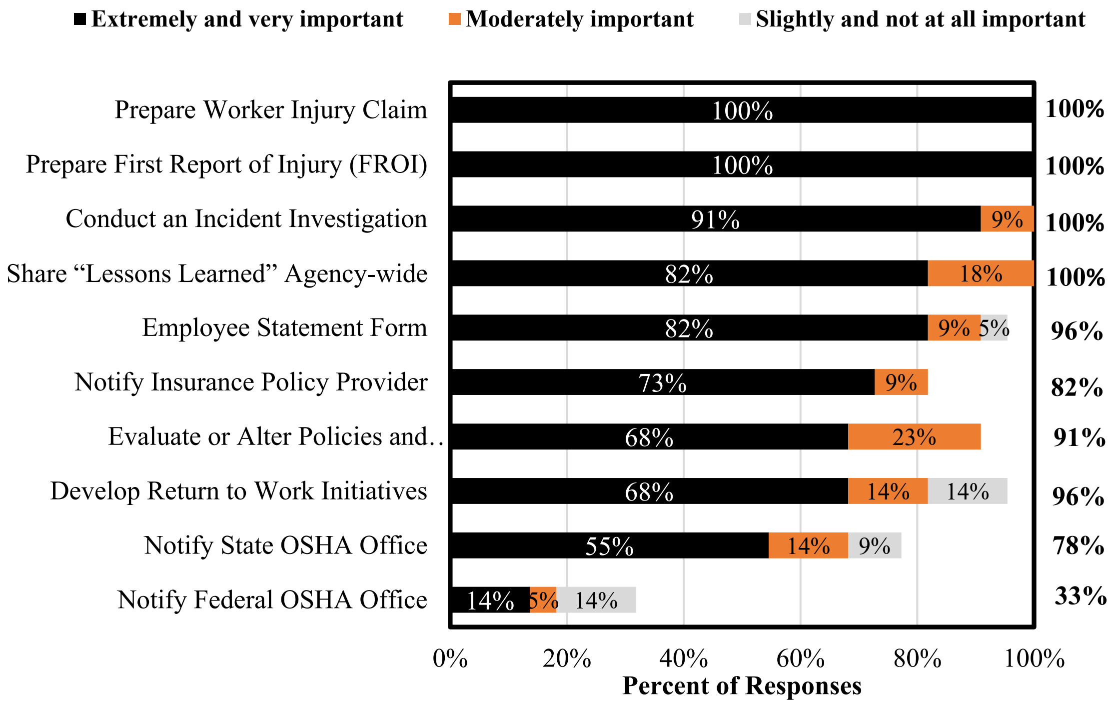


**Figure 3-4 Actions Taken Following an Incident by Importance for Injury Reporting and Recordkeeping.**

The format utilized by a DOT to record injury data must be convenient, efficient, and allow for maintaining of injury records. The survey results indicated that an online database is the preferable option, with 73% respondents employing one and 41% using discrete electronic means of documentation. However, 27% of responding agencies still use paper copies and another 5% reported that they are not using any specific format. A substantial need to enhance state DOTs injury reporting, record keeping, and data collection methods exists. Available methods used to collect and maintain injury data utilizing web-based platforms include, Intelex Software, Velocity EHS Software, and Internal Excel Spreadsheet.

A near-miss is an incident that does not cause injury or damage to equipment but has high potential to do so. Reporting near-misses improves identifying and controlling hazards; further reducing risks and injuries by implementing corrective measures before an actual event takes place. Respondents were asked to indicate if their agency has a system to report such occurrences and whether this system is complementary to reporting injuries. In total, 59% of respondents indicated that their agency records near misses, while 38% of these agencies have a similar reporting procedure for near misses as for incidents causing injuries or fatalities. The differences in reporting near misses were identified through a thematic method of analyzing survey responses. The survey collected information on the reporting procedures for near misses, including whether identification was required, what information was collected, and who was responsible for reporting. The survey also asked about the reasons for not reporting near misses. The responses were analyzed to identify the different approaches to reporting near misses, including anonymous reporting, verbally reporting to a supervisor or safety officer, and conducting a joint investigation with the employee(s) involved and their supervisor. A study by Gambatese et al., 2017, found the main reason for not reporting near misses was the absence of a precise description of a near miss (Gambatese et al., 2017). Overall, the survey responses were used to identify the different approaches to reporting near misses and to provide recommendations for improving near-miss reporting practices.

A study conducted by Marks et al. (2014) revealed that the prevailing approach to recording near misses is through a highly secure online database, particularly designed to facilitate queries based on industry-specific criteria. These databases consist of voluntarily submitted data, either by individuals directly involved in the incident or by mere eyewitnesses. While submissions can be made anonymously or with the identity of the reporting person disclosed, most of the literature examined reported a penchant for anonymous submissions. The study goes on to propose a comprehensive framework for a near miss reporting program that encompasses various domains including: (1) general program information, (2) a comprehensive definition of a near miss, (3) the flow of information, (4) knowledge dissemination, (5) a checklist for near miss reports, (6) establishment of a near miss database, (7) employee training activities, and (8) fostering an environment that encourages reporting, as well as diligent investigation process (Marks et al., 2014).

Furthermore, emphasizing the importance of documenting and tracing near misses regarding workplace safety in general and the relation between near misses and injuries will encourage employing near-miss reporting practices (Winkler et al., 2019).

The survey collected information on a state DOTs means for further categorizing actual injuries within their databases. Figure 3-5 displays the common injury classification criteria and is ranked according to the percentage of response.

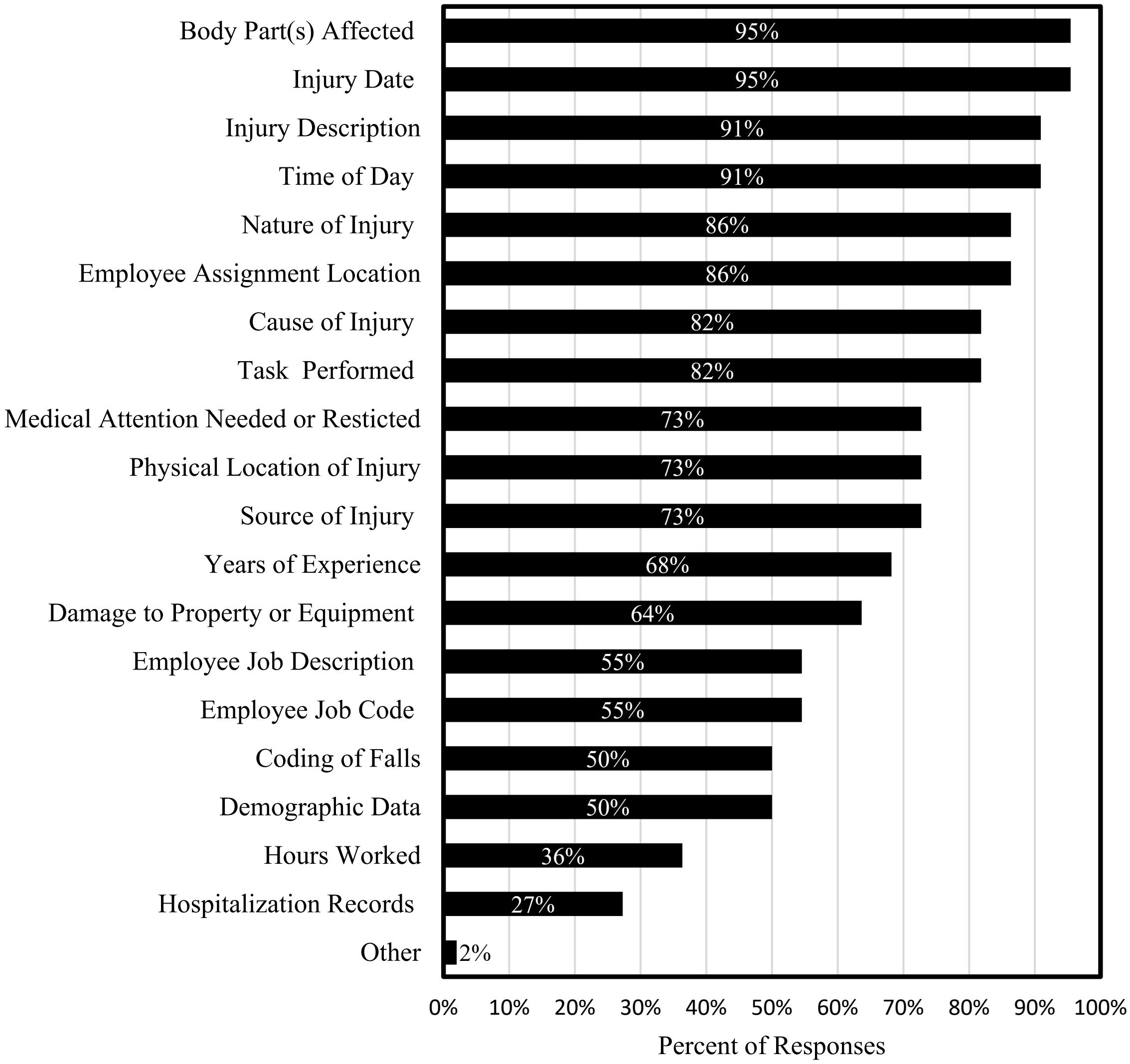
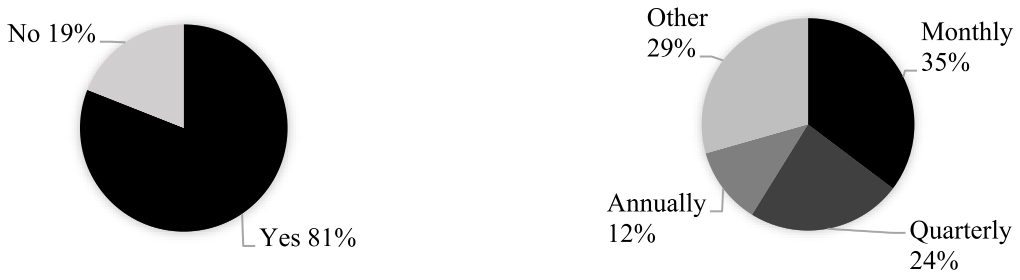


**Figure 3-5 Criteria for Categorizing Injuries in the Database.**

### *3.4.3 Injury Trends*

The survey identified common and unique injury trends experienced by state DOTs. Recognizing trends and common hazards allows for implementing effective countermeasures, and for the evaluation of successes and comparison of different data sets and time frames. In total, 81% of respondents reported that their agencies analyze injury trends consistently; as shown in Figure 3-6a. Respondents who answered yes to performing injury analysis were then prompted to indicate the frequency of the analysis. The most common analysis frequency reported was monthly as shown in Figure 3-6b. Other reported frequencies included weekly, depending on requests and agency demands.



(a) Percent of Responding Agencies Analyzing Injuries (b) Frequency of Injury Analysis by Agencies Analyzing Injuries

**Figure 3-6 Injury Analysis and Frequency of Injury Analysis by Percent of Responses.**

Maintaining records allows agencies to comply with mandatory OSHA's regulations pertaining to recordkeeping. More critically, it also provides an efficient tool to identify injury trends, assess the monetary implications of fatalities and/or injuries, investigate current procedures, plan future improvements to guidelines and procedures, as well as evaluate the success of employed measures. Figure 3-7 shows that the majority of responding agencies use injury records to review and evaluate safety procedures and training (86%), as well as identify injury trends (86%). Other reported uses included improving the recordkeeping and recording process and evaluations for senior leaders/supervisors.

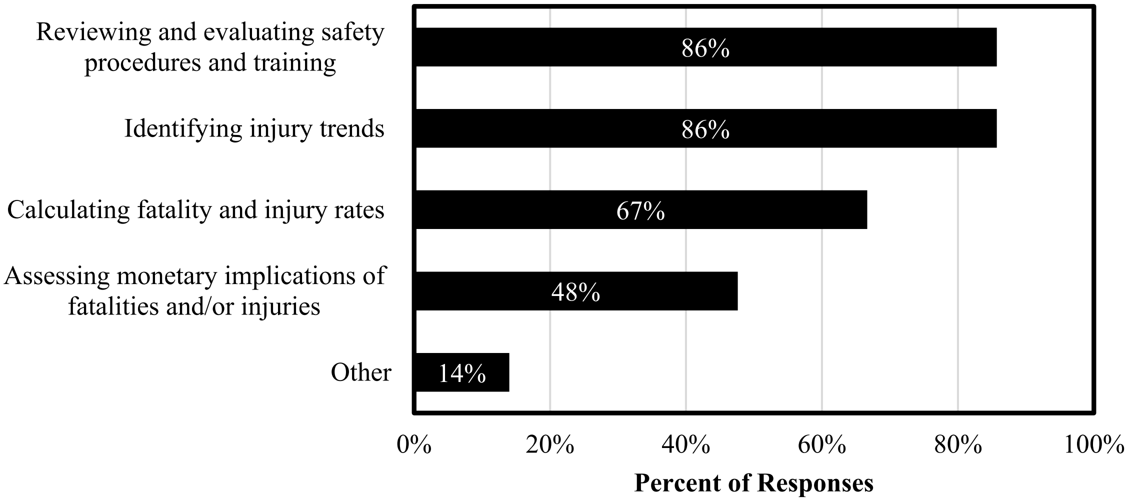


**Figure 3-7 Use of Fatality/Injury Records.**

Fatal injury rates assess the likelihood of sustaining a fatal work injury and are expressed as the ratio of fatalities per total hours worked per 100,000 full-time equivalent employees (FTE, working 40 hours per week, 50 weeks per year). Nonfatal injury rates by industry are calculated using hours-worked data expressed per 100 FTE (BLS, 2020). Rates can be utilized to explore a comparative level of injuries and/or fatalities among different DOTs, industries, and job descriptions whether on a state- or nationwide-level.

Only two respondents reported a fatality rate of zero and one agency reported a rate of 1 per 100,000 FTE while the remaining respondents did not indicate a rate. Although anonymity of respondents was promised and the purpose of the survey was communicated, the low response rate might be explained by legal and liability concerns of disclosing sensitive information. As for the non-fatal injury rate, 10 respondents reported rates ranging between 1.6 to 9.4 per 100 FTE, with an average of 4.05 and a median of 3.66 per 100 FTE.

Under-reporting is a factor that should be taken into consideration when calculating injury rates. It can lead to (1) a substantial underestimation of work-related injuries on the national level, (2) difficulty in identifying and addressing workplace hazards and risks, (3) inability to accurately measure the effectiveness of safety and health programs, (4) reduced ability to target resources to high-hazard industries and occupations, (5) increased costs to workers, employers, and society due to lost productivity, medical expenses, and workers' compensation claims, (6) reduced trust between workers and employers, which can negatively impact workplace safety culture, and (7) difficulty in accurately characterizing and eliminating barriers to gathering correct work related injury and illness rates. Under reporting can involve two types of actions; employers who provide incorrect information to the Bureau of Labor Statistics (BLS) regarding the number and severity of workplace injuries and illnesses and employees who choose not to report their work-related injuries or illnesses to their employers. There are reasons why under reporting occurs, such as inadequate recordkeeping practices by employers limited understanding of regulations among workers, fear of job loss if injuries are reported and employer programs that discourage reporting by offering rewards or punishments. The Recordkeeping National Emphasis Program conducted by OSHA between 2009 and 2012 indicated that fear of retaliation among workers and disciplinary measures implemented by employers as the primary factors contributing to, under reporting (Fagan & Hodgson, 2017).

The questionnaire requested respondents to identify the job description(s) or occupational group(s) that experienced or are most likely to experience the highest number of injuries. All respondents indicated that Transportation and Maintenance workers experienced the highest number of injuries in their agencies, which is expected considering that this group constitutes the highest percentage of DOTs’ employees as well as the hazardous nature of their assigned duties. Other Job Descriptions included Highway Incident Response staff, Equipment Operators & Toll Collectors, and Traffic Painters.

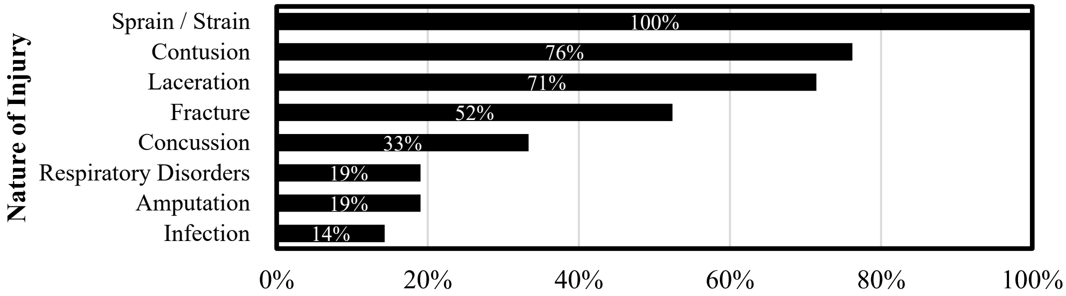
The survey investigated the most common injury characteristics suffered by employees. Certain types or characteristics of injuries occur more often than others. Examining such characteristics helps DOTs better understand and develop safety polices and countermeasures. The survey focused on four characteristics which are: nature, source, cause of injuries, and body part affected.

The nature of injury is the principal physical characteristic(s) of the injury or illness (Van Eerd et al., 2006). Figure 3-8(a) shows the most common natures of injury cited by responding agencies. The figure shows that the highest natures reported by agencies are sprain/strain with a 100% response rate, followed by contusion (76%), laceration (71%), and fracture (52%), respectively. These statistics are similar to the most common natures of nonfatal occupational injuries recorded in the 2020 Bureau of Labor Statistics (BLS) annual report for all industries (BLS, 2020).

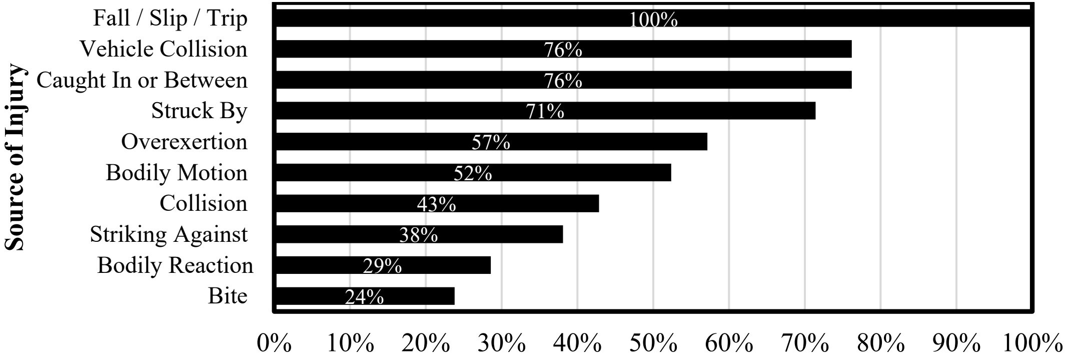
As part of the questionnaire, a distinction was made between the source and cause of injuries. The source mainly describes "the manner in which the injury was produced or inflicted" (BLS, 1992), while the cause of injury identifies the object, substance, bodily motion, or exposure which directly produced or inflicted the injury. The most cited sources of injuries by percent of responses are shown in Figure 3-8(b) with Fall/Slip/Trip (100%), Vehicle Collision (76%), Caught-In or Between (76%), Struck By (71%), and Overexertion (57%).

The causes reported by respondents are shown in Figure 3-8(c), which indicates that Lifting (86%), Bending/Twisting (76%), Motor Vehicle (71%), Pushing/Pulling (71%), and Climbing/Descending (67%) are the top 5 reported causes of injuries. It is worth noting that Lifting, Bending/Twisting, Pushing/Pulling, and Climbing/Descending can all be listed under Overexertion and Bodily Motion.

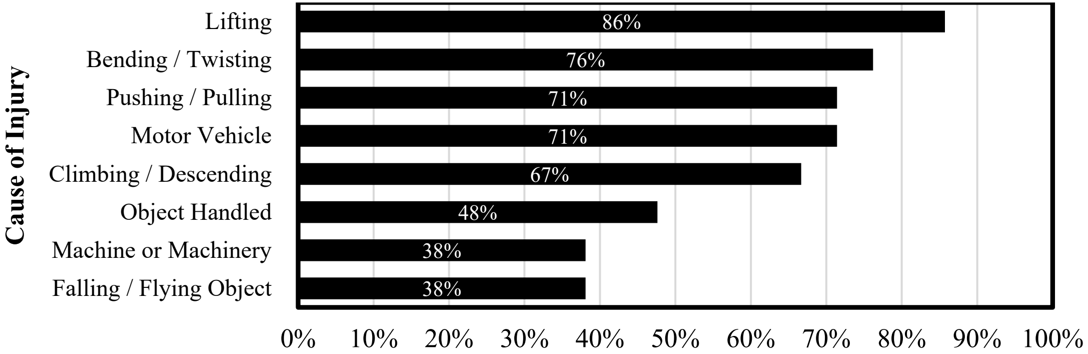
Figure 3-8(d) shows the most affected body parts by percent of responses. The top 5 most frequently injured body parts reported were the back (90%), hand and shoulder (81%), knees (67%), and fingers (62%).



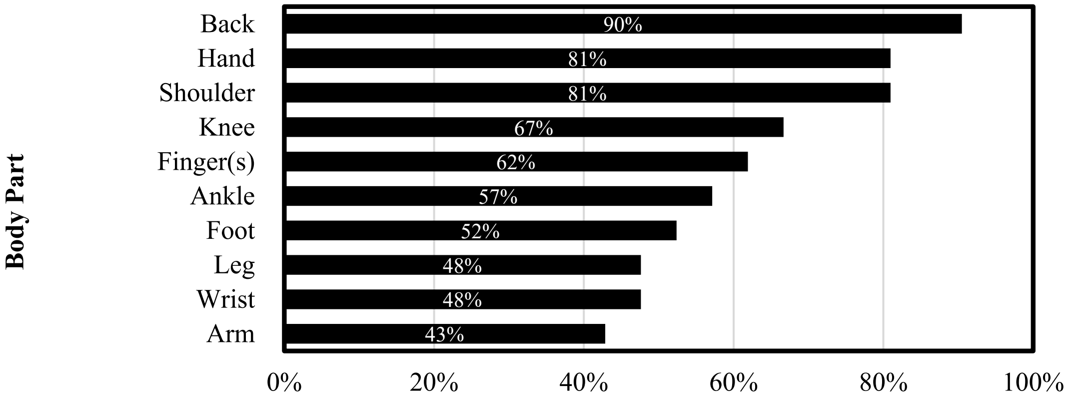
(a) Common Natures of Injuries by Percent of Responses



(b) Common Sources of Injuries by Percent of Responses



(c) Common Causes of Injuries by Percent of Responses



(d) Common Body Parts Affected by Percent of Responses

**Figure 3-8 Most Commonly Cited Injury Characteristics by Percent of Responses.**

The manner of addressing the hazards resulting in near misses, injuries, or fatalities was also explored. Figure 3-9 shows methods practiced, addressing hazards by percent response.

90% of respondents indicated that the hazards are investigated when an injury or a near miss is reported. Only 10% stated that their agencies have a yearly budget allocated for correcting hazards. One other reported method was toolbox/tailgate meetings specific for recognizing the hazards with employees that will be working during a specific job.

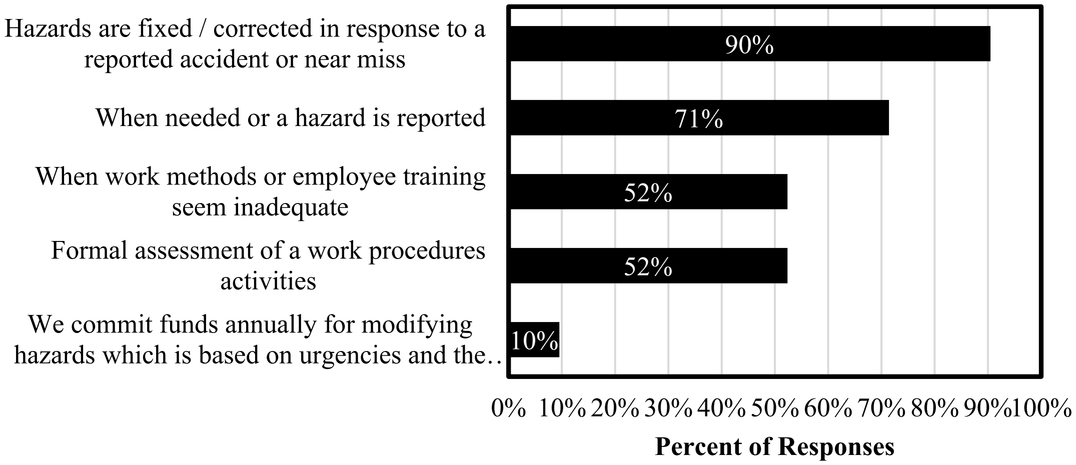


**Figure 3-9 Methods of Addressing Hazards by Percent of Respondents.**

### *3.4.4 Data Collection*

Part four of the survey sought to examine the sources of data available and analyzed by different agencies. Respondents were requested to check all available datasets used by their state DOT, as well as rank these sources based on the completeness of available information. "Completeness" refers to the extent to which the database contains all the relevant records and data elements that it should, i.e., number of missing records and the number of missing data elements within existing records. A data element refers to an individual field or piece of information that is coded within each record. For example, in a sprain injury record, data elements might include the date and time of the injury, the location, the task performed during injury, and the severity of injuries sustained. "Complete" signifies that the dataset has no missing records but might have missing data elements, however the adequacy of the dataset is not compromised. While "Very Complete" indicates a higher degree of completeness and excellence. On the other hand, "Incomplete" suggests that the information in the dataset is partially unfinished, while "Very Incomplete" indicates a more severe level of incompleteness. The choice between these scales depends on the level of detail and differentiation needed to capture the data. The authors chose to combine the scale of "Very Complete" with "Complete" as well as "Incomplete" with "Very incomplete" for (1) simplicity and ease of interpretation, (2) ease of reporting and visualization, (3) more meaningful comparisons, (4) reduction of data noise, and (5) to avoid subjectivity and inconsistency in responses.

Most available sources identified in the survey included safety training records, injury/fatality data, and insurance claims as seen in Figure 3-10. Respondents were asked to rank these sources on a scale from 1-5, 5 being very complete and 1 being very incomplete. The average “completeness” rank was as follows: Safety training records (4.6), Fatality/Injury data (4.5), Insurance claims (4.1), Medical records (3.4), and Annual performance reviews (3.2). These sources include many of the main safety information necessary for reviewing, improving, and evaluating safety programs and policies. Medical records and annual performance reviews scored lower in completeness, which may indicate restrictions on information because of confidentiality or health information privacy concerns.

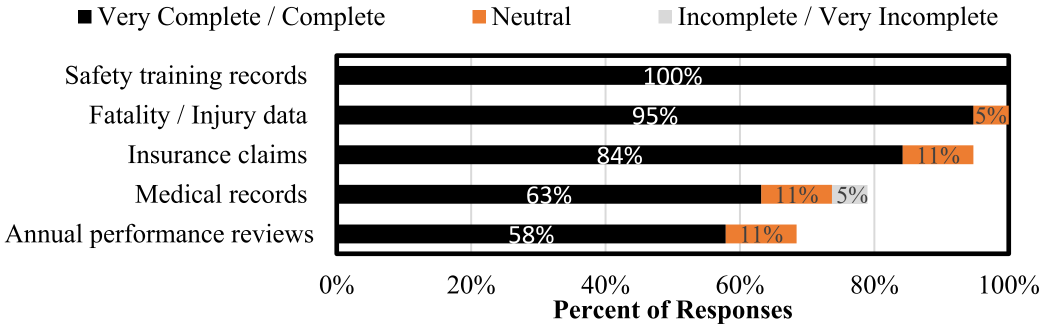


**Figure 3-10 Available Health & Safety Data by Percent of Responses & Level of Completeness.**

A study by McInnes et al., 2014 identified three primary sources for data collection: compensation claims, emergency department data, and hospital admissions data. Each of these sources provided a unique perspective on the historical trends of injuries. The research aimed to compare how different datasets captured the weight of occupational injuries based on injury or population level characteristics. Interestingly, workers' compensation and emergency department data demonstrated a decline in injury risk over time. In contrast, hospital admissions data revealed an elevated risk of injuries. Analyses further indicated that emergency department data had the highest rate of injuries among younger workers and accounted for a significant percentage of open wound and burn injuries. On the other hand, workers' compensation data revealed the highest percentage of musculoskeletal injuries. Fracture injury rates were comparable amongst all three datasets. Based on these findings, it becomes evident that utilizing various data sources for occupational injury investigation can influence different inferences as it relates to injury trends. Therefore, it is important to use multiple data sources to obtain a more comprehensive understanding of work-related injuries. The study also highlights the need for ongoing monitoring and evaluation of work-related injury surveillance systems to ensure that they are capturing accurate and complete data (McInnes et al., 2014).

In total, 74% of respondents indicated that the previously mentioned data is integrated into programmatic decision making as it relates to worker safety. To gain a better understanding of how different state DOTs integrate available data into their decision-making process, the survey requested respondents to elaborate. The survey collected the following responses:

- Hazard recognition and elimination,
- Updating training and awareness programs for specific jobs and conditions,
- Calculating injury and incident rates, which is then used to modify or implement policies,
- Reviewing safety/injury data for budgetary and hiring processes,
- Identifying areas having repeated issues,
- Re-aligning work habits to better protect employees against hazards,

- Evaluating senior leaders based on safety performance, and
- Advocating for funding and policy updates.

An additional factor that needs to be considered is how quickly data is available after an incident occurs. Obtaining information on injuries in a timely manner is crucial for updating and adjusting strategies based on current problem areas or injury trends. 63% of agencies indicated that data becomes available immediately after an incident, 26% obtain data within few days, and 11% have the information available within a week as shown in Figure 3-11.

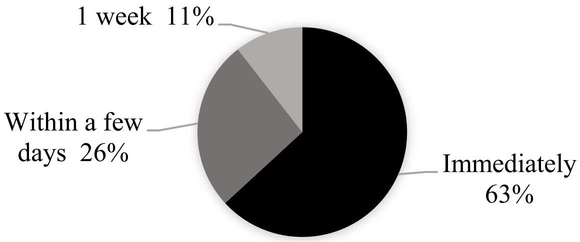


**Figure 3-11 Data Availability Speed After an Incident by Percent of Responses.**

An important measure of any safety program is ensuring on-going data analysis pertaining to work injuries, associated costs, and assessment of countermeasure effectiveness is being performed. In total, 79% of respondents answered yes to conducting previous or ongoing analysis. The processes reported were: (1) making queries to database, (2) developing a platform to allow for gathering and comparing data, (3) tracking multiple metrics on a monthly basis, (4) reviewing collected data on a regional/statewide basis during high level executive management meetings to ensure dissemination of information, (5) evaluating injury trends based on all compensation claims to identify short and long term solutions, and (6) reviewing incidents on a weekly basis with the agency's safety team and a third party administrator.

### *3.4.5 Training*

The next section of the questionnaire involved questions about the safety training programs provided at different state DOTs. A successful training program is designed to build and improve practical skills and knowledge to perform tasks efficiently and safely. Employees of different state DOTs have common tasks and shared training topics. Agencies can benefit from the experience of peer DOTs while at the same time tailoring their training programs to accommodate the specific needs and concerns of their state agency.

It was found that 84% of responding agencies address OSHA regulations, or follow an OSHA approved State Plan for training, and reported similar types of training provided at their agency. In total, 100% of respondents provide regular training in groups as well as lectures, seminars, or other presentations led by safety personnel, meanwhile 95% of agencies reported providing on the job training led by a supervisor or coworker and self-directed training via handouts, videos, or pamphlets. The question also instructed respondents to rate the type of training based on effectiveness. The effectiveness was judged according to how well the type of training contributes to the success of the agency's safety program, worker satisfaction and performance improvements. Figure 3-12 below shows different types of training practiced at state DOTs ranked by degree of effectiveness. The most effective type of training found in the survey was lectures, seminars, or other presentations with 68% of respondents reporting it is extremely or very effective. The least effective training type, as reported by respondents, was on-the-job training by a supervisor or coworker.

It is particularly important to offer updated training regularly to address new hazards that can arise from adjustments in job tasks or procedures. OSHA also requires more frequent training if worker conduct indicates that previous training has been insufficient or not completely grasped (OSHA, 2015a). Figure 3-12 below shows the frequency of training offered by percent of responses. The figure illustrates that the majority of responding DOTs (84%) offer training during employee onboarding, while 26% percent indicated that the training is offered once a year. Although training requirements in OSHA standards state that training is to be conducted at least once a year, it is urged that safety meetings, discussions and drills be organized more often (OSHA, 2015a). This is consistent with the survey responses that indicate training is offered multiple times throughout the year (i.e., more than once a month, monthly, and more than once a year).

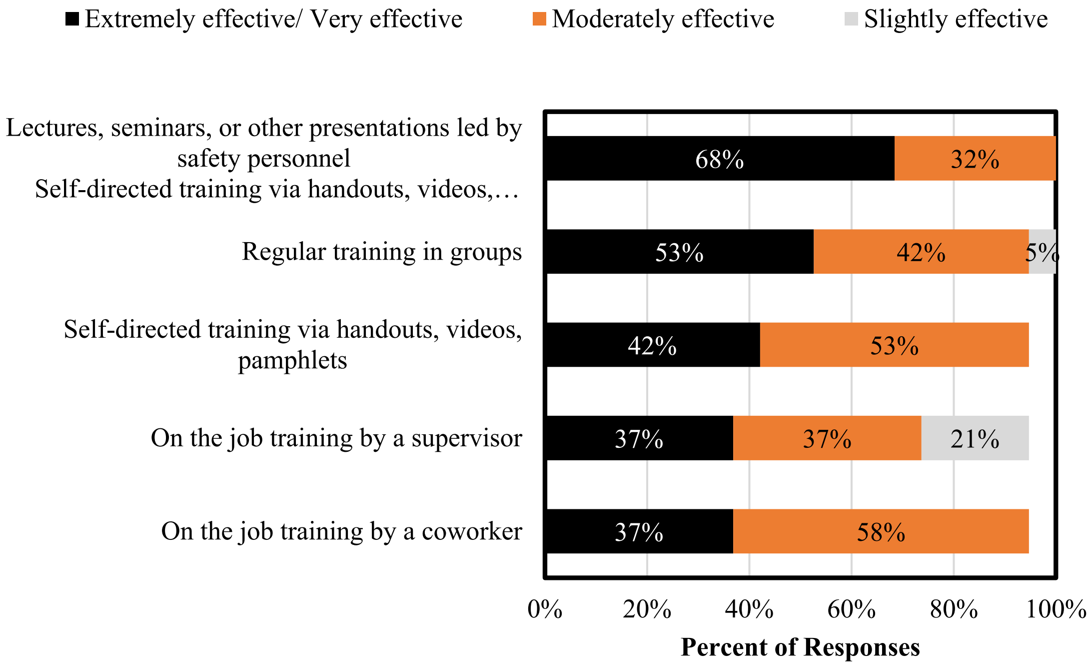


**Figure 3-12 Effectiveness of Training Natures by Percent of Responses.**

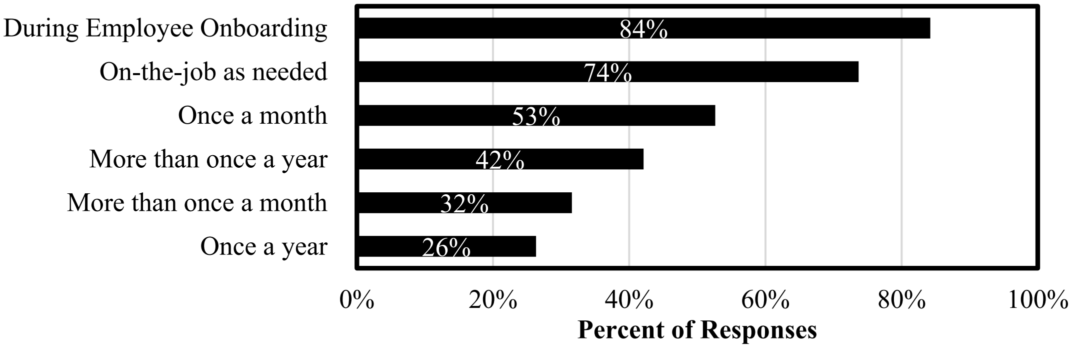


**Figure 3-13 Frequency of Training by Percent of Responses.**

The survey further solicited feedback on the training topics offered at different DOTs. Responses included litter pickup training, ergonomics, poisonous plants, insects, terrain hazards, confined spaces, Mine Safety and Health Administration (MSHA), tower climbing and rescue, lock-out/tag out, trenching/excavation, defensive driving, traffic control related topics, maintenance activity related topics, loading/unloading equipment, preventing runovers/backovers, fall protection, and homeless encampment cleanup.

### *3.4.6 Safety Program Funding, Related Topics, and Procedures*

The final section of the survey investigated different safety focuses amongst state DOTs. 60% of respondents indicated that their agency has a current safety focus, program, theme, or initiative(s) which included:

- C.A.R.E.S program: C: Communicate; A: Ask questions; R: Responsibility; E: Empower; S: Share, (Utah DOT),
- ALSAFE Go the extra mile for safety, (Alabama DOT),
- Everyone Goes Home Safely, (Kansas DOT),
- What's your Why, (Washington DOT),
- Leading Indicators and the Culture of Safety, (Washington DOT),
- Think Safe Work Safe all the time, (Mississippi DOT),
- Stop Work Authority type campaign, (Texas DOT),
- A focus on trenching and the proper use of wheel chocks, (Wyoming DOT,)
- A safety award program which awards each department that has zero or the lowest amount of recordable/lost time injuries and equipment damage, (West Virginia DOT).

Regarding the frequency with which safety meetings were held, 89% of respondents indicated that their supervisors hold regular safety meetings with employees as shown in Figure 3-14. The least reported element of the safety focus is acquiring safety and health guidance from the insurance company of the state DOT. Other reported elements included: communication, safety orientations, training throughout the year as needed, conducting incident safety reviews, encouraging the use of a safety application safety meetings and daily safety huddles, and working hard to use all safety and injury information effectively.

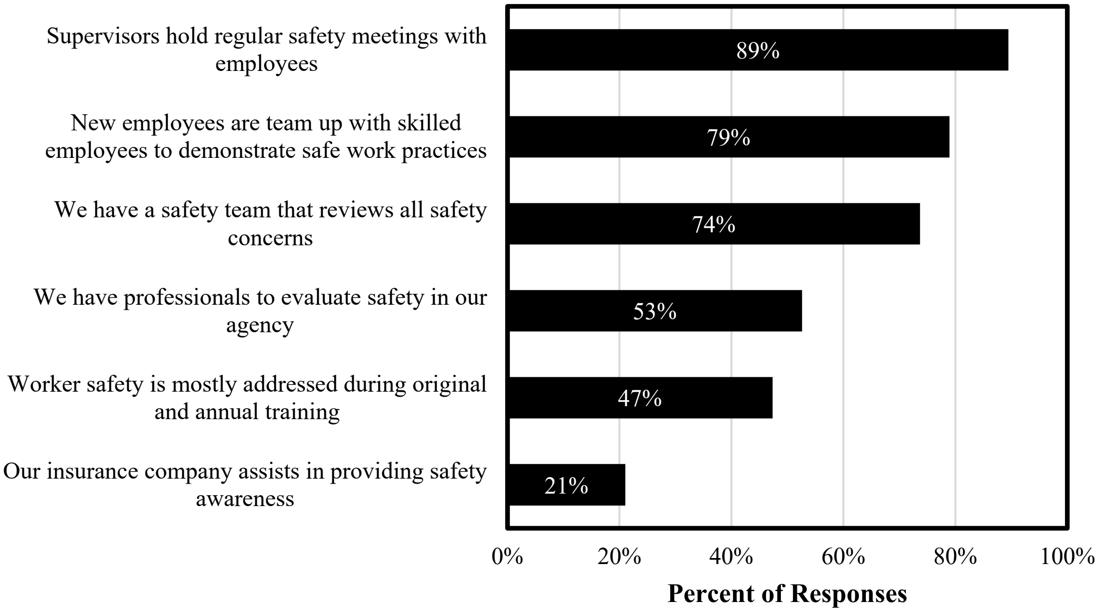


**Figure 3-14 Safety Focus Elements by Percent of Responses.**

The survey also explored the percentage of DOTs committing funds annually to successfully implement a safety program and/or safety initiative(s). In total, 74% of Respondents indicated that their agencies commit funds annually for the purpose of implementing a safety program and/or safety initiative(s). The amount of funds committed annually by percent of responses is shown in Figure 3-15. Respondents who committed USD 2.5M to USD 5M had more than 10,000 employees at their agency with a zero-fatality rate and the lowest reported nonfatal injury rate of 0.94 per 100 FTE.

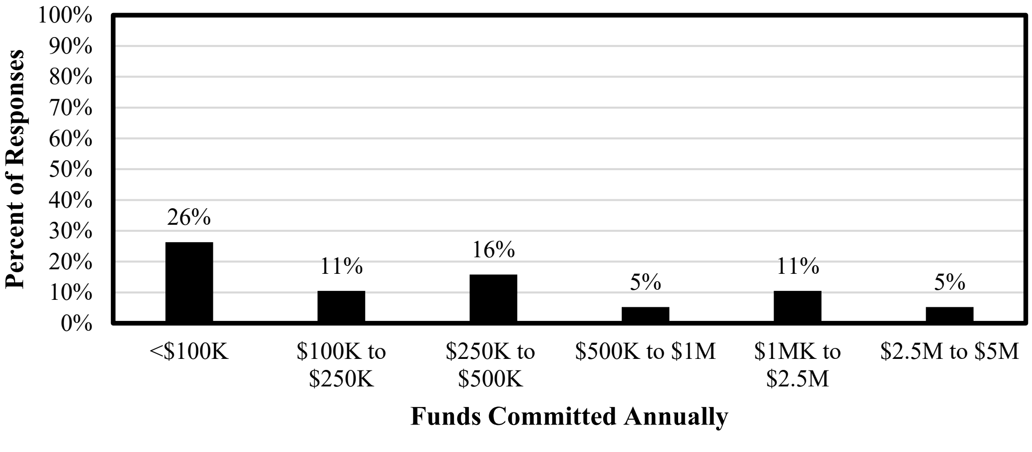


**Figure 3-15 Funds Committed Annually to Successfully Implement a Safety Program and/or Safety Initiative(S) by Percent of Responses.**

## 3.5 Conclusions, and Recommendations

According to the responses collected, the size of DOTs (by number of employees) varies greatly, which can be influenced by lane miles of state highways, number of bridge structures, population, passenger trips per year, etc. Nevertheless, over 60% of respondents reported that more than half of their employees work in construction/maintenance operations, which highlights the necessity for DOTs to prioritize worker safety given the inherent hazards associated with these operations.

Agencies who responded to having no specific format or a paper copy format also did not report near misses and were the smaller size agencies with 2,000-4,000 employees. Additionally, they responded “No” to integrating worker safety data into programmatic decision making as it relates to worker safety. Largest state agencies with 7,000-10,000 and more than 10,000 employees are more likely to have an "Other" type of categorization such as Intelex and were committing $250,000 to $500,000 towards the implementation of safety program. Agencies with no specific format also reported that their state committed less than $100K annually towards the implementation of safety programs and/or initiatives. The U.S. National Research Council stated that the funding of transportation department workers training is inadequate. Research has shown that successful private and federal agencies invest 2% of wages on training, which is four times higher than the amount DOTs typically spend on training. Investing 2% of wages corresponds to 40 hours of training per employee per year (OSHA, 2015b).

All responding agencies have records of workplace injuries, which include information provided by third parties (i.e., insurance claims and medical records). These records include essential information that can be utilized for the development of future safety initiatives. Such records are usually mandatory by state law and/or OSHA regulations. Therefore, the high level of completeness reported of such data is expected. Although this data is available and adequately complete, DOTs are not utilizing the full advantage of this information. According to research published by The National Cooperative Highway Research Program (NCHRP), there is insufficient integration of the available information into administrative decision making as it relates to worker safety. Such lack of integration can decrease the efficiency of an agency’s risk management plan. Integrating all available information and safety records allows for the development or enhancement of safety programs and recognizing injury trends (G. B. Dadi et al., 2022).

Nineteen percent of respondents indicated that their agencies do not analyze injury trends and more than half of respondents (55%), who work closely with injury claims, indicated that were not aware of the injury or fatality rates at their agency. Incident rates (i.e., near miss, injury, or fatality rates) are collectively known as lagging indicators. Safety programs established based on lagging indicators are more popular in the construction and maintenance sector and can reveal the level of safety performance in an organization (Gambatese et al., 2017), as well as allow for assessing the efficiency of implemented safety controls. Many worker safety programs are designed to monitor lagging indicators; however, a modern approach includes analyzing leading indicators. OSHA defines leading indicators as “proactive, preventive, and predictive measures that provide information about the effective performance of safety and health activities" (OSHA, 2015b). This approach is currently employed by Texas DOT who began collaborating with a third party to fully automate the tracking of leading indicators, and integrate data on training, hazard evaluation, Job Hazard Analysis, near misses, etc. into the incident reporting system. This approach also allows for analyzing trends and the assessing efficiency of their safety program (Laffey & Zimmerman, 2015). However, there are several challenges associated with adopting leading indicators for assessment. One challenge is that The selection of safety indicators is a complex task that is influenced by theoretical perspectives and personal beliefs regarding the definition and explanation of safety. Furthermore, the inconsistent use of leading/lagging terminology in reference to these indicators can be problematic and hinder understanding. The assumption that leading indicators measured at one point in time will accurately predict safety outcomes at a later point in time is also challenging since the inter-relationships between different safety indicators over time can be complex and difficult to interpret, which can make it challenging to identify effective safety management actions (Lingard et al., 2017).

According to the Bureau of Labor Statistics (BLS), Highway Maintenance Workers in all U.S state government agencies had a non-fatal injury and illness rate involving days away from work of 538.9 per 10,000 FTE in the year 2020, three times higher than compared to a rate of 174.5 per 10,000 FTE for all other state government occupations (BLS, 2022b). Disturbingly, this rate is also 4.5 higher than Highway Maintenance Workers in the private industry (118.5 per 10,000 FTE) (BLS, 2022b).

The BLS further provides statistics of the nature, event or exposure and the body part affected by injuries by occupation. For Highway Maintenance Workers, the highest occurring natures of injuries involving days away from work in 2020 were: (1) sprains, strains, tears, (2) soreness, pain, (3) fractures, (4) cuts, lacerations, punctures, and (5) bruises, contusions (BLS, 2022a). These natures also recorded the highest number of responses in the survey reflecting a representative sample of the population. Highest occurring events or exposures according to BLS were (1) overexertion and bodily reaction, (2) contact with object, equipment (ex.: struck by, struck against, caught in or between), (3) falls, slips, trips, (4) transportation incidents, (5) exposure to harmful substances or environments. The most affected body parts published by BLS were (1) hand, (2) back, (3) knee, (4) foot, and (5) shoulder (BLS, 2022a).

Transportation maintenance workers carry out a variety of tasks under difficult weather and traffic conditions. This requires acquiring the appropriate expertise, skill, and ability to perform their tasks efficiently and in a safe manner, therefore proper training is essential to these workers. Respondents reported different topics of training offered at their agencies all related to maintenance workers. Synthesis 483, published by the National Cooperative Highway Research Program (NCHRP), reported that nearly all state DOTs offer training to highway maintenance workers, despite the number of their maintenance staff or if they hire contract maintenance workers (U.S. National Research Council, 2003). The training topics reported by the NCHRP synthesis 483 were: (1) bridges, (2) highway safety and reliability, (3) pavements, (4) roadway/roadside, and (5) general maintenance skills.

The most practiced and effective training method reported was lectures, seminars, or other presentations with 84% percent of responses indicating that training is carried out during employee onboarding and the least frequency of once a year received 26% of responses. However, the previous NCHRP survey deployed in 2015 indicated that most DOTs offer mandatory training once a year and, in some cases, more than once a year. The synthesis recommended using technology-based training methods, such as web/computer-based training, or video conference training to solve some issues such as time conflicts and travel budget. The main reason reported for re-training is when recommended by supervisors to increase worker awareness. Additional recommendations mentioned in the synthesis is the need to report the association between training and performance and the dissemination of information to state DOTs, such as measuring tracking and reporting strategies, and how to use the information to assess worker improvement (U.S. National Research Council, 2003).

Finally, respondents reported other safety and health information that would be valuable to their state DOT and is not available. The responses suggested several possible improvements that they believe their agencies can benefit from. These suggestions included (1) near miss reporting, (2) improving complacency issues for any duty, (3) pre-employment physicals, (4) disseminate and make captured information from the FROI and other sources (ex. task performed at the time of injury, equipment being used) available to the injury dashboard for deeper analysis, (5) developing better dashboards and widgets to provide live data to agency employees, and (6) tracking property damage costs accurately.

To improve complacency issues, a study was conducted to assess the effectiveness of 26 measures aimed at enhancing productivity and safety in the workplace, specifically in relation to severe occupational accidents. According to the participants, enhancing machinery and equipment, creating more spacious work areas, and implementing better housekeeping practices were identified as the most effective means of improving both productivity and safety. The study also revealed that increasing available work time, implementing additional safety measures for machinery, providing personal protective equipment, and promoting better coordination among work units were all viable methods for enhancing safety (Salminen & Saari, 1995).

Safety auditing is a common form of measuring an organization's safety performance. It involves examining an organization's safety activities to determine their effectiveness and impact and can take various forms and purposes. The goal of safety auditing is to stimulate comprehensive organizational change and improve long-term safety performance (Huang & Brubaker, 2006). Huang mentions that workplace audits and assessments can have various forms and purposes, and that determining the appropriate dimensions or topics can render a wide variety of conclusions. It also suggests that in some circumstances, a better option is an audit tailored particularly for a specific purpose, based on the organization’s needs and goals.

OSHA's "Program Evaluation Profile" (PEP) illustrates 3 core actions needed to assess and enhance safety programs. These actions are:

1. Examine performance and development: This involves defining indicators to measure safety performance and development, as well as establishing practices to gather,

investigate, and assess performance records. Employers, managers, supervisors, and workers should all be involved in monitoring the program.

2. Confirm the program is executed and operational: This involves verifying that the core elements of the program are in place and operating as intended. Key processes such as reporting injuries and illnesses, organizing site surveillance and incident investigations, as well as measuring improvements in managing recognized hazards should be in place and operating effectively.
3. Fix program shortcomings and find prospects for enhancement: When an obstacle is recognized in the program, employers should implement corrections promptly to fix the issue and avert its reoccurrence. Employers should involve supervisors, managers, and workers in identifying opportunities to improve the program and take action to implement those improvements. (OSHA, 2016).

Recommendations for state DOTs to help in directing their worker safety efforts based on the survey findings can be summarized and listed as follows:

1. Developing a comprehensive safety program that incorporates management dedication, employee participation, risk identification and control, and training.
2. Analyzing injury trends consistently to recognize common hazards and implement effective countermeasures.
3. Collecting and analyzing data on near-miss incidents to identify potential hazards and prevent future injuries.
4. Providing regular and updated training to address new hazards that can arise from adjustments in job tasks or procedures.
5. Ensuring that safety programs are adequately funded and that resources are available to support program efforts.
6. Establishing a safety committee or team to oversee the safety program and ensure that the program is effective.
7. Encouraging employee participation in safety programs and providing incentives for safe behavior.
8. Conducting regular safety audits and inspections to identify hazards and ensure compliance with safety regulations.
9. Providing personal protective equipment (PPE) and ensuring that workers are using it properly.
10. Developing a return-to-work program to help injured workers return to work as soon as possible.
11. Providing ergonomic assessments and training to prevent musculoskeletal injuries.
12. Encouraging a culture of safety by recognizing and rewarding safe behavior and promoting open communication about safety concerns.

This report has several implications related to highway worker safety. The report highlights the importance of collecting and analyzing data related to highway worker safety to develop effective safety programs. The report also identifies several data sets that can be used to quantify and describe current issues in highway worker safety, including incident reports, worker insurance claims, and fatality/injury data. Each of the data sets has advantages and limitations, and that combining them can be challenging due to differences in recording methodology and data format. However, analyzing these data sets collectively could lead to more powerful data analysis and more effective safety programs.

Overall, the study emphasizes the importance of ongoing efforts to improve highway worker safety and provides insights into the types of data that can be used to inform these efforts. Implications of this study include: (1) providing guidance to state DOTs to help in directing their worker safety efforts and implementing effective safety programs, (2) encouraging near miss reporting as the survey highlights the importance of documenting and tracing near misses regarding workplace safety in general and the relation between near misses and injuries. This can encourage the adoption of near miss reporting practices, which can help prevent future accidents, (3) improving data collection such as gathering information on injury classification criteria used by state DOTs, which can help improve data collection and analysis of worker injuries and illnesses, and (4) enhancing worker safety and reduce the number of work-related injuries and illnesses among transportation maintenance workers.

In addition to the implications for state DOTs, this study can also have wider implications for other organizations and industries. For example:

1. Other government agencies that employ workers in hazardous environments, such as the military or law enforcement, will find the results of this study useful.
2. Private sector organizations that employ workers in hazardous environments can also benefit from the recommendations provided in this study.
3. Occupational safety and health professionals can use the findings of this study to develop and implement effective safety programs and training for workers in hazardous environments.
4. Researchers can use the data collected in this study to conduct further research on worker safety and injury prevention.

Finally, The data sets analyzed in this study have several strengths and limitations. For example, incident reports provide detailed information on individual incidents but may not be representative of all incidents due to reporting biases. Worker insurance claims provide a broader picture of injuries sustained by highway workers but may not capture all incidents due to underreporting. Fatality/injury data provide a comprehensive view of fatalities and injuries but may not capture all incidents due to differences in recording methodology across states. Understanding the strengths and limitations of each data set is important for conducting effective research and developing effective safety programs.

# CHAPTER 4: SAFETY CULTURE AND WORKER PERCEPTION IN HIGHWAY MAINTENANCE OPERATIONS: A SURVEY OF ALA-BAMA DEPARTMENT OF TRANSPORTATION MAINTENANCE TECHNICIANS

## ABSTRACT

The survey entitled "Field Survey of Alabama Department of Transportation (ALDOT) Transportation Maintenance Technicians (TMTs) Perception of Worker Safety" investigates the safety perceptions and concerns of maintenance workers within ALDOT through a multifaceted analysis approach. The findings reveal critical insights that can significantly enhance ALDOT's safety practices, training programs, and overall safety culture. Disparities in safety perceptions across different ALDOT's areas were found, emphasizing the need for ALDOT to tailor its strategies to meet the unique needs of each area, ensuring that safety measures are both relevant and effective. The study emphasizes the importance of implementing targeted interventions focused on high-risk activities and prevalent safety concerns, allowing ALDOT to prioritize resources effectively. Additionally, the research highlights the necessity for continuous improvement by regularly evaluating safety initiatives based on feedback and best practices. This ongoing evaluation ensures that safety measures remain relevant and effective in addressing the evolving needs of TMTs. By integrating these insights into its safety management practices, ALDOT can cultivate a more proactive and resilient work environment that not only addresses immediate safety concerns but also establishes a sustainable culture of safety prioritizing employee well-being. The study provides a roadmap for future improvements in workplace safety and initiates discussions on the implications and recommendations for enhancing ALDOT's and other transportation agencies' safety management practices.

**Keywords:** safety perception; transportation maintenance technicians (TMTs); Alabama Department of Transportation (ALDOT); safety factors; survey study

## 4.1 Introduction

Highway maintenance workers face significant safety concerns due to the hazardous nature of their work environments. These concerns include exposure to occupational hazards like dust, noise, heat, vibration, and chemicals, potentially leading to health issues such as hearing loss, respiratory disorders, musculoskeletal problems, and skin irritations (Al-Bayati et al., 2023). Additionally, the risk of injuries and fatalities are heightened by factors like working in live traffic, night shifts, limited maneuverability in tight work areas, weather conditions, and lack of safety training, which can lead to catastrophic consequences if not addressed promptly (Arba et al., 2019). While quantitative analyses (i.e., roadway characteristics, crash data, and traffic volume data) have traditionally dominated road safety research, qualitative insights from workers directly involved in roadway maintenance activities offer valuable perspectives on hazards, incidents, and mitigating measures (A. Debnath et al., 2015). This study examines the perceptions of Transportation Maintenance Technicians (TMTs) regarding job safety, through a comprehensive survey of 99 TMTs employed at the Alabama Department of Transportation (ALDOT).

### *4.1.1 Research Background*

Workers' perception of safety is crucial for several reasons, as it directly influences their behavior, attitudes, and overall safety outcomes in the workplace. These perceptions significantly affect how employees act on the job; when workers believe that their workplace prioritizes safety and that they are supported in their safety efforts, they are more likely to engage in safe work practices, follow safety protocols, and report hazards. Conversely, negative perceptions can lead to risky behaviors and a disregard for safety measures (Xia et al., 2017). A positive safety perception is also linked to a lower incidence of workplace accidents and injuries, as workers who feel that safety is a shared value within the organization tend to be more cautious and proactive in identifying and mitigating potential hazards.

Moreover, workers who perceive a strong safety climate are more likely to communicate openly about safety concerns and report unsafe conditions, fostering a culture of safety that benefits the entire organization. This open communication is essential for identifying risks and implementing corrective measures. Additionally, positive safety perceptions contribute to higher levels of employee engagement and morale; when workers feel that their safety is valued, they are more likely to be satisfied with their jobs and committed to their organization, leading to improved productivity and lower turnover rates (Zhao et al., 2021).

Understanding workers' safety perceptions can provide valuable insights for organizations seeking to improve their safety programs. By assessing and addressing the factors that influence these perceptions, organizations can implement targeted interventions that enhance safety culture and practices. A key element in understanding safety perception is the concept of safety climate, which refers to the shared beliefs and attitudes regarding safety within an organization (Nævestad et al., 2018).

The interaction between workers and their supervisors is particularly significant in shaping safety perceptions. Effective communication and feedback from supervisors can reinforce safe behaviors and encourage workers to voice concerns about safety issues. Conversely, a lack of engagement or negative feedback can lead to a diminished perception of safety, potentially increasing the likelihood of accidents. Studies have emphasized the importance of fostering a supportive supervisory approach that prioritizes safety discussions and encourages open communication about safety practices (Kwon et al., 2021).

Additionally, individual factors such as personal attitudes towards risk and safety, as well as the influence of group norms, play a crucial role in shaping workers' safety perceptions. Workers who perceive risk-taking as an inherent part of their job may be less vigilant about safety, while those who recognize the importance of safety protocols are more likely to adhere to them. Understanding workers’ safety perceptions allows for providing actionable insights that can enhance safety practices and reduce the accidents in this critical field (Xia et al., 2017).

### *4.1.2 Research Gaps*

Research gaps represent critical areas that have not been thoroughly explored or understood, highlighting opportunities for further investigation to enhance knowledge and inform practice. Longitudinal studies are particularly lacking, as most research on this topic is cross-sectional and therefore limited to a temporary view of survey participants’ opinions. A longitudinal study would provide useful information on how workers’ safety perceptions change over time, such as through management developments, training programs or changes in organizational culture (Al-Shabbani et al., 2018). There is also a need for studies that explore safety perceptions across a broader range of work environments. Understanding how safety perceptions differ in various contexts, such as urban versus rural road maintenance or different types of machinery used, could provide valuable insights.

Another area that requires further investigation is the impact of technology on safety perceptions. With the increasing use of automated machinery and safety apps in road maintenance, research could explore whether these advancements enhance or diminish safety awareness and how workers adapt to these changes. Furthermore, cultural influences on safety perception are underexplored, comparative studies across different regions could shed light on how cultural differences impact safety attitudes and behaviors among workers (Sabeti et al., 2022).

Individual differences, such as age, experience, and risk tolerance, can significantly influence safety perceptions. Studies that explore these individual factors could lead to more tailored safety interventions. Lastly, there is a need for research examining the balance between safety and productivity in road maintenance jobs. Understanding how workers perceive the trade-offs between these two aspects could inform better management practices that prioritize both safety and efficiency. By addressing these research gaps, future studies can contribute to a more comprehensive understanding of workers' safety perceptions and lead to improved safety practices and outcomes in road maintenance and other industries.

### *4.1.3 Significance of The Study*

The findings from the survey on safety perceptions, training needs, and risk perceptions among ALDOT TMTs can serve as a model for other transportation organizations seeking to enhance their safety culture and practices. Understanding the dynamics of workplace safety is crucial, as it directly impacts community well-being and public safety. The study highlights the importance of fostering a proactive safety culture, which can lead to reduced workplace injuries and accidents. By sharing the methodologies and findings, this paper can inform readers about effective strategies for assessing and improving safety perceptions in their own workplaces. The emphasis on qualitative data collection can also encourage organizations to listen to their employees' opinions, fostering a culture of open communication and continuous improvement. The study underscores the significance of tailored safety interventions based on specific workforce needs and risks. This approach can inspire other organizations to conduct their own assessments and develop customized safety programs that address the unique challenges faced by their employees. By demonstrating the value of data-driven decision-making in safety management, the manuscript can motivate organizations to prioritize safety and invest in the well-being of their workforce.

### *4.1.4 Structure of The Study*

The structure of this research is organized into several key sections to facilitate a clear understanding of the study. The second section presents a comprehensive literature review, which contextualizes the study within existing research on workplace safety and safety culture. The third section details the survey instrument used to gather data, including the development process, question types, and the rationale behind the selected safety perception factors. Following this, the fourth section outlines the methodology employed in the study, including data collection procedures, and analytical techniques. The fifth section presents the results of the survey, offering a detailed analysis of survey responses. The sixth section discusses the implications of the results. The seventh section provides recommendations for improving safety practices, while the last section suggests opportunities for future research. This structured approach ensures a logical flow of information, facilitating a clear understanding of the study's contributions to the field.

## **4.2 Literature Review**

This section serves as a foundation for understanding the multifaceted nature of workplace safety culture and the various factors that influence safety perceptions among roadway maintenance workers.

### *4.2.1 Demographics and Safety Perception*

When investigating the relationship between demographics and the impact on worker's perception of safety, the literature demonstrates that variables such as age, job title, work experience, and location can influence an individual's perception of safety in their workplace (A.

Debnath et al., 2015). Different age groups were reported to have a notable impact on the perception of worker safety (Rinsky-Halivni et al., 2022). Studies have shown that older employees typically demonstrate enhanced safety perceptions, increased job satisfaction, better adherence to safety protocols, and reduced injury rates in comparison to their younger counterparts (Arcury et al., 2019). On the other hand, younger workers, specifically under the age of 25, frequently exhibit hesitancy in reporting occupational health and safety concerns, despite their capability to recognize potential hazards (Gyekye & Salminen, 2009). Job titles and their effect on safety perception were also investigated in previous studies, highlighting that highway maintenance workers with different levels of exposure (i.e., traffic volume, performed tasks, etc.) had varying perceptions of hazards and safety measures. For example, workers directly involved in tasks that required them to be in close proximity to traffic or machinery noted issues like wet weather, driver distraction, and driver aggression more frequently than the less exposed groups (A. K. Debnath et al., 2015), however, previous research identifies that task related accidents in the work area are 2.5 times greater than traffic accidents sustained by roadway workers, highlighting the critical need for safety awareness within the work zone, highlighting the perception that workers may feel more vulnerable to accidents occurring in their immediate work environment compared to those involving traffic (Mohan & Zech, 2005). Workers with more experience were found to have better situational awareness due to their familiarity with the dynamic conditions and potential hazards during roadway maintenance activities, which helps them detect and respond to hazards more effectively (Han et al., 2022). Similarly, a qualitative study performed by interviewing roadway workers reported that experienced workers highlighted the challenges of dealing with nearby traffic over which they have no control. Whereas inexperienced workers mentioned how constant alerts and noise from work vehicles and machinery may be disruptive or stressful that could lead to reduced attentiveness, especially if they are still adjusting to the work environment (A. K. Debnath et al., 2015).

The impact of work location was also discussed in previous studies. One such study noted that setting up temporary traffic control in locations with narrow roads presents unique challenges due to the limited space available for implementing safety measures, and the more significant disruption of traffic flow compared to wider roads. Lane closures, detours, or lane shifts may be more challenging to implement without causing congestion or delays, thereby impacting both motorist and worker safety. The study further suggested the utilization of new technologies for improving motorist and worker safety included (1) Intrusion prevention and warning systems including sensors, cameras, and alarms, (2) Speed reduction systems, (3) Drone radar, (4) Proximity warning systems, and (5) Human-machine interaction detection systems(Al-Bayati et al., 2023). Another study suggests that different regions may have varying safety regulations and enforcement mechanisms, impacting how safety is perceived and as well as the economic pressure and the overall safety climate in a specific location, including factors like communication, leadership, and training (Han et al., 2019).

### *4.2.2 Management Approaches Towards Safety*

Training frequency and providing tailored safety training plays a crucial role in decreasing work-related injuries in highway maintenance activities. Research emphasizes the need for specialized safety training beyond standard courses to address the unique hazards faced by highway maintenance workers (Ammar & Dadi, 2023).

A study conducted on safety behavior and the perceived work pressure indicated that organizations could implement several strategic approaches to foster a healthier workplace and mitigate pressures that compromise safety. Examples of such strategies included: (1) Promoting work-life balance, (2) Ensuring employees have access to the necessary resources and tools, (3) Clear job roles and expectations, (4) Ongoing training and development programs, (5) Encouraging an environment of open communication allowing employees to voice concerns, (6) Equitable task delegation for fair distribution of work, and (7) Recognizing and rewarding employees' contributions (Ghasemi et al., 2018).

A recent study on improving the safety of the workplace discussed creating or improving the Safety Management Systems (SMS) with an emphasis on encompassing elements such as risk assessment, hazard identification, safety training, incident reporting, including reporting procedure, and continuous improvement based on metrics, data analysis, and lessons learned from near misses and accidents(Tsopa et al., 2022).

Current practices and capabilities of various SMS used among Departments of Transportation (DOTs) in managing highway maintenance worker safety emphasized the importance of electronic data management, with a significant majority of DOTs storing safety data electronically. Research revealed that while many DOTs utilize SMS for collecting and managing safety data, there is a notable gap in the documentation of written policies and procedures, which are essential for effective safety management (G. B. Dadi et al., 2022)

To effectively address the safety concerns faced by maintenance workers, it is essential to implement comprehensive training programs. Training programs for maintenance workers can encompass a variety of critical topics such as: (1) Equipment maintenance and repair, (2) Safety procedures and regulations, (3) Technical skills development, (4) Risk identification and analysis by to analyzing the root causes of safety threats, and conducting thorough investigations, (5) Preventive maintenance practices, (6) Communication and teamwork as well as implementing innovative conflicts resolution strategies, (7) Time management and prioritization depending on the maintenance workload, and (8) Continuous improvement for new, and existing employees (Wilson & Smith, 1974).

While comprehensive training programs are vital for enhancing the skills and safety awareness of maintenance workers, it is equally important to recognize how these training initiatives can significantly influence overall job satisfaction and employee morale within the workforce. A study that aimed to assess job satisfaction and work performance among employees suggested that a friendly atmosphere, stable employment, and good physical working conditions contribute significantly to employee satisfaction and, consequently, to their work performance and safety (Dziuba et al., 2020).

### *4.2.3 Factors of Safety Perception*

Safety perception has an impact on safety behavior and workplace incidents (Asih & Herlina, 2022). It is crucial for organizations to prioritize safety culture dimensions like communication, management commitment, employee engagement, and training to enhance workers' safety perception and reduce workplace incidents (Nawi et al., 2022). Outcomes of the safety culture are often demonstrated through worker motivation and their safety knowledge (Griffin & Neal, 2000). Research conducted in power plant construction projects aimed to assess safety behavior by examining nine factors: (1) Management Dedication to Safety, (2) Establishing a Supporting Environment, (3) Safety Management System, (4) Employee Participation, (5) Safety Awareness, (6) Safety Mindset, (7) Motivation, (8) Resource Allocation, and (9) Perceived Work Pressure. Results indicated that most employees did not consistently follow safety rules and norms at the workplace. Safety attitude, safety knowledge, and supporting environment were identified as significant predictors of safety behavior. Instantaneous improvements in the supporting environment and enhancing employee participation were recommended as effective strategies to promote improved safety behavior (Mohammadfam et al., 2017). This literature highlighted the critical interplay between various safety factors, setting the stage for this research effort, which adopted an examination of the nine key factors to assess ALDOT TMTs perception of safety culture within the organization.

## **4.3 Survey Instrument**

The worker perception survey designed for assessing safety perceptions among ALDOT TMTs involved a systematic instrument development process, which included several key stages: initial development, pilot testing, and validation of the survey questions.

The survey instrument was developed based on a comprehensive review of existing literature on workplace safety and previous studies that focused on safety perceptions in similar contexts. This review informed the selection of relevant factors and variables to be measured, ensuring that the survey addressed critical aspects of safety culture, training needs, and risk perceptions. The instrument included a variety of question types, such as multiple-choice, Likert scale, rank order, and open-ended questions, to capture a wide range of data and perspectives.

Once the initial draft of the survey was created, it underwent pilot testing with a group of ALDOT safety managers. This pilot phase aimed to identify any ambiguities or issues with the questions, as well as to assess the overall clarity and flow of the survey. Feedback from the pilot participants was instrumental in refining the questions, ensuring that they were easily understood and relevant to the respondents' experiences.

The survey was distributed across four ALDOT area offices that have been identified as having some of the highest numbers of injuries among ALDOT TMTs based on historical ALDOT injury data. The research team collaborated with ALDOT to gather TMTs working in each of the areas and achieved a near 100% response rate with 99 total responses. After collecting survey responses, the data was digitized and uploaded into Qualtrics, a survey management and data analysis platform. A copy of the survey instrument can be found here: https://uab.co1.qualtrics.com/jfe/form/SV_bEeUJo5TrsnP6HY.

The transition to a digital format facilitated a streamlined process for organizing and preparing responses for detailed analysis. To further evaluate and understand the patterns and insights gathered from the survey data, the data was imported into Statistical Package for the Social Sciences (SPSS). This process preserved the integrity of the data collected and enabled comprehensive statistical analyses of the demographic information, training practices, risk assessments, and safety perceptions of ALDOT's TMT workforce.

The survey questionnaire covered various aspects of workplace safety and organizational practices within ALDOT. It included a wide range of question types such as: multiple choice (6), rank order (1), Likert scale (48), and open-ended questions (3). This varied approach was strategically chosen to gather comprehensive insights into the safety culture and management practices within the organization. Multiple choice questions were used to gather demographic data and to quantify the prevalence of worker training, a rank order question was used to allow TMTs to rank ALDOT activities by perceived risk, whereas Likert scale questions measured the degree of agreement or disagreement with statements related to safety culture and workplace safety. Open-ended questions provided TMTs the opportunity to express their thoughts, experiences, and suggestions in their own words, offering deeper context and richer insight into the day-to-day operations and safety management within ALDOT. This multifaceted approach aimed to ensure a thorough understanding of the safety environment, identifying strengths, possible weaknesses, areas for improvement, and driving factors behind the existing ALDOT safety culture.

The aims and objectives of the worker perception survey are as follows:

- Assess the safety culture, practices, and contributing factors to worker injuries among ALDOT TMTs.
- Identify areas of strength, potential weakness, and the potential for improvement in safety management within chosen ALDOT area offices.
- Gain an insight into the effectiveness of safety training programs and resources provided to TMTs.
- Provide a measure and a benchmark for different factors associated with worker safety perception.
- Identify workers’ safety concerns and activities within ALDOT that are perceived to pose the highest risk of injuries.

## 4.4 Materials and Methods

To transform the collected data into meaningful insights, a multifaceted analysis approach was employed. This section outlines the methodologies used to perform a detailed analysis of the survey responses, aiming to unfold the layers of safety perceptions among ALDOT workers. Through the adoption of quantitative and qualitative analysis techniques, a holistic understanding of the prevailing safety culture within the organization was sought. Quantitative analysis primarily focused on statistical evaluations of multiple choice, Likert scale, and rank order question responses to identify patterns, trends, and correlations. Meanwhile, the qualitative analysis was focused on exploring the open-ended responses, allowing for a deeper understanding of personal experiences and opinions of workers.

### *4.4.1 Descriptive Statistics*

Quantitative analyses were performed for the initial interpretation of the results using descriptive statistics to summarize the data and present results in a meaningful way. Basic statistical measures such as means, medians, frequencies, and percentages were used to provide an overview of the data.

### *4.4.2 Reliability Test of Survey Questions*

Likert scale questions compromised of 48 statements related to nine different safety perception factors used in a previous study (Mohammadfam et al., 2017) and included: (1) Management Dedication to Safety, (2) Motivation, (3) Supportive Environment, (4) Safety Management Systems, (5) Employee Participation, (6) Resource Allocation, (7) Safety Mindset, (8) Safety Awareness, and (9) Work Pressure. Each of the nine safety perception factors were assessed using several Likert scale statements. Cronbach's Alpha was employed to measure the reliability of the statements within the survey indicating how closely related the items are to each other, which is used to assess the internal consistency of questionnaire items (Kotian et al., 2022). In other words, based on the value of Cronbach's alpha the internal consistency of these statements was evaluated to ensure their coherency in representing the safety perception factor measured. To calculate Cronbach's alpha, responses for several statements or questions designed to measure the same concept are defined and the variances are calculated for each set of responses corresponding to one distinct safety perception factor. The next step is to calculate the variance for all items of the questionnaire. The variance measures how responses for each item differ from the average response. Then the variances of all items are summed to obtain the total variance that helps in understanding the overall variability in the responses. Covariance between each pair of items is then calculated to measure the interrelatedness between each pair. Cronbach's alpha value can be calculated using Eq. 4-1 as follows:

$$\boldsymbol{\alpha = \frac{N\bar{c}}{\bar{v}+(N-1)\bar{c}}} \qquad \text{Eq. 4-2}$$

where,

$\alpha$ = Cronbach's alpha

$N$ = Number of items

$\bar{c}$ = Average inter-item covariance among items

$\bar{v}$ = Average variance

In this study SPSS was used to calculate Cronbach's Alpha values for safety perception factors.

Validity was addressed through both content and construct validation. Content validity was ensured by applying the opinions of experts in the field of occupational safety from the literature as well as safety experts working closely with ALDOT TMTs.

### *4.4.3 Assigning Weights to Statements*

To further analyze the responses effectively and derive meaningful insights, we employed statistical techniques to calculate the overall scores of each factor and assess the relative importance, or weights of each question contributing to the concept of the corresponding safety perception factor. These weights were assigned based on the literature review and using confirmatory factor analysis (CFA).

The literature assigned weights to statements through a process involving experts' opinions and the application of Dempster-Shafer theory. In the previous study, five experts were consulted to assign probabilities to three possible relationships between each pair of variables. These probabilities provided a basis for determining the weights of statements. The selection of experts for the study was a systematic process aimed at ensuring the credibility and relevance of their contributions. Experts were chosen based on their experience in safety behavior research, which ensured they possessed the necessary background and understanding of the subject matter. Prior to their selection, interviews were conducted with each potential expert to assess their knowledge about existing models of safety behavior. This assessment was crucial in confirming that the experts had a comprehensive understanding of the field. Only those who demonstrated sufficient knowledge and expertise were selected, thereby enhancing the quality and reliability of the opinions gathered (Mohammadfam et al., 2017).

Dempster-Shafer theory, a mathematical theory for reasoning with uncertainty, was then used to combine the experts' opinions and assign weights to the statements based on the degree of agreement among the experts (Mohammadfam et al., 2017). The steps taken in the CFA process, focusing on the use of factor analysis and factor loadings to determine the weights of the survey Likert statements were all carried out using SPSS. The normalized weights were then calculated to reflect the adjusted influence of each question on the outcome factor.

Likert scale responses were converted from "strongly disagree" to "strongly agree" into numerical values 1 to 5, respectively, which allowed us to calculate the mean of responses to each statement for an initial understanding. Then the mean for the statement was multiplied by its corresponding weight.to accurately represent the score of workers’ perceptions of each safety factor. Eq. 4-2 was formulated to calculate factors’ scores as follows:

$$S_{Fi} = \sum (W_{Fi_{Y_j}} * \bar{X}_{Fi_{Y_j}}) \qquad \text{Eq. 4-3}$$

where,

$i$ = *factor number ranges from 1-9*
$j$ = *statement number ranges from 1-9*
$S_{Fi}$ = *score of factor i*

$W_{Fi_{Y_j}} = weight\ of\ statement\ j\ of\ the\ factor\ i$
$\bar{X}_{Fi_{Y_j}} = mean\ of\ responses\ to\ statement\ Yj\ of\ the\ factor\ i$

The factor number $(i)$represents the specific safety perception factor being evaluated. In a study with multiple factors (e.g., *Management Dedication, Motivation*, etc.), each factor is assigned a unique number (1, 2, 3, to 9.) to differentiate them in the analysis. Statement number *(j)* refers to the individual statements or questions that contribute to the assessment of a particular safety perception factor. Each factor consists of several statements that respondents evaluate, and each statement is numbered accordingly. Weight of statement $(W_{Fi_{Y_j}})$ indicates the assigned weight for each statement *(j)* within the factor *(i)*. Weights were determined based on the importance of each statement in contributing to the overall understanding of the factor. Higher weights are assigned to statements deemed more critical to safety perception. Mean of responses ( $\bar{X}_{Fi_{Y_j}}$) to statement *(Yj)* represents the average response score for the specific statement *(j)* within the factor *(i)*. It is calculated based on the responses from all participants regarding that statement, providing a quantitative measure of how respondents perceive that particular aspect of safety. Finally Score of Factor *($S_{Fi}$)* is the calculated score for the specific safety perception factor *(i)*. It reflects the overall perception of that factor based on the responses collected from the survey participants. The scores initially calculated out of 5 were then converted to a scale of 100 for easier interpretation. In this new scale, any factor that received a score of less than 60% was identified as needing immediate intervention due to critical deficiencies. Factors that scored between 60% and 79.9% were recognized as having room for improvement, indicating areas where enhancements could significantly benefit the safety culture. Scores of 80% and higher were regarded as positive aspects, reflecting strong and effective elements within the existing safety culture.

### *4.4.4 Visualization of Results*

To simplify the visualization of the agreement spectrum of each statement and to explore correlations effectively, survey responses were grouped into three main categories: agree, neutral, and disagree. Responses indicating "strongly agree" and "agree" were combined to represent a general “agree” category. Similarly, responses of "disagree" and "strongly disagree" were merged into a single “disagree” category. The "neither agree nor disagree" responses were maintained as a separate, neutral category. This grouping strategy facilitated a clearer, visual understanding of the overall trends in safety perception among the workers and allowed for a more straightforward analysis of correlations between different statements and other survey responses.

### *4.4.5 Chi Square Test*

Chi-square test is a statistical method used to determine whether there is a significant association between categorical variables. It can be especially helpful in survey data, where researchers are trying to understand trends among groups of people and the ways different demographic characteristics correlate with responses. In essence, the Chi-Square test evaluates the null hypothesis, which postulates that there is no relationship between the variables being studied. By calculating the Chi-Square statistic, we can interpret the value using a significance level (commonly set at 0.05), where a p-value below this threshold indicates that the observed relationship is statistically significant.

In this study, the chi-square test was used to determine the significance of any relationship between different demographic variables and overall safety perceptions. This allowed for the identification of potential patterns in the demographics (i.e., age, job title, level of experience, and ALDOT area) may influence workers' perception of workplace safety. The Chi-Square test was also used to identify significant relationships between ALDOT area and job title with the scores of ALDOT's riskiest activities based upon workers perceptions and experiences. This provided valuable insights into how workers in each area and job title perceive the safety of their work environment, and which specific tasks may be perceived as more hazardous compared to others.

## 4.5 Results

The representativeness of the survey sample data set was achieved through its diverse demographic composition, balanced distribution, statistical significance, reliability testing, and comprehensive analysis techniques. In this section, a detailed analysis of the survey results is presented, encompassing a comprehensive review of the demographic information, training activities, safety concerns, and worker safety perceptions among ALDOT TMTs. Through a series of visualizations, we aim to highlight how various factors interplay to shape the safety culture within the organization. These findings can be employed to guide future strategies to enhance workplace safety while ensuring that initiatives are tailored to meet the specific needs and concerns of ALDOT's workers. For statements regarding worker safety perceptions, Cronbach's alpha was used to assess the internal consistency of survey items, the measurement evaluates the reliability of survey statements by determining the degree of their interrelatedness. Cronbach's alpha values range from 0 to 1. A higher Cronbach's alpha (closer to 1) indicates better internal consistency among the items while values above 0.7 are generally considered a reliable score in measuring the same factor (Kotian et al., 2022). In this study SPSS was used to calculates Cronbach's Alpha values for safety perception factors and were compared to a previous study with similar items measuring these factors and these values are shown in Table 4-1 below.

**Table 4-1 Cronbach's Alpha of Safety Perception Factors**

| Safety Perception Factor | Cronbach's Alpha (current study) | Cronbach's Alpha (previous study) (Mohammadfam et al., 2017) |
|---|---|---|
| 1. Management Dedication to Safety | 0.832 | 0.831 |
| 2. Motivation | 0.795 | 0.800 |
| 3. Supportive Environment | 0.783 | 0.751 |
| 4. Safety Management Systems | 0.930 | 0.719 |
| 5. Employee Participation | 0.819 | 0.611 |
| 6. Resource Allocation | 0.773 | 0.650 |
| 7. Safety Mindset | 0.735 | 0.768 |
| 8. Safety Awareness | 0.890 | 0.875 |
| 9. Work Pressure | 0.708 | 0.756 |

### *4.5.1 Demographics*

The first section of the survey aimed to collect demographic data, including age group, job title/class, years of experience, and the ALDOT area in which they are currently working. This information helps understand the composition of the surveyed sample and set the stage to explore subsequent correlations between safety perceptions and demographics.

Figure 4-1(a) provides a visual representation of the distribution of survey responses across various age groups of ALDOT TMTs. The '45-54' age group exhibits the highest participation rate, accounting for 34% of the total responses, and indicating a high response rate from mid-career employees. Conversely, the '65 or over' age group, along with the '18-24' category, shows a lower survey response rate, with 6% and 5% respectively. This age distribution highlights the predominance of middle-aged employees in contributing to the survey, which may reflect a vested interest in the organizational practices and safety culture at ALDOT, as well as more positive attitudes towards safety (Arcury et al., 2019).

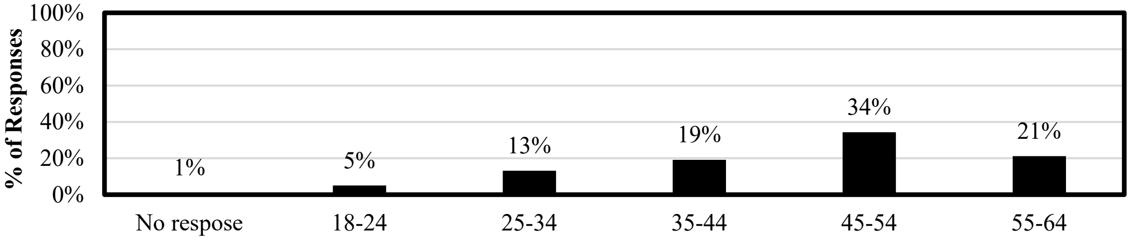
TMTs at ALDOT have 3 different classes based on experience. TMT I, TMT II, and TMT III. The highest percentage of responses came from employees with the job class of TMT II, accounting for 40% of total responses, is followed by TMT III at 26%, TMT I at 17% as shown in Figure 4-1(b), which suggests a higher engagement level among mid-level maintenance staff. Other reported job descriptions account for 15% of responses and included Transportation Worker, Transportation Manager, Lowboy Driver, and District Administrator.

As for the level of experience, the largest groups of employees have been in their current job title for '1-5 years' and '5-10 years', each accounting for 24% of responses. Meanwhile, a significant portion of respondents, 21%, have held their title for more than 20 years, indicating a considerable level of experience and long-term commitment within the organization. Responses with less than 1 year of experience had the smallest representation (8%). Figure 4-1(c) shows an illustration of respondents' experience level by percent of responses.

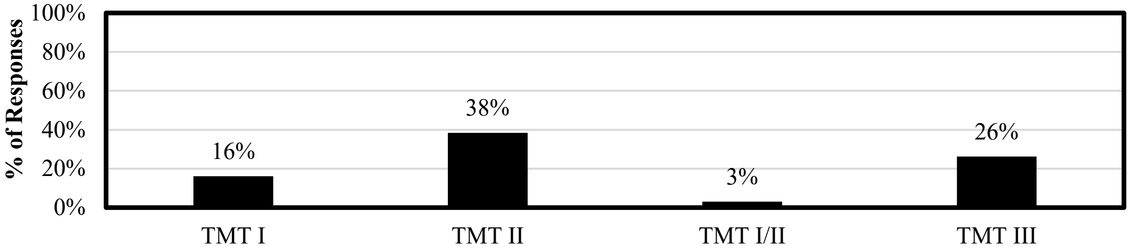
Responses were collected from 3 different ALDOT areas and were closely similar in response proportion. The highest percent of responses was collected from Alexander City area (36%), followed by Birmingham and Tuscaloosa area with 32% and 31% percent of responses, respectively, as shown in Figure 4-1(d).

By running a chi-square test it was discovered that there is a statistically significant relationship (p-value < 0.05) between ALDOT area and job title/class, which can potentially influence training needs across the three areas. Figure 4-1(e) provides a comparative analysis of job titles or classes across the three different areas: Tuscaloosa Area, Birmingham Area, and Alexander City Area. TMT II category shows a substantial presence in Birmingham Area, accounting for 47% of Birmingham respondents, followed by 42% of Alexander City responses and 25% in Tuscaloosa. In contrast, the TMT I category is more evenly distributed within Tuscaloosa Area and Birmingham Area showing close percentages (29% and 31%, respectively), however none of Alexander city respondents were classified as a TMT I. The TMT III category shows a higher concentration in Alexander City Area at 31%.

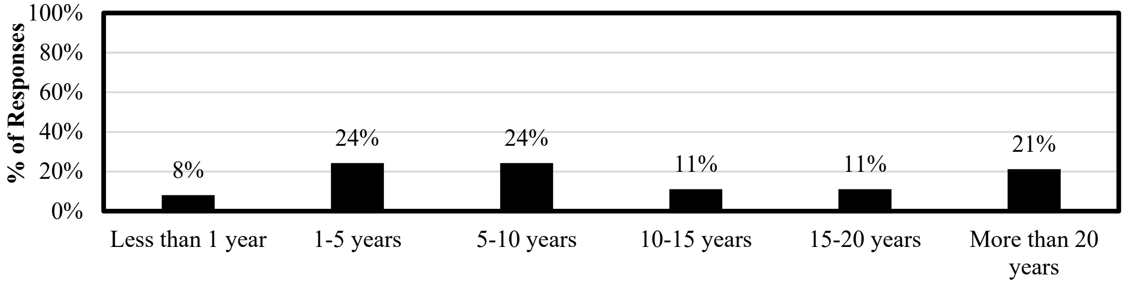
The "Other" category, which includes other job roles not classified under the TMT titles but still involved in highway maintenance activities, shows a higher percentage in Alexander City Area (22%) and Birmingham (19%) compared to Tuscaloosa (6%). This might indicate a narrower diversity of job roles in Tuscaloosa.



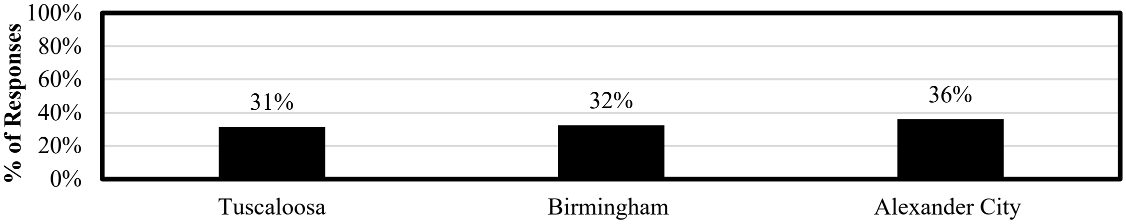
(a) Age Groups by Percent of Responses



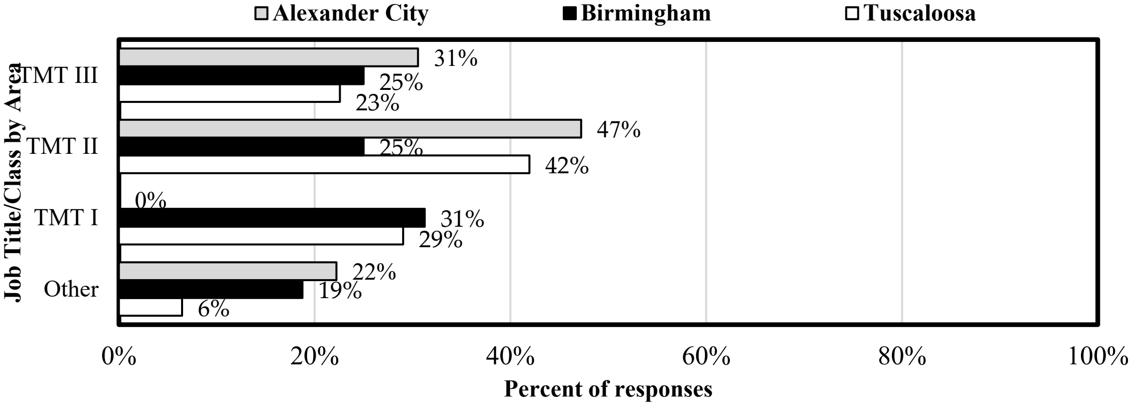
(b) Job Title/Class by Percent of Responses



(c) Years of Experience by Percent of Responses



**(d) Location/Area by Percent of Responses**



(e) Job Title/Class Across Different ALDOT Areas by Percent of Responses

**Figure 4-1 Demographic Data of Survey Responses.**

### *4.5.2 Training*

Work-related injuries in highway maintenance jobs can be reduced by offering training designed to appropriately target specific hazards confronted by highway maintenance workers (Ammar & Dadi, 2023). A breakdown of training frequency within ALDOT by percent of responses is shown in Figure 4-2. Yearly training was cited as the most occurring frequency with 52% of responses. Monthly training followed with 22% of all responses. Weekly training was the least common response at 6%. The other category was selected by 19% of respondents, which compromised irregular training sessions as needed.

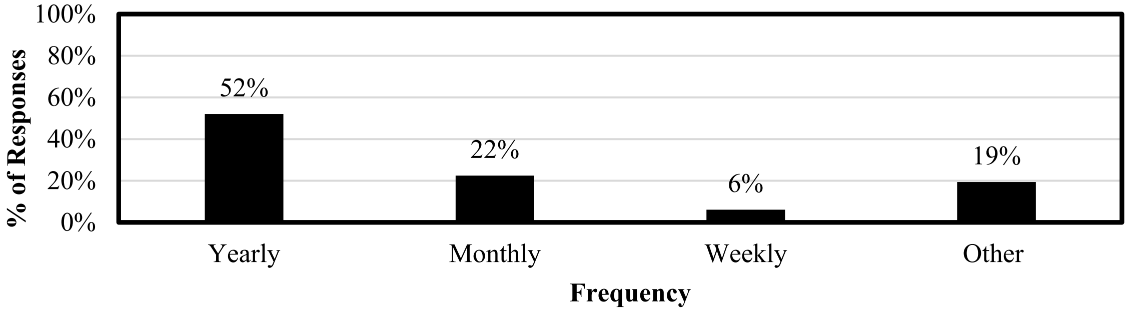


**Figure 4-2 Training Frequency by Percent of Responses.**

Respondents were asked to list the training topics they had received as TMTs in an open-ended question. The responses highlighted several topics that were grouped and ranked from most frequently mentioned, to least mentioned. (1) Equipment Operation Safety Training was the most frequently cited topic, underlining the critical importance of handling machinery with expertise and caution. This was followed by (2) Temporary Traffic Control (TTC) as well as (3) Flagging and (4) Safety Awareness, emphasizing the need for vigilance and proactive measures in ensuring safety within work zones and public safety. (5) Personal Protective Equipment (PPE) training was also notably mentioned. Other significant areas included (6) Hazardous Materials, (7) Emergency Response, and (8) Loading/Unloading/Hauling Materials.

### *4.5.3 Safety Concerns*

To further assess the safety perception and exposure of TMTs, respondents were given a list of ten activities and were asked to select their top 3 most hazardous activities. These rankings were then converted to a weighted value, where a value of 3 was assigned to the riskiest, 2 to the second riskiest, and 1 to the third riskiest activity. A higher weighted value score represents riskier activities compared to lower weight value scores based upon worker perception. Figure 4-3 provides a quantitative analysis of the perceived risk associated with various maintenance activities, as ranked by ALDOT TMTs.

As seen in Figure 4-3, the activities that accumulated the highest scores were: (1) Roadway/Shoulder Maintenance, (2) Guardrail/Cable Rail Maintenance, (3) Mowing & Trimming, and (4) Patching. These activities are indicative of those perceived as the most hazardous by the

TMTs. This ranking method highlights not only the frequency of selection but also the ranking of perceived risk associated with each activity. The top-ranked activities, therefore, represent those that are considered to pose the greatest safety challenges and require the most attention in terms of risk management and safety protocols.

This ranking approach will allow ALDOT to prioritize additional safety measures and training more effectively by focusing on the activities that are considered the most hazardous by workers directly involved in their execution. It also provides valuable insights into the risk perception among the workforce, which can be crucial for developing targeted training, safety interventions, encouraging worker participation, and improving overall safety culture within the organization.

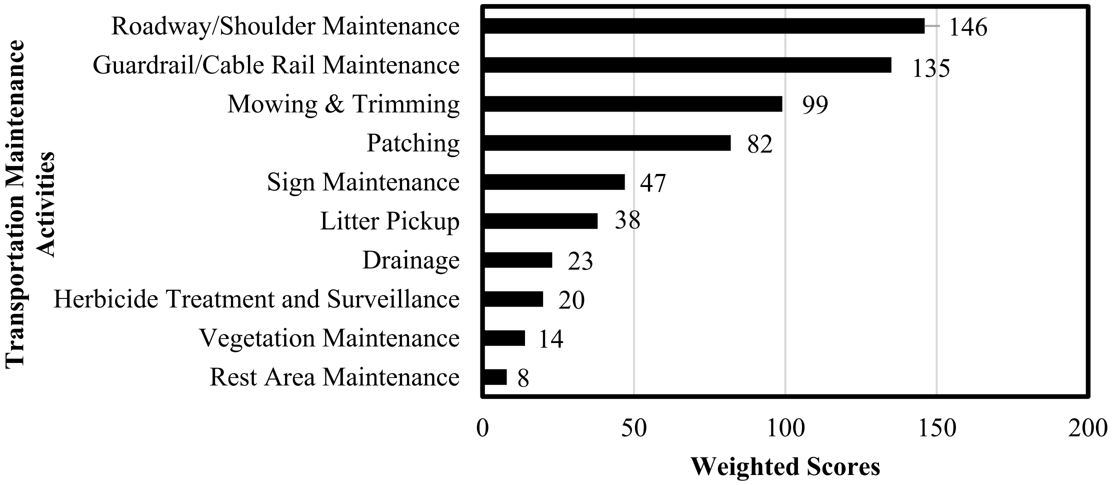


**Figure 4-3 Sum of weighted Scores of TMTs' Riskiest Activities.**

Additionally, to gain a better understanding of the specific concerns faced by ALDOT TMTs, they were asked to list their top safety concerns in an open-ended question. The most cited concern by most respondents was getting struck by vehicular traffic. This concern is not surprising due to the nature of the work environment and it has been noted in several studies (A. Debnath et al., 2015; Mohan & Zech, 2005). Other commonly mentioned safety concerns include: (1) proper use and maintenance of equipment (i.e., backhoes, tractors, chainsaws, and mowers), (2) flagging, Temporary Traffic Control (TTC), and general work zone safety, (3) availability and use of proper PPE, (4) handling hazardous materials, (5) lack of training especially for new employees, and (6) lack of manpower, which increases work pressure and the risk of accidents and injuries.

### *4.5.4 Worker Safety Perception*

As mentioned earlier, nine safety factors were used to assess the safety perception of ALDOT TMTs in this survey study. Responses and perceptions to each of these factors will be discussed in this section.

Survey respondents were asked to assess all nine safety factors using Likert scale questions. This method allowed participants to express their level of agreement or disagreement with various statements. To quantify survey responses, a scoring system was used: 1 for "Strongly Disagree," indicated the respondent completely rejects or is in strong opposition; 2 for "Disagree," showing a less intense opposition; 3 for "Neither Agree nor Disagree," reflecting a neutral stance and they are indifferent; 4 for "Agree," indicating a positive opinion that they accept or support; and 5 for "Strongly Agree," indicates a firm and clear support that they accept and endorse. The aggregation of these scores provided a comprehensive overview of employee perceptions regarding the effectiveness of safety measures and management's commitment to a secure workplace. The response mean of each statement (i.e., F1_1, F1_2, etc.) was calculated.

### 4.5.5 Management Dedication to Safety

Management plays a significant role in promoting a positive safety culture by demonstrating commitment to safety, which has shown positive influence in safety compliance and overall worker's safety perception (Yule et al., 2007). According the ALDOT TMT's responses, *Management Dedication to Safety* was assigned a score of 69% (3.46/5.00) according to Eq. 4-3 below, indicating a room for improvement.

$$\boldsymbol{Management\ Dedication\ to\ Safety} = 0.18 * \bar{x}(F1_1) + 0.19 * \bar{x}(F1_2) + 0.16 * \bar{x}(F1_3) + 0.17 * \bar{x}(F1_4) + 0.12 * \bar{x}(F1_5) + 0.18 * \bar{x}(F1_6) \qquad \text{Eq. 4-4}$$

where:

$F1$ = *safety factor 1 (i.e., Management Dedication to Safety)*
*F1_X= statement number X under safety factor 1*

The value of 3.46 reflects a positive recognition of management dedication to safety at ALDOT.

Figure 4-4 provides a visualization of the response spectrum of each statement used to quantify Management Dedication to Safety, which reveals a skew towards positive responses, suggesting that many ALDOT TMTs recognize and appreciate the efforts made by management to uphold and enhance safety. Statistics of responses (Mean (x̅), Standard Deviation(σ), Variance($\sigma^2$)) for each statement are shown on the Y-axis below the corresponding statement.

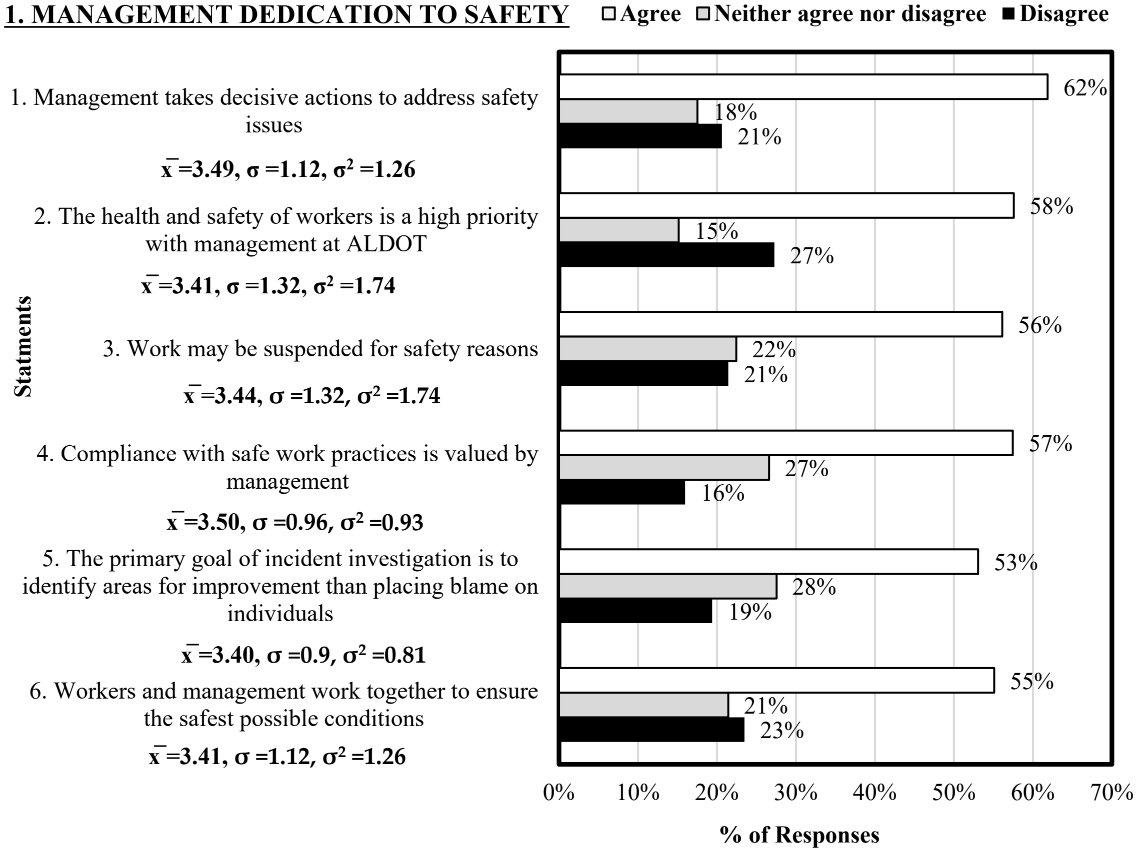


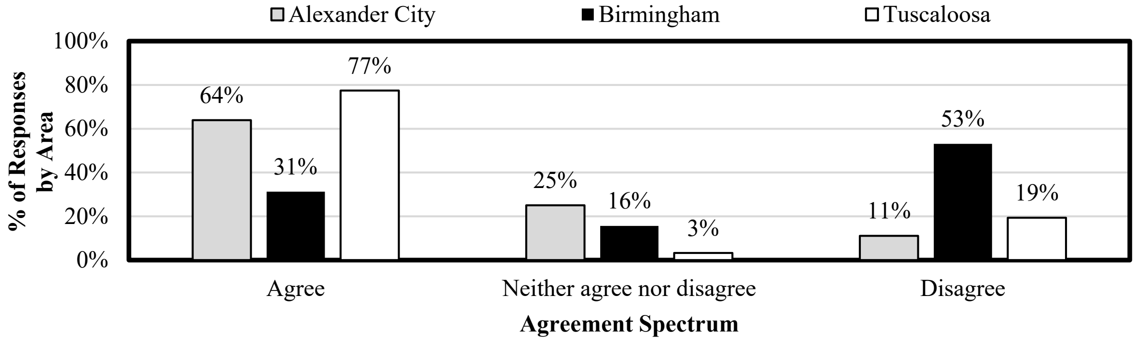
**Figure 4-4 Agreement Spectrum of Statements Related to *Management Dedication to Safety*.**

Delving further into the responses and identifying contributing factors and other correlations, it was found that some of the variance in responses to certain statements were correlated with the ALDOT area in which the employees worked. This pattern suggests that geographical location and the specific operational environments within ALDOT may significantly influence employees' perceptions and experiences as it relates to *Management Dedication to Safety*. Understanding these area-specific factors is crucial for tailoring safety measures and policies to address the unique needs and concerns of employees in different ALDOT areas.

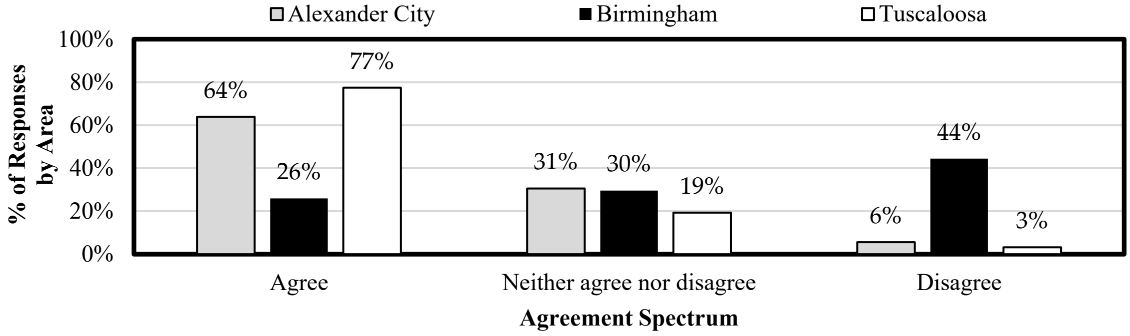
Statements pertaining to management prioritizing worker's safety, and valuing compliance of safe work practices were significantly correlated (p-value<0.05) with ALDOT areas and received an inconsistent response spectrum among workers in varying locations and reflect varying levels of satisfaction or concern with how management prioritizes worker safety. Figure 4-5(a) shows that 77% of respondents of Tuscaloosa area perceive their management as committed prioritize workers' safety. On the other hand, more than half of Birmingham area respondents (53%) disagreed with that statement indicating a need for management to enhance their focus on safety, increase training, improve communication regarding safety procedures, or more actively engage in safety practices in worksites. Most responses collected from Alexander City area (64%) show an agreement, however they conveyed the highest percentage of neutrality or uncertainty that reflects a neutral position.

Figure 4-5 (b) shows that majority of TMTs in Tuscaloosa Area (77%) and Alexander City Area (64%) feel recognized and appreciated for their adherence to safety standards, which can enhance worker morale and encourage even greater compliance. However, most TMTs in the Birmingham Area expressed disagreement with the statement indicating that they may feel that despite their efforts to comply with safety procedures, their contributions are not adequately acknowledged by management. This perception could potentially lead to decreased motivation and a careless attitude towards safety protocols. A high rate of neither agree nor disagree responses were observed in Alexander City (31%) and Birmingham area (30%), which could reflect uncertainty about how their safety efforts are valued. Such a neutral stance may suggest a need for clearer communication and more visible recognition efforts from management to ensure employees feel their compliance efforts are noticed and valued.

Overall, this detailed breakdown by percentages allows management to pinpoint specific areas where improvements in recognition and communication may be necessary. By addressing these gaps, ALDOT can work towards fostering a uniform positive safety culture across all areas, ensuring that every employee feels valued for their commitment to safety.



(a) The Health and Safety of Workers is a High Priority with Management at ALDOT



(b) Compliance with Safe Work Practices is Valued by Management

**Figure 4-5 Agreement Spectrum of TMTs in Different ALDOT Areas regarding Management Dedication to Safety.**

### *4.5.6 Motivation*

*Motivation* is an important aspect of safety perception reflecting on the overall safety culture at an organization. Education and training help employees develop their knowledge, abilities, and skills pertaining to safety, making them feel more competent and confident in their roles, which naturally leads to increased motivation as they see a clear path for growth and improvement (Vladenska & Permana, 2023). *Motivation* amongst ALDOT TMTs scored a value of **82%** (4.08/5.00) based on Eq. 4-4 below, reflecting a positive aspect of the safety culture at ALDOT.

$$\boldsymbol{Motivation} = 0.22 * \bar{x}\,(F2\_1) + 0.22 * \bar{x}\,(F2\_2) + 0.21 * \bar{x}\,(F2\_3) + 0.14 * \bar{x}\,(F2\_4) + 0.21 * \bar{x}\,(F2\_5) \qquad \text{Eq. 4-5}$$

where:

$\mathrm{F2} = factor\ 2\ (Motivation)$

$F2\_X = statement\ number\ X\ under\ factor\ 2$

Survey responses from ALDOT employees regarding *Motivation* can be seen in Figure 4-6. For the first statement, only 1% disagreed with it, indicating that the vast majority of respondents prioritize safety and the use of PPE in their daily work. Most respondents agree (77%) that they report safety incidents, which is crucial for maintaining a safe work environment, though there's a noticeable percentage that is neutral (19%). Believing in informing colleagues about hazards in their work environment received the highest agreement (94%), showing a strong culture of team communication regarding safety among colleagues. While a majority agree (67%) that management encourages safety contributions, there's a significant proportion that feels neutral (19%) or disagrees (13%), suggesting potential areas for management to strengthen their support. Three-quarters (75%) of the respondents feel involved in safety procedures, which is positive, but there's still room for improvement in terms of involving more employees as 19% of respondents had a neutral stance. Statistics of responses (Mean (x̅), Standard Deviation(σ), Variance($\sigma^2$)) for each statement are shown on the Y-axis below the corresponding statement.

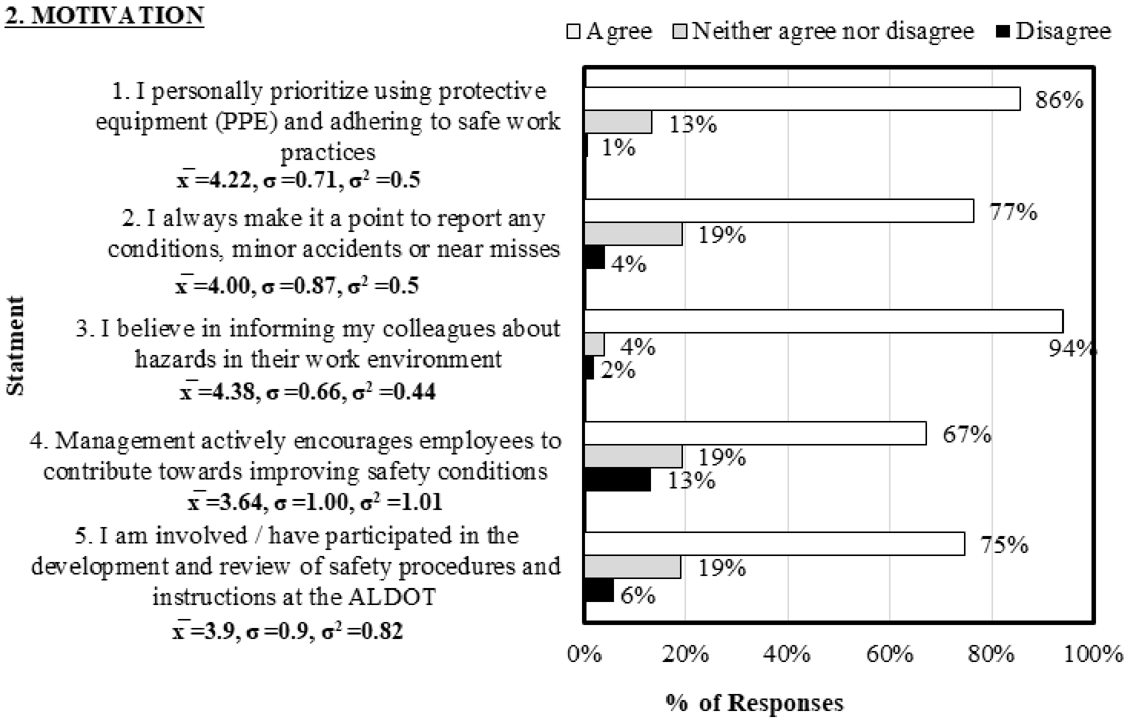


**Figure 4-6 Agreement Spectrum of Statements Related to Motivation.**

Overall, Figure 4-6 reflects a generally positive attitude towards *Motivation* among the employees, with high levels of agreement on most statements. However, the presence of neutral and disagreeing responses, especially regarding management's role in encouraging safety, highlights areas where further engagement and improvement could be beneficial. Chi-square tests were conducted to explore significant relationships with other contributing factor that might influence these results and it was found that involvement in the development and review of safety procedures at ALDOT was correlated with ALDOT Area as seen in Figure 4-7. In Alexander City, there was a 0% disagreement, and only 3% disagreed in the Tuscaloosa Area. However, in Birmingham Area, a 16% disagreement was observed, which is notable and suggests that a significant number of workers feel left out of safety discussions or processes.

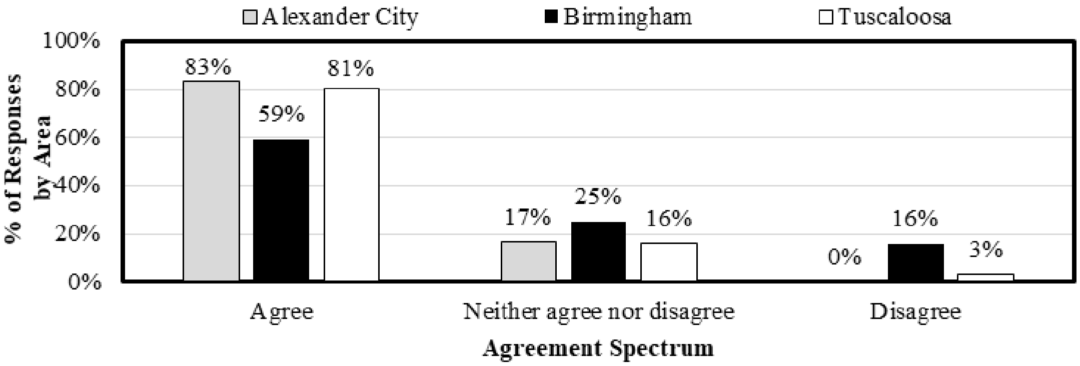


**Figure 4-7 Agreement Spectrum of TMTs in Different ALDOT Areas Regarding Involvement in the Development and Review of Safety Procedures at ALDOT.**

### 4.5.7 Supportive Environment

Establishing a *Supportive Environment* in the workplace is crucial for ensuring safety, efficiency, and effectiveness. This can be achieved by considering various aspects of the work environment (i.e., safety protocols, equipment design, and support systems). Studies emphasize the importance of providing clear guidelines for physical, cognitive, and psychological safety to enhance engagement, effort, and satisfaction of workers (Gerzina, 2020). In calculating the score for the overall influence of *Supportive Environment* and other factors, an adjustment was made to account for the inherent negativity in some statements, such as those expressing a lack of concern for the risky behavior of others. The reversed scoring method is a technique employed to accurately capture the sentiment of respondents regarding negatively framed statements. In this context, certain survey statements may imply a lack of concern for safety or risky behaviors, which could lead to a misunderstanding of the respondents' agreement if scored in a traditional manner. The traditional manner scores responses from 1 to 5, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, and 5 = Strongly Agree. For statements that express a negative view (e.g., "I do not care about the risky behavior of others"), a straightforward application of the scoring system could lead to a higher score indicating a positive perception, which is misleading. To address this, the scoring is inverted for negatively framed statements. This means a response of "Strongly Agree" to a negative statement would be treated as a low score (assigned a score of 1 instead of 5), reflecting a negative perception. Conversely, a response of "Strongly Disagree" would be treated as a high score (assigned a score of 1 instead of 5), indicating a positive perception.

This approach ensured that the final score for *Supportive Environment* accurately reflected the employees' true sentiment about safety culture. For example, if many respondents strongly disagree with a negative statement, it indicates a strong commitment to safety, which would be reflected in a higher overall score. The calculated score for *Supportive Environment* indicated room for improvement in the existing safety culture with a value of 77% (3.86/5.00) based on Eq. 4-5:

$$\boldsymbol{Supportive\ Environment} = 0.14 * \bar{x}\ (F3\_1) + 0.12 * \bar{x}\ (F3\_2) + 0.15 * \bar{x}\ (F3\_3) + 0.16 * \bar{x}\ (F3\_4) + 0.12 * \bar{x}\ (F3\_5) + 0.21 * \bar{x}\ (F3\_6) + 0.1 * \bar{x}\ (F3\_7) \quad \text{Eq. 4-6}$$

where:

$F3$ = factor 3 (Supportive Environment)
$F3\_X$ = statement number X under factor 3

The descriptive analysis shown in Figure 4-8 highlights that a significant majority of employees recognize supervisors' critical role in communicating workplace risks, with 64% agreeing, though 15% are neutral, and 21% disagree, indicating some inconsistency in supervisors' effectiveness. 59% agreed that new employees quickly adapt to safety standards, despite 24% neutrality and 17% disagreement indicating potential gaps in training or orientation. Additionally, 70% of employees actively share perceived risks with colleagues, essential for maintaining a safe work environment, and 74% feel peer support in safe work practices, enhancing the safety culture. The data reveals that 73% believe their safe performance is valued, yet some feel this recognition is insufficient with 11% disagreement. Notably, 86% disagree with the indifference towards others' risky behaviors, underscoring a collective safety commitment. Furthermore, 85% of respondents feel empowered to report safety issues, which is crucial for an effective safety management system. Overall, the data indicates a Supportive Environment exists, however several areas of potential improvement were identified that include enhancing supervisor communication and the onboarding process for new employees. Statistics of responses (Mean ($\overline{x}$), Standard Deviation(σ), Variance($\sigma^2$)) for each statement are shown on the Y-axis below the corresponding statement.

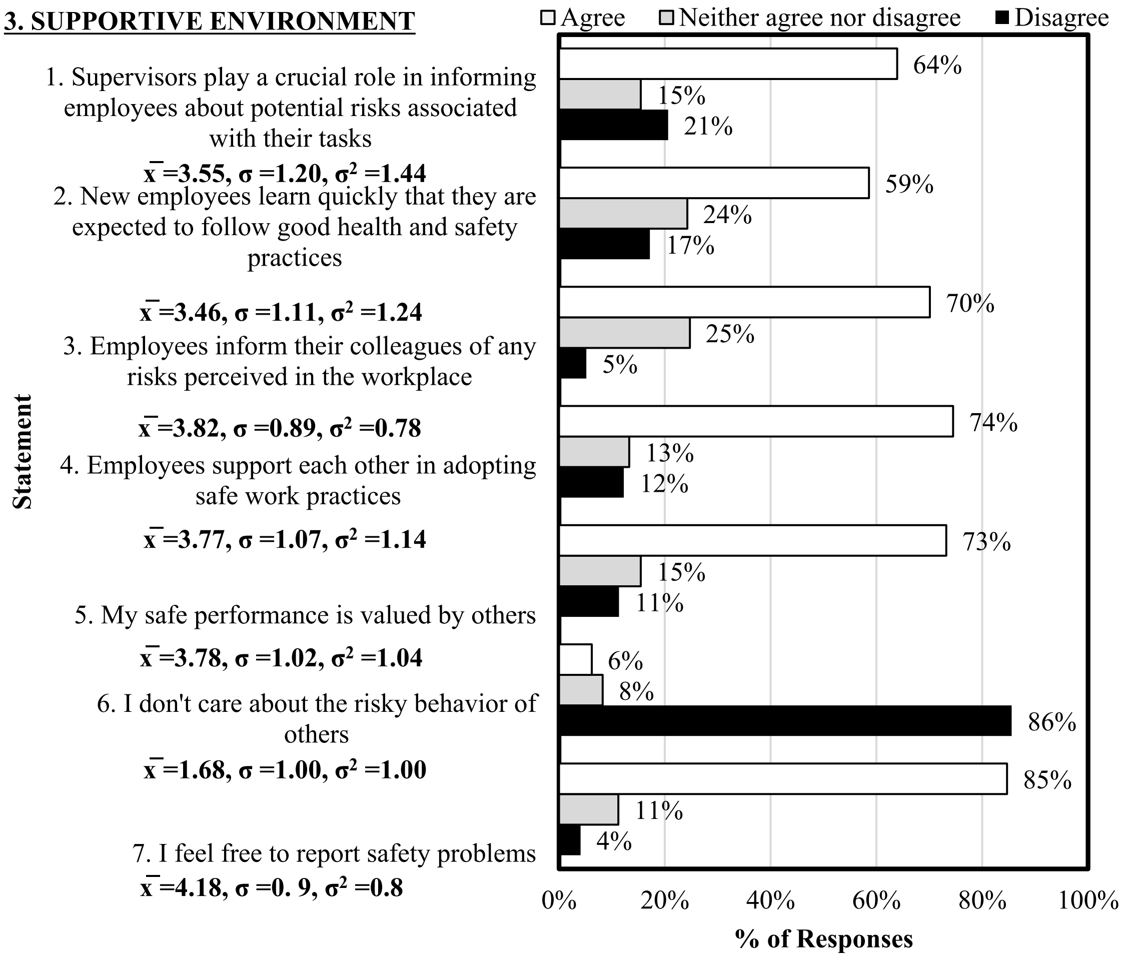
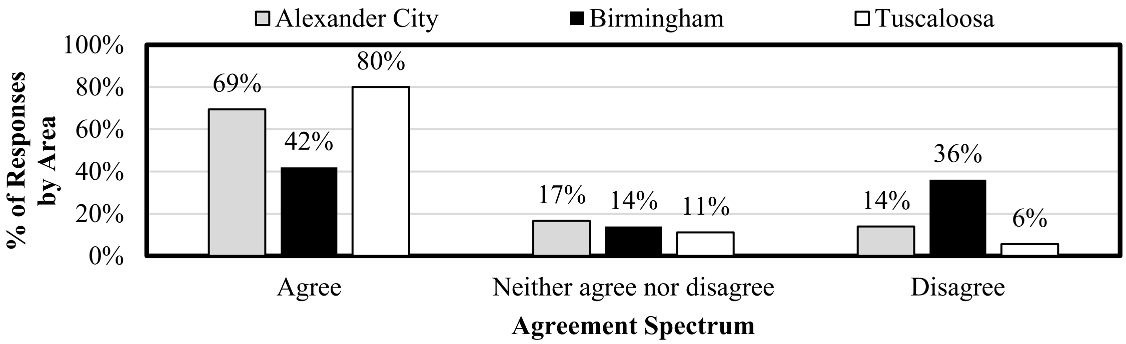


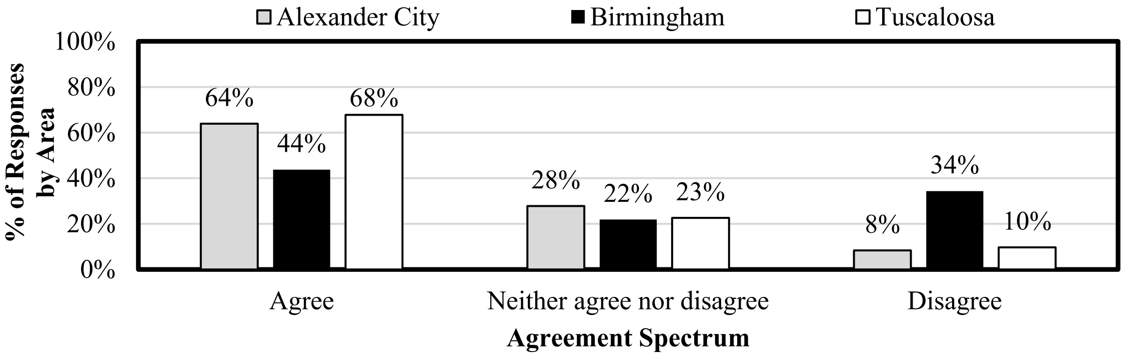
**Figure 4-8 Agreement Spectrum of Statements Related to Establishing a *Supportive Environment*.**

Further analysis revealed that responses for 2 statements under *Supportive Environment* were correlated with ALDOT area. Figure 4-9(a) reveals varied perceptions across ALDOT areas regarding supervisors' roles in communicating potential task risks to TMTs. In Alexander City area, a strong majority (69%) agree that supervisors effectively communicate risks, contrasting with only 42% in Birmingham area, suggesting potential communication issues there. Tuscaloosa area shows the highest satisfaction at 80% agreement. Neutrality on the effectiveness of supervisors' communication is evident, with 17%, 14%, and 11% in Alexander City, Birmingham, and Tuscaloosa areas, respectively, indicating some respondents are uncertain or indifferent. Disagreement rates further emphasize the results, with 14% for Alexander City, a notable 36% for Birmingham, and 6% for Tuscaloosa, underscoring concerns about supervisor communication in Birmingham. The variances across areas could stem from differences in supervisor training, organizational culture, employee expectations, and communication practices, underlying the importance of addressing these factors to enhance safety communication efficacy.

Examining the agreement spectrum concerning the statement that new workers rapidly grasp the importance of adhering to proper health and safety protocols across various ALDOT areas is shown in Figure 4-9(b). In Alexander City area, 64% of respondents agree, demonstrating a positive reception towards the effectiveness of safety training for new employees. Tuscaloosa area shows a slightly higher agreement at 68%, suggesting perhaps more robust training or orientation processes are in place. However, Birmingham area stands out with only 44% agreement, indicating potential deficiencies in training or orientation procedures that necessitate attention. Neutrality is relatively consistent across areas, with Alexander City at 28%, Birmingham at 22%, and Tuscaloosa at 23%, indicating some uncertainty or variability in perceptions regarding training effectiveness. Disagreement rates, particularly the 34% in Birmingham, underscore critical concerns about the communication of safety practices to new hires, compared to lower rates in Alexander City and Tuscaloosa. These variations could stem from differences in training program quality, supervisory support, cultural differences, and the efficacy of feedback mechanisms, highlighting areas for potential improvement to ensure all new employees quickly assimilate good health and safety practices.



(a) Supervisors Play a Crucial Role in Informing Employees about Potential Risks Associated with Tasks



(b) New Employees Learn Quickly That They Are Expected to Follow Good Health and Safety Practices

**Figure 4-9 Agreement Spectrum of TMTs in Different ALDOT Areas Regarding Establishing a *Supportive Environment*.**

### *4.5.8 Safety Management System*

A *Safety Management System* within an organization is crucial for managing risks effectively and ensuring a safe working environment. It refers to the comprehensive set of procedures, documentation, and processes used to control and enhance safety performance (Stroeve et al., 2022) including risk assessment, hazard identification, safety training, emergency preparedness, incident reporting, data analysis, and lessons learned from near misses and accidents (Tsopa et al., 2022). The overall *Safety Management System* score was calculated to be 66% (3.31/5.00) based on Eq. 4-6 below, suggesting a need for improvement.

$$\boldsymbol{Safety\ Management\ System} = 0.13 * \bar{x}\ (F4\_1) + 0.15 * \bar{x}\ (F4\_2) + 0.15 * \bar{x}\ (F4\_3) + 0.15 * \bar{x}\ (F4\_4) + 0.14 * \bar{x}\ (F4\_5) + 0.14 * \bar{x}\ (F4\_6) + 0.13 * \bar{x}\ (F4\_7) \qquad \text{Eq. 4-7}$$

where:

*F*4 = *factor 4 (Safety Management System)*
*F4_X= statement number X under factor 4*

The responses from ALDOT employees regarding the Safety Management System reveal concerning trends of dissatisfaction and areas needing improvement as shown in Figure 4-10. A significant percentage express dissatisfaction with both the quality and practicality of safety training provided, with 22% disagreeing that the training meets their needs, and 16% feeling that they haven't received adequate training for safety considerations in their roles. Concerns extend to the handling of hazardous situations, where 18% disagree and 24% neither agree nor disagree with the effectiveness of current practices. Satisfaction with incident investigations scored lowest amongst ALDOT TMTs with 26% expressing dissatisfaction and 28% of respondents had a neutral stance. Furthermore, 18% of respondents perceive no improvement in the safety culture, and a similar sentiment is echoed in their views on management's responsiveness to reported hazards or suggestions for safety improvements. Although some statements show a slightly more balanced viewpoint, the predominant feedback indicates a considerable gap between employee expectations and their experiences with safety management at ALDOT, highlighting an urgent need for general revisions to enhance training, incident handling, and the overall safety culture. Statistics of responses (Mean (x̅), Standard Deviation(σ), Variance(σ2)) for each statement are shown on the Y-axis of Figure 4-10 below the corresponding statement.

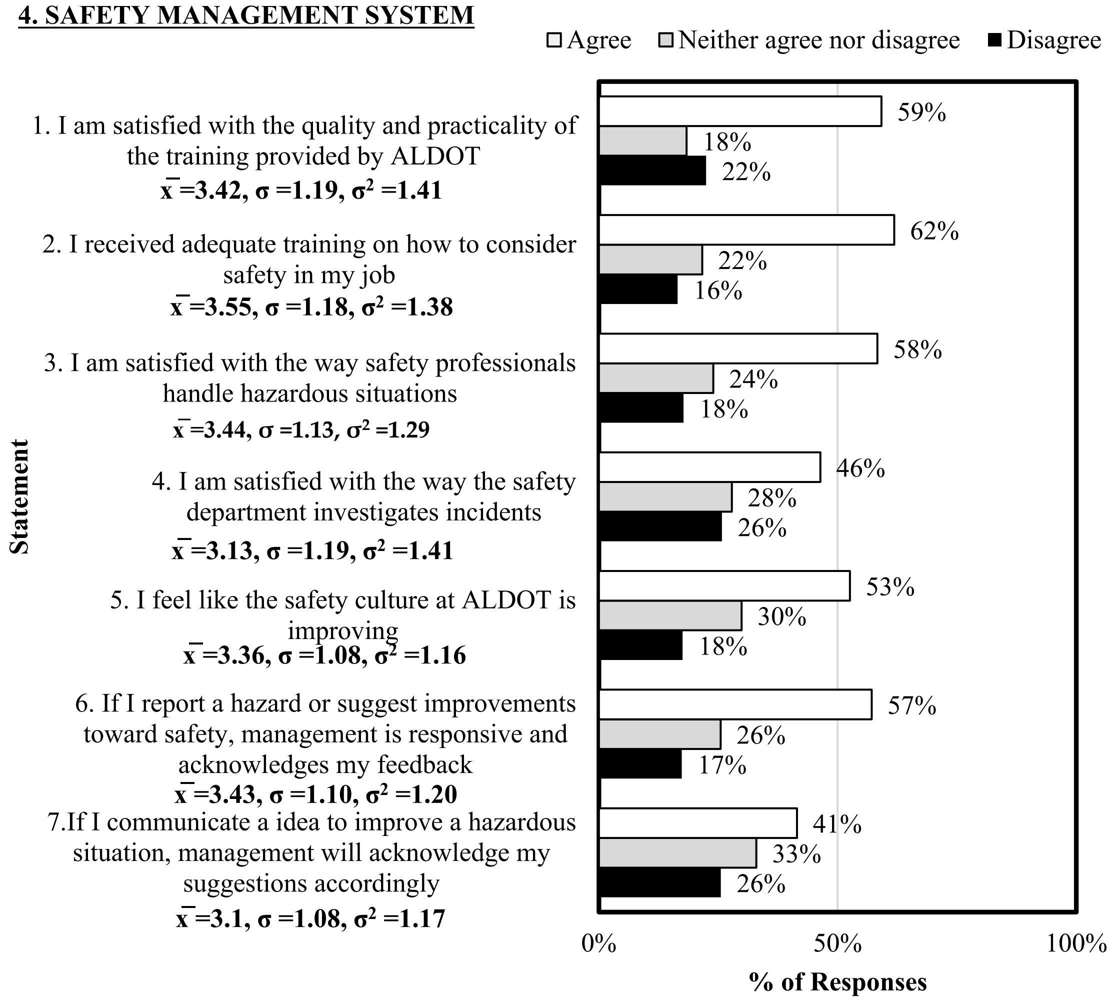


**Figure 4-10 Agreement Spectrum of Statements Related the *Safety Management System*.**

All seven statements pertaining to the *Safety Management System* showed a statistically significant correlation with ALDOT area, in which Birmingham demonstrated the lowest level of agreement.

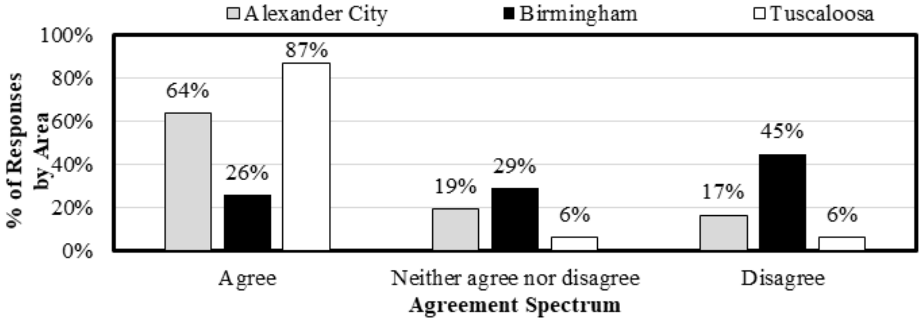
In this section of data analysis pertaining to *Safety Management System* perceptions among ALDOT areas, not all graphs were included in this report for brevity. However, those selected for inclusion highlight critical areas needing immediate attention. The charts in Figure 4-11 present key areas related to statement 1; receiving adequate safety training, statement 4; satisfaction with management's way of investigating incidents, and statement 7; acknowledgment by management when workers propose ideas to improve hazardous situations. These charts not only pinpoint where ALDOT needs to focus its efforts in enhancing safety training and education but also emphasize the importance of addressing these concerns promptly to cultivate a culture of safety and proactiveness.

Figure 4-11(a) illustrates significant regional differences in employees' satisfaction with the training provided by ALDOT across Alexander City, Birmingham, and Tuscaloosa areas. In Alexander City, a majority of 64% expressed satisfaction, indicating a positive reception towards the training's quality and practicality. However, Birmingham area exhibits a notable contrast, with only 26% satisfaction, emphasizing a critical need for evaluating and enhancing the training programs to address the apparent gaps. Conversely, Tuscaloosa area stands out with 87% satisfaction rate, suggesting that the training there likely aligns closely with employee expectations and job requirements, possibly due to more tailored, practical sessions or effective delivery methods. The varied responses also hint at underlying factors such as the quality and relevance of content, delivery methods, employee backgrounds, and the efficiency of feedback mechanisms. This diversity in satisfaction levels underscores the importance of a tailored approach to training, with a particular focus on improving Birmingham Area's programs to achieve higher overall training effectiveness across ALDOT.

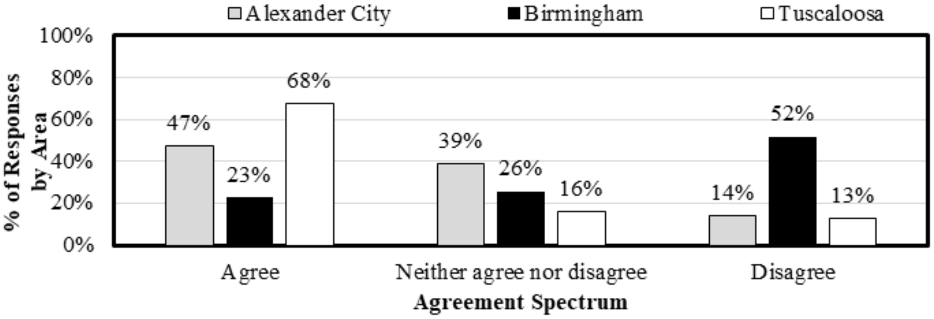
Figure 4-11(b) details the agreement spectrum in different ALDOT areas regarding their satisfaction with safety department incident investigations. The percentage of respondents in agreement reflects their satisfaction with the investigation process, showing a widespread from 23% in Birmingham to 68% in Tuscaloosa, indicating a significantly more positive perception in the latter. Additionally, the neutral responses, accounting for a notable percentage, illustrate a level of indecision or neutrality about the investigation process' effectiveness, varying from area to area. This neutrality suggests that while some respondents are neither satisfied nor dissatisfied, there may be underlying factors that could change their perceptions towards a more positive or negative view, depending on improvements or changes in the process, while the high percentage of disagreement in Birmingham (52%) identifies/highlights a critical area of concern regarding dissatisfaction or perceived gaps in the investigation process. These results stress the importance of assessing and refining incident investigation protocols within ALDOT, especially in areas with notable disagreement. Investigative thoroughness, transparency, response times, and the availability of resources and training could be key factors influencing these perceptions. Additionally, past experiences with incident investigations may heavily impact current trust levels and satisfaction levels. Addressing these elements could enhance the effectiveness of incident investigations, improve employee satisfaction and trust in the safety department, and ultimately foster a safer, more engaged work environment.

The analysis of responses by area regarding management's acknowledgment of suggestions for improving hazardous situations is shown in Figure 4-11(c). Notably, the Tuscaloosa Area exhibits the most positive response, with 68% agreeing that their suggestions are acknowledged by management, suggesting a high level of confidence in management's responsiveness. This is contrasted by the Birmingham Area, where only 16% share this sentiment, and the Alexander City Area, where only 36% feel their suggestions are acknowledged.

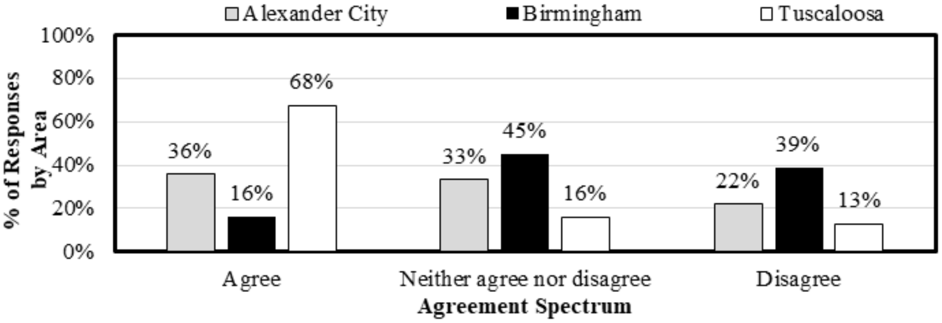
The levels of neutrality, with 33% in Alexander City Area, 45% in Birmingham Area, and 16% in Tuscaloosa Area, suggest high degrees of indecisiveness in opinions about management's response to safety suggestions. Disagreement levels present a clear area for concern, especially in Birmingham Area, where 39% do not feel their suggestions are acknowledged. This is followed closely by the Alexander City Area at 22%, indicating a significant portion of the staff feels overlooked. The Tuscaloosa Area stands out positively, with only 13% disagreeing. These results underline the necessity for ALDOT to consider varying management practices, the effectiveness of communication channels, cultural differences regarding employee input across different areas, and the impact of previous experiences on current perceptions of management's responsiveness.



(a) I am Satisfied with the Quality and Practicality of The Training Provided by ALDOT



(b) I am Satisfied with the Way the Safety Department Investigates Incidents



(c) If I Communicate an Idea to Improve a Hazardous Situation, Management Will Acknowledge My Suggestions Accordingly

**Figure 4-11 Agreement Spectrum of TMTs in Different ALDOT Areas Regarding the *Safety Management System*.**

### *4.5.9 Employee Participation*

*Employee Participation* in safety activities and perceived organizational support play crucial roles in shaping safety perceptions in the workplace. Research has shown that perceived organizational support significantly predicts psychological safety (Joe-Akunne et al., 2022), while employee participation in voluntary safety activities is linked to preventing accidents and injuries (Laurent et al., 2021). The calculated score for *Employee Participation* indicated room for improvement with a value of **76%** (3.82/5.00), based on Eq. 4-7 below:

$$\boldsymbol{Employee\ Participation} = 0.2 * \ \bar{x}\ (F5\_1) + 0.27\ * \ \ \bar{x}\ (F5\_2)\ +\ 0.27\ * \ \ \bar{x}\ (F5\_3)\ +\ 0.26 * \ \ \bar{x}\ (F5\_4) \qquad \text{Eq. 4-8}$$

where:

$F5 \quad = factor\ 5\ (Employee\ Participation)$

$F5\_X \quad = statement\ number\ X\ under\ factor\ 5$

The analysis of ALDOT employees' responses to participation in safety-related activities is shown in Figure 4-12. 45% of employees agree that they participate in safety-related activities such as incident investigation and purchasing personal protective equipment, whereas a combined 56% of respondents are either neutral or disagree. This discrepancy suggests a perceived gap in involvement or awareness of such activities among a significant portion of the workforce. 77% believe they are proactive in forwarding suggestions for hazardous situations, and a notable 80% of respondents agree that they report safety issues. Furthermore, 79% of respondents see the benefit in having pre-task safety talks, indicating a strong belief in preventive measures to reduce injuries. Statistics of responses (Mean (x̅), Standard Deviation(σ), Variance($\sigma^2$)) for each statement are shown on the Y-axis below the corresponding statement.

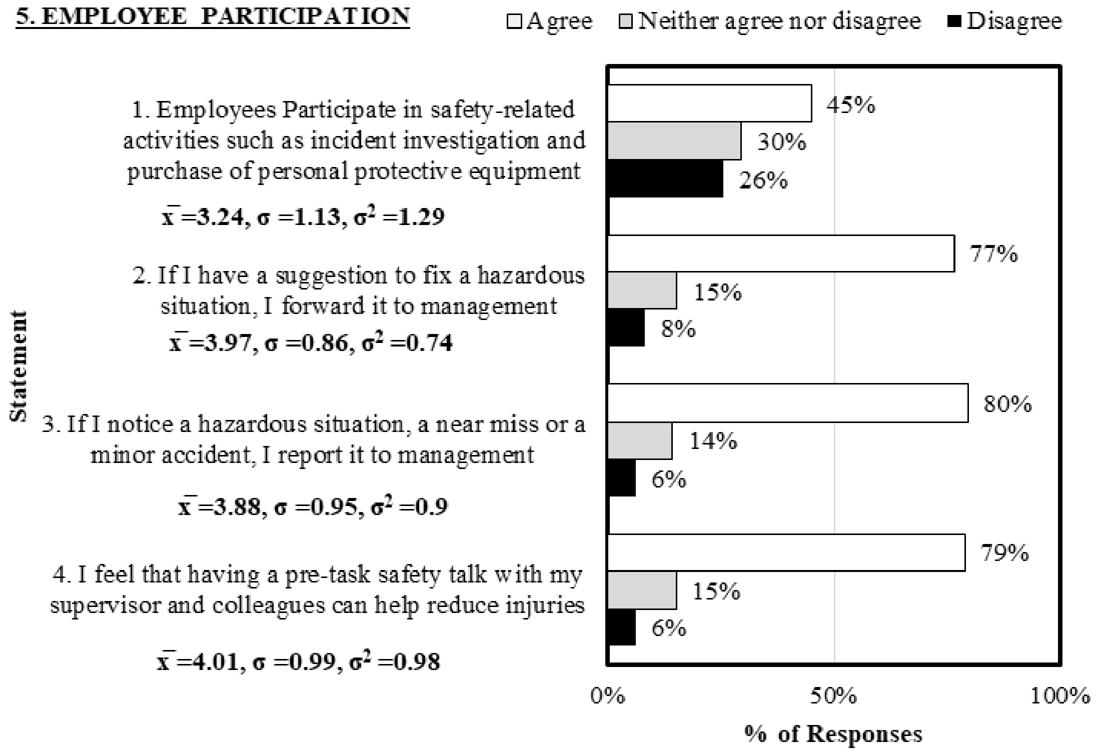


**Figure 4-12 Agreement Spectrum of Statements Related to Employee Participation.**

The only significant correlation found was found between statement 1 and ALDOT area shown in Figure 4-13. The bar chart's analysis regarding employee participation in safety-related activities across different ALDOT areas shows that in the Tuscaloosa Area, a substantial 71% of employees agree that they actively engage in safety initiatives like incident investigation and purchasing personal protective equipment. This level of agreement suggests effective communication and implementation of safety practices in Tuscaloosa, setting a benchmark for other areas. Conversely, the Birmingham Area exhibits the lowest agreement rate at 26%, paired with the highest rate of neutrality at 39%. This indicates a potential lack of clarity, motivation, or awareness among employees regarding their roles in safety practices. Such insight calls for a tailored approach in Birmingham to enhance employee engagement and participation in safety activities. Alexander City Area shows a balanced distribution of responses across all three categories, with 39% agreement and equal parts of neutrality and 31% in disagreement. This balance may point to varied experiences or perceptions of safety practices among employees, suggesting a need for further investigation to identify and address specific barriers to higher engagement levels. In summary, while the Tuscaloosa Area demonstrates strong employee participation in safety-related activities, the data from Birmingham and Alexander City Areas highlight a crucial need for targeted strategies to foster a more inclusive and proactive safety culture.

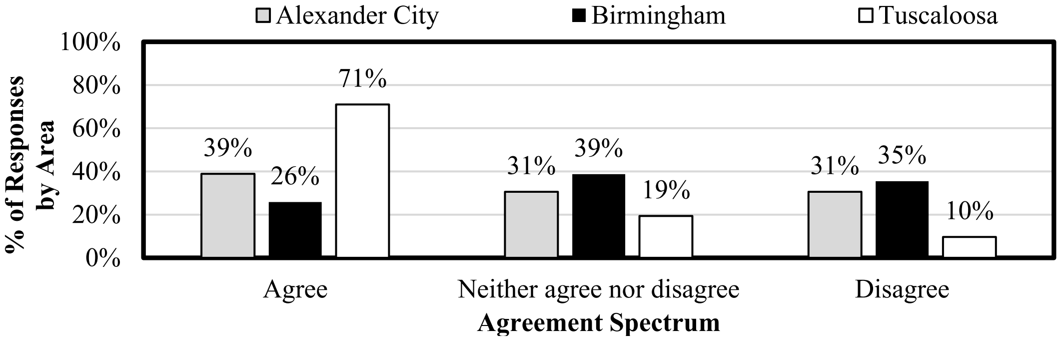


**Figure 4-13 Agreement Spectrum of Employee Participation in safety-related activities by ALDOT Area.**

### *4.5.10 Resource Allocation*

Allocating resources effectively is fundamental to managing safety and health, ensuring minimal mishaps and injuries, while the perception of management's commitment to safety, potentially influenced by the allocation of resources like manpower and PPE, significantly impacts safety behaviors and violations (O'Toole & Nalbone, 2011). Responses to statements regarding Resource Allocation within ALDOT scored the second lowest amongst all factors with a value of 62% (3.11/5.00), according to Eq. 4-8 below, signifying a room for improvement.

$$\boldsymbol{Resource\ Allocation} = 0.31 * \ \bar{x}\ (F6\_1) + 0.36 * \ \bar{x}\ (F6\_2) + 0.33 * \ \bar{x}\ (F6\_3)$$

Eq. 4-9

where:

$F6$ = *factor 6 (Resource Allocation)*

$F6\_X \quad = statement\ number\ X\ under\ factor\ 6$

The analysis of ALDOT employees' responses regarding Resource Allocation sheds light on several key areas of concern and is shown in Figure 4-14. The question regarding the sufficiency of workers available to complete tasks safely revealed that 44% of respondents disagreed, indicating a perception of insufficient staffing levels at certain times. This magnitude of disagreement emphasizes a critical area for potential improvement in ensuring that enough personnel are on-hand to maintain safety standards. Responses regarding the availability of necessary equipment to perform tasks safely were also almost evenly split, with a slight majority (42%) agreeing that equipment availability generally meets needs. However, the nearly equal distribution of disagreement (41%) signals a significant number of employees who feel that equipment availability could be enhanced to better support safe working conditions. The most comparatively positive feedback was regarding the condition and compatibility of PPE, with 60% of respondents agreeing that the provided PPE is adequate for required tasks, and 23% disagreeing. This highlights the importance of ongoing attention to maintain high standards of PPE quality and suitability. It is crucial to address the highlighted concerns about staffing and equipment to mitigate safety risks fully and ensure the well-being of ALDOT employees. Statistics of responses (Mean (x̅), Standard Deviation(σ), Variance(σ2)) for each statement are shown on the Y-axis of Figure 4-14 below the corresponding statement.

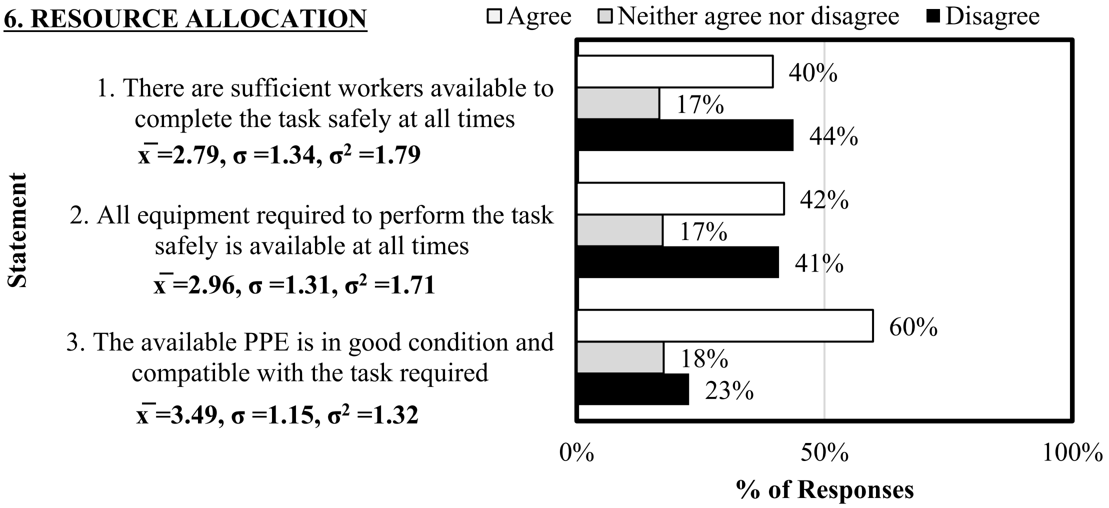


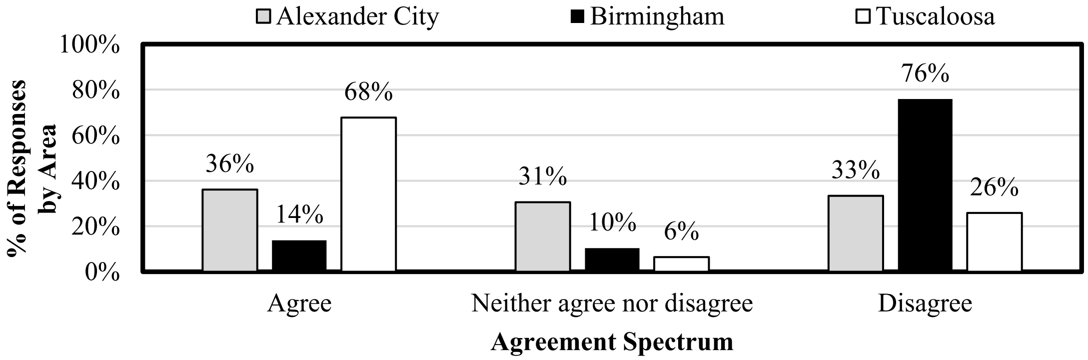
**Figure 4-14 Agreement Spectrum of Statements Related to *Resource Allocation*.**

All three statements were found significantly correlated with ALDOT area. Figure 4-15(a) shows variances in employee perceptions regarding the availability of sufficient workers to complete tasks safely across different ALDOT areas. Tuscaloosa Area exhibits a relatively high level of agreement (68%) concerning adequate staffing, which might reflect either a more streamlined approach to task allocation, efficient workforce management, or comparatively fewer tasks necessitating rigorous safety measures. This suggests that employees in this area generally feel well-supported with the necessary manpower to uphold safety standards effectively. Conversely, Birmingham Area presents a notable contrast, with only 14% of respondents affirming sufficient worker availability and a significant majority (76%) expressing disagreement. This stated discrepancy may point towards issues such as heightened task demands, potential understaffing, or systemic challenges in managing workforce deployment within the area. The substantial rate of disagreement underscores an urgent need for interventions aimed at bolstering staffing levels to ensure the safety and efficacy of task completion.

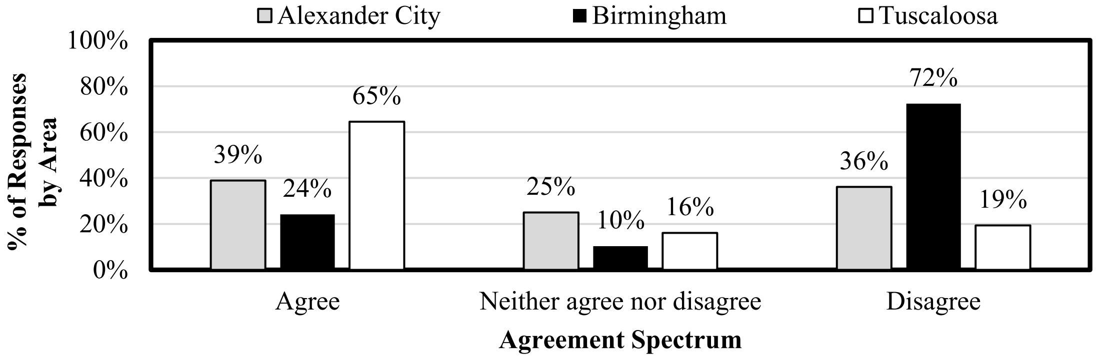
Alexander City Area displays a more evenly distributed set of responses, possibly indicating a fluctuating staffing adequacy that could vary depending on specific tasks or periods. Such a pattern suggests a potentially inconsistent experience among employees regarding worker availability, indicating areas where staffing optimization could enhance task safety.

Responses from employees in three different ALDOT areas regarding the statement: "All equipment required to perform the task safely is available at all times" are shown in Figure 4-15(b). Tuscaloosa Area shows a significantly higher agreement (65%) compared to the other areas. This could indicate better management and availability of equipment necessary for safety, suggesting that Tuscaloosa has a more effective system in place for ensuring that all required safety equipment is accessible when needed. Birmingham Area shows the lowest agreement (24%) and the highest disagreement (72%). This notable contrast suggests a significant issue with equipment availability in this area. Possible reasons could include logistical challenges, higher demand for resources due to larger scale projects, or inefficiencies in inventory management. The responses from Alexander City Area are more balanced across the three categories, indicating a mixed perception among employees. This might suggest that while some teams have adequate access to safety equipment, others may not, pointing to inconsistencies in resource distribution.

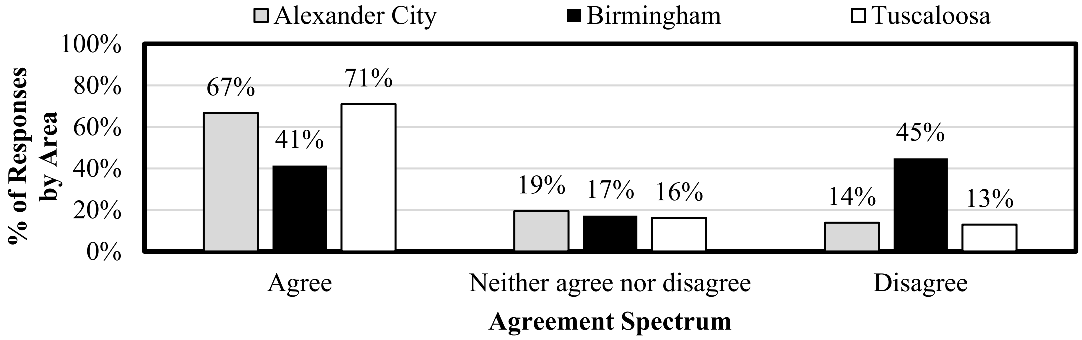
Figure 4-15(c) shows high agreement rates in Tuscaloosa (71%) and Alexander City (67%) regarding the condition and suitability of Personal Protective Equipment (PPE). Such statistics suggest that these regions may either have effective systems in place for ensuring the quality and appropriateness of PPE or that the equipment undergoes less intensive usage, thereby prolonging its lifespan and effectiveness. Birmingham's considerably lower agreement rate (41%) paired with a higher disagreement rate (45%) presents an area of concern. This could indicate a variety of challenges including, but not limited to, higher wear and tear due to more rigorous use, inadequate replacement cycles leading to the use of worn-out or outdated equipment, and potential mismatches between the PPE provided and the specific requirements of the tasks at hand. Meanwhile, relatively consistent percentages of respondents who neither agree nor disagree were found across all areas.



(a) There Are Sufficient Workers Available to Complete the Task Safely at All Times



(b) All Equipment Required to Perform the Task Safely is Available at All Times



(c) The Available PPE is in Good Condition and Compatible With the Task Required.

**Figure 4-15 Agreement Spectrum of TMTs in Different ALDOT Areas Regarding *Resource Allocation.***

### *4.5.11 Safety Mindset*

*Safety Mindset* refers to the way employees think about and prioritize safety in their daily work. It is about being aware of safety at all times and making it a key part of how everyone operates (Rasmussen & Ahsan, 2022). When determining the overall impact of responses to *Safety Mindset*, modifications were implemented to compensate for the natural negativity found in certain statements, for example, those that convey that a brave worker does not have to worry about safety. Consequently, as discussed in section (*Supportive Environment*) the scoring scale for answers from "Strongly Disagree" to "Strongly Agree" was deliberately reversed. Hence, a "Strongly Agree" response to a statement with negative connotations (suggesting a pessimistic view of the Safety Mindset) was assigned a reduced score, whereas a "Strongly Disagree" reaction to such a statement was awarded an elevated score. The calculated score for the *Safety Mindset* factor indicated a room for improvement with a value of 78% (3.91/5.00) based on Eq. 4-9 below:

$$\boldsymbol{Safety\ Mindset} = 0.17 * \bar{x}\ (F7\_1) + 0.13 * \bar{x}\ (F7\_2) + 0.14 * \bar{x}\ (F7\_3m) + 0.15 * \bar{x}\ (F7\_4) + 0.12 * \bar{x}\ (Q17\_5m) + 0.15 * \bar{x}\ (F7\_6m) + 0.13 * \bar{x}\ (F7\_7m) \qquad \text{Eq. 4-10}$$

where:

$F7$ = *factor 7 (Safety Mindset)*

$F7\_X$ = *statement number X under factor 7*

The survey results shown in Figure 4-16 reveal a significant emphasis on safety among TMTs at ALDOT, with 87% agreeing that safety is their principal concern. This attitude is further underscored by the 83% who believe in the importance of a safe working environment. While 62% find the current safety procedures helpful and effective, a considerable proportion of respondents (26%) hold neutral views or disagree (12. A strong agreement exists against the notion that bravery exempts one from safety concerns, with 86% disagreeing with the idea that a brave worker need not worry about safety. This is in line with the 70% who express concern over work-related injuries. The mixed responses regarding the inevitability of accidents, with 41% disagreeing, suggesting a belief among TMTs that many workplace accidents can be prevented through adequate safety measures. Furthermore, most of the disagreement with the statement that safety training and procedures are impractical indicates a widespread acknowledgment of their necessity and value. Statistics of responses (Mean ($\overline{x}$), Standard Deviation($\sigma$), Variance($\sigma^2$)) for each statement are shown on the Y-axis below the corresponding statement.

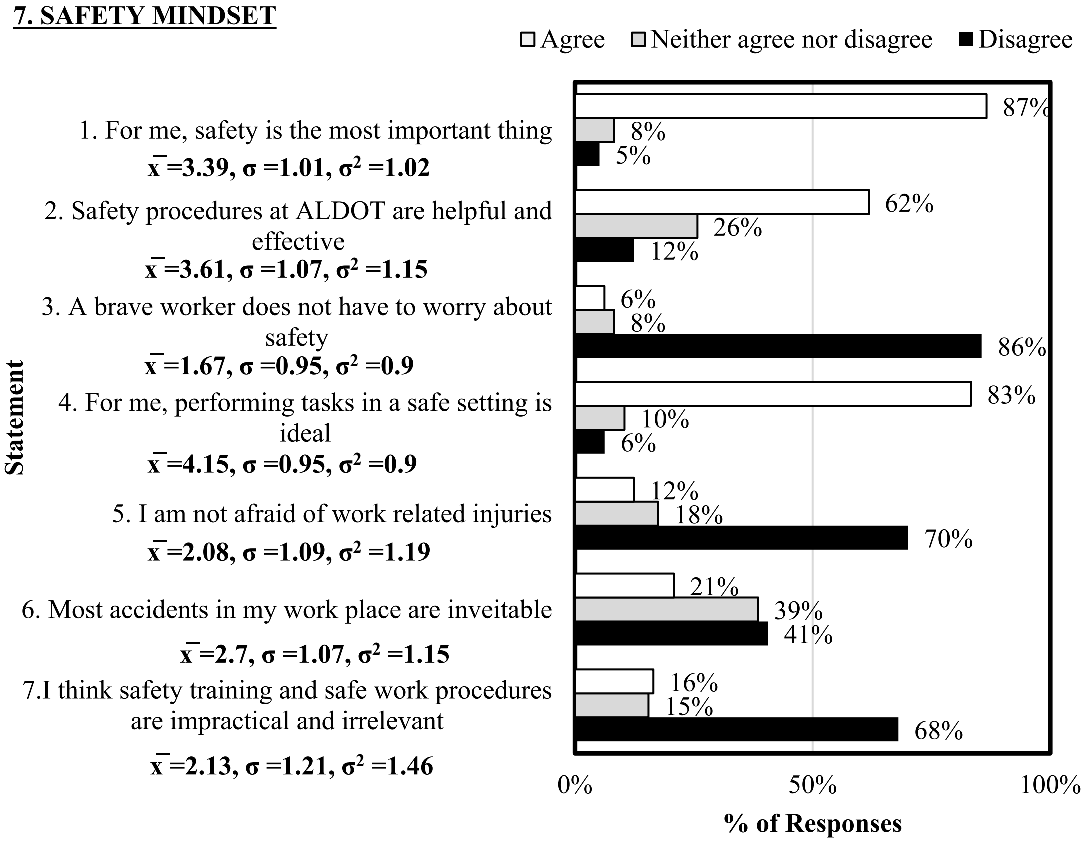
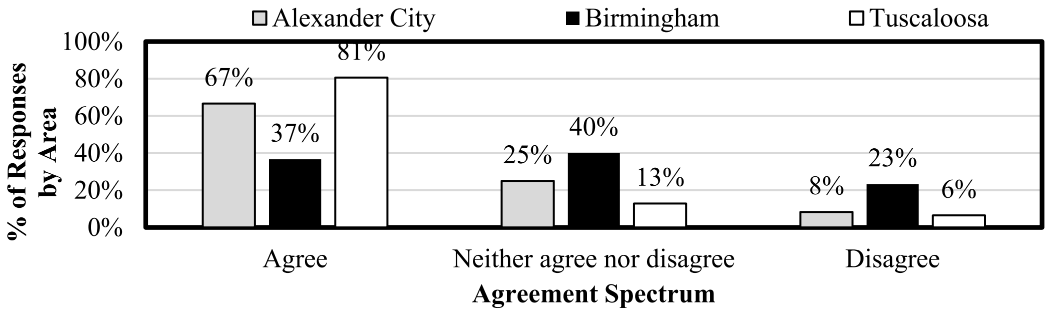


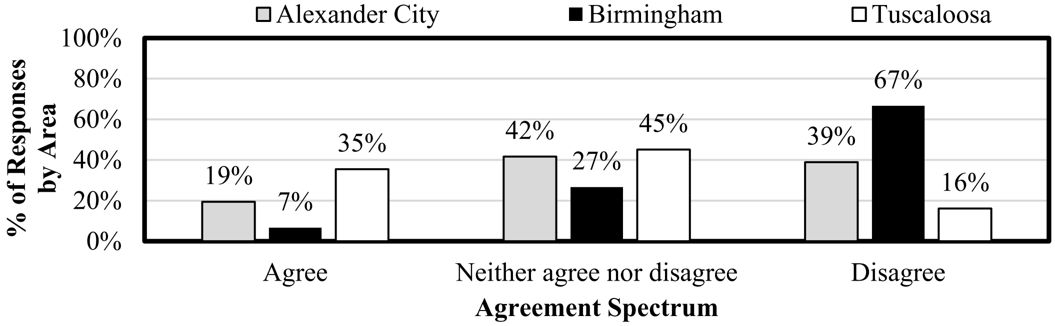
**Figure 4-16 Agreement Spectrum of Statements Related to *Safety Mindset*.**

Two statements were found significantly correlated with ALDOT area and are shown in Figure 4-17. Figure 4-17(a) demonstrates high agreement in Tuscaloosa Area where it shows the highest agreement (81%) that safety procedures are helpful and effective. Birmingham Area shows a significantly lower agreement (37%) compared to the other areas. This might suggest issues such as inadequate training, outdated procedures, or possibly a lack of enforcement of existing safety protocols. The relatively high percentage of disagreement (23%) and neutrality (40%) further indicates potential dissatisfaction or ambivalence towards the effectiveness of safety measures. The agreement level in Alexander City was 67%, with a small percentage of disagreement (8%).

When examining the perspectives across the three ALDOT areas regarding the inevitability of most workplace accidents, significant variation in responses was noticed as shown in Figure 4-17(b). In Alexander City Area, opinion is nearly evenly split, with slight agreement towards accidents being preventable (39% disagreeing with the inevitability of accidents). This contrasts with Birmingham Area, where a strong majority (67%) believe that proper measures can prevent most accidents. On the other hand, Tuscaloosa Area presents a more pessimistic stance, with 35% agreeing that accidents are inevitable and only 16% disagreeing.



(a) Safety Procedures at ALDOT are Helpful and Effective



(b) Most Accidents in My Workplace Are Inevitable

**Figure 4-17 Agreement Spectrum of TMTs in Different ALDOT Areas Regarding *Safety Mindset*.**

### *4.5.12 Safety Awareness*

Safety awareness in the workplace refers to the level of knowledge and consciousness among employees regarding potential hazards, safety protocols, and the importance of maintaining a safe work environment. Workers' safety awareness in highway maintenance activities is crucial to mitigate hazards and prevent incidents and injuries. The responses concerned with *Safety Awareness* scored the highest amongst all nine factors suggesting it to be the most positive aspect of the existing safety culture with a score of 82% (4.12/5.00) based on Eq. 4-10 as follows:

$$\boldsymbol{Safety\ Awareness} = 0.21 * \bar{x}\ (F8\_1) + 0.18 * \bar{x}\ (F8\_2) + 0.2 * \bar{x}\ (F8\_3) + 0.2 * \bar{x}\ (F8\_4) + 0.21 * \bar{x}\ (F8\_5) \qquad \text{Eq. 4-11}$$

where:

$\mathrm{F8}$ = *factor 8 (Safety Awareness)*
$F8\_X$ = *statement number X under factor 8*

The results shown in Figure 4-18 reveal a strong foundation of perceived safety awareness among ALDOT employees. A substantial majority of respondents feel confident in their understanding of safety practices, with over 80% affirming their familiarity with the safety protocols relevant to their specific tasks, risks inherent in their work, implementation of job duties in a safe manner, appropriate use of personal protective equipment, and overall risks present in the workplace. While these positive responses are promising, it's important to consider that such high levels of agreement may partially stem from overconfidence or a desire to project competence in their roles. No variances in responses were present to be explained by other correlations. Statistics of responses (Mean (x̅), Standard Deviation(σ), Variance(σ2)) for each statement are shown on the Y-axis of Figure 4-18 below the corresponding statement.

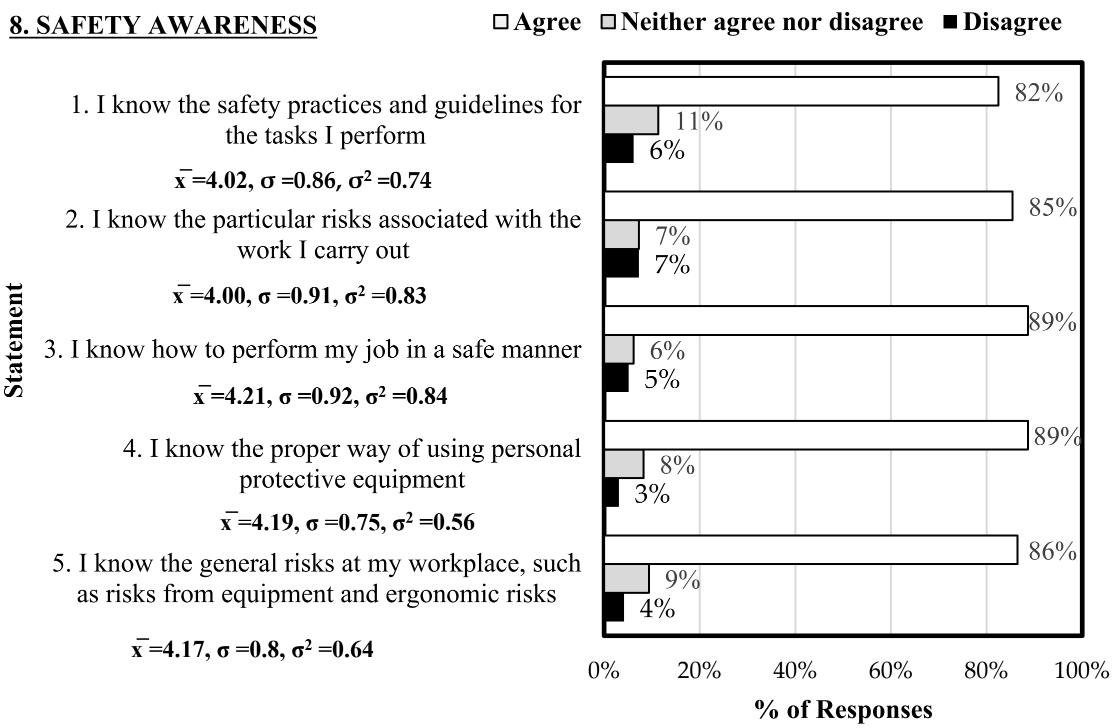


**Figure 4-18 Agreement Spectrum of Statements Related to *Safety Awareness*.**

### *4.5.13 Work Pressure*

*Work Pressure* can lead to unsafe behaviors and risk compensation, where workers take more risks to cope with time pressure and cognitive demands (Ghasemi et al., 2018). The scoring for this factor was adjusted to account for the negativity in all statements. The responses were reversed so that a "Strongly Agree" to a negatively framed statement resulted in a lower score, while a "Strongly Disagree" response yielded a higher score. *Work Pressure* scored the lowest score of all assessed factors with a value of 56% (2.81/5.00) amongst all safety perception factors based on Eq. 4-11 below, demonstrating a need for immediate intervention.

$$\boldsymbol{Work\ Pressure} = \mathbf{0.25} * \ \bar{x}\ (\boldsymbol{F9\_1}) + \mathbf{0.26}\ *\ \ \bar{x}\ (\boldsymbol{F9\_2})\ +\ \mathbf{0.22} *\ \ \bar{x}\ (\boldsymbol{F9\_3})\ +\ \mathbf{0.26}\ *\ \ \bar{x}\ (\boldsymbol{F9\_4}) \qquad \text{Eq. 4-12}$$

where:

*F9 = factor 9 (Work Pressure)*
*F9_X= statement number X under factor 9*

Figure 4-19 illustrates ALDOT workers' responses to statements about *Work Pressure*. With 59% agreeing that the rush to meet deadlines can result in unsafe practices, it's apparent that time constraints are a significant concern. This viewpoint by the majority underscores the challenge ALDOT faces in balancing productivity demands with safety protocols. It also suggests a potential area for intervention, such as revising unrealistic deadlines or providing additional resources to manage time pressures without compromising safety. The evenly divided responses (34% agree, 33% neutral, 33% disagree) on whether there is enough time to follow safety guidelines illustrate a division among employees. This division indicates that while some teams might be experiencing time adequacy for safety, others feel rushed. This variability could stem from departmental differences or uneven workload distribution, highlighting the need for a standardized approach to time management in safety procedures across all departments. Nearly half (45%) of the respondents acknowledge economic considerations sometimes override safety priorities. This significant proportion points to a trend where cost-cutting or financial objectives might compromise safety measures. Over half (51%) believe previous injuries were due to work pressure. This statistic is an indicator of the tangible consequences of excessive work demands. Implementing measures to alleviate work pressure, such as better workload management, stress reduction programs, and more effective communication channels, could mitigate the risk of future injuries.

These findings collectively highlight the imperative need for ALDOT to reassess its approach to work pressure and safety. A concerted effort to address the underlying issues leading to unsafe behavior and injuries is needed. By fostering an environment where safety is always prioritized above time and economic constraints, ALDOT can prioritize its employees' safety and improve operational efficiency. Enhancing the safety culture, through education, clear communication, and engagement strategies, will ensure that safety standards are not only maintained but championed by all employees. The division in perceptions also calls for more tailored approaches to safety management, recognizing the unique challenges different departments or teams may face. Statistics of responses (Mean ($\bar{x}$), Standard Deviation($\sigma$), Variance($\sigma^2$)) for each statement are shown on the Y-axis of Figure 4-19 below the corresponding statement.

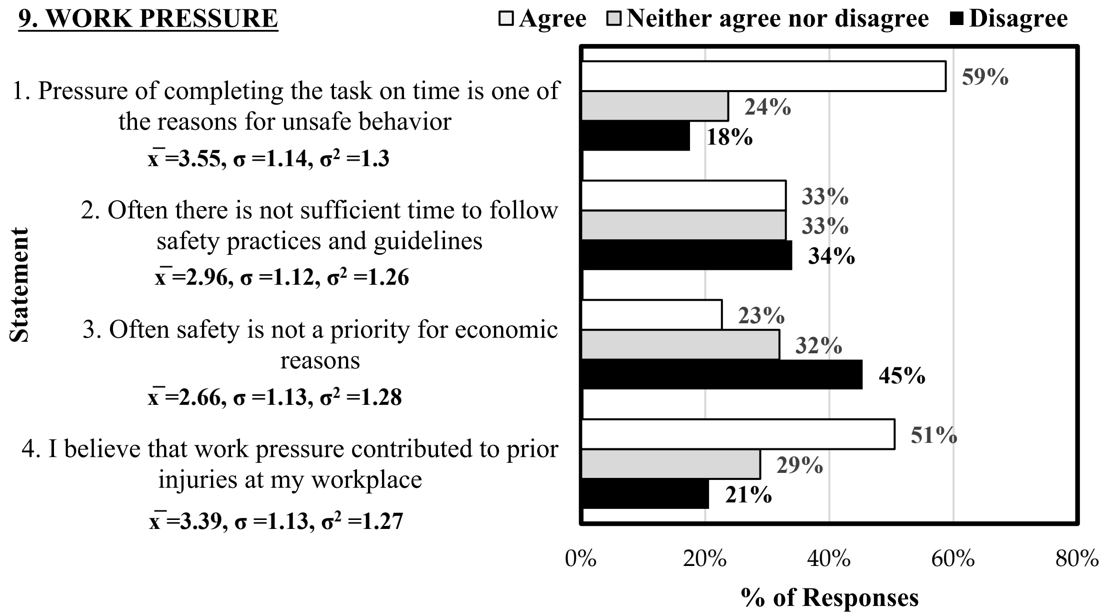


**Figure 4-19 Agreement Spectrum of Statements Related to *Work Pressure*.**

### *4.5.14 Summary of Survey Responses and Results*

The results of the survey conducted among ALDOT TMTs provided a broad snapshot of the workforce demographics. Among the data collected were age groups, job titles/classes, total experience in years, and ALDOT area in which TMTs are employed. The findings displayed diversity in the survey respondent pool. Age groups revealed that the '45-54' group had the highest participation rate, while the '65 or over' and '18-24' had low participation rates. The survey also aimed to draw correlations between demographic variables and respondents' safety perceptions – that is, to explore how workers' age, title, experience, and location can influence how they perceive safety at work.

The training section identified Equipment Operation Safety Training, Temporary Traffic Control (TTC), Flagging, Safety Awareness, and Personal Protective Equipment (PPE) training as the most topics of training received. The survey also revealed disparities in training satisfaction across different ALDOT areas, with varying levels of contentment reported in Alexander City, Birmingham, and Tuscaloosa areas. This insight emphasizes the need for evaluating and enhancing training programs to address specific gaps and ensure alignment with employee expectations and job requirements.

The activities with the highest perceived risk, as ranked by TMTs, included Roadway/Shoulder Maintenance, Guardrail/Cable Rail Maintenance, Mowing & Trimming, and Patching. These activities were assumed to pose the greatest safety challenges and require heightened attention to risk management and safety protocols. By prioritizing these high-risk activities, ALDOT can focus on implementing targeted safety measures and training interventions to mitigate potential hazards and enhance worker safety. The most cited concern among respondents was the risk of getting hit by moving traffic, highlighting the significant danger posed by working near roadways. Other prevalent safety concerns encompassed worries related to equipment safety, proper handling of machinery, traffic control measures, PPE usage, awareness of safety protocols, emergency preparedness, and lack of manpower. Addressing these safety concerns is crucial for minimizing risks associated with maintenance activities and ensuring the well-being of TMTs while they perform their duties.

By analyzing the 9 different factors of safety perception, a generally more positive attitude was found in Tuscaloosa area, while Birmingham area responses exhibited a drastically more negative attitude. Scores for each factor were calculated as shown in Table 4-2 below, then were subsequently ranked according to respondents' perceptions, ranging from most positive to least. The ranking unfolded as follows: (1) *Safety Awareness*, receiving the highest level of positive perception, followed by (2) *Motivation*, (3) *Safety Mindset*, (4) *Supportive Environment*, (5) *Employee Participation*, (6) *Management Dedication*, (7) *Safety Management System* (8) *Resource Allocation*, and (9) *Work Pressure* ranking the least, emphasizing its significant impact as perceived negatively by respondents. This ranking provides a clear insight into the areas requiring further attention and those regarded as strengths within ALDOT’s current safety culture.

**Table 4-2 Safety Perception Factors' Formulas**

| Factor | Formula | Score<br>Score interpretation |
|---|---|---|
| 1. Management Dedication to Safety | $= 0.18 * \bar{x}(F1\_1) + 0.19 * \bar{x}(F1\_2) + 0.16 * \bar{x}(F1\_3) + 0.17 * \bar{x}(F1\_4) + 0.12 * \bar{x}(F1\_5) + 0.18 * \bar{x}(F1\_6)$ | 69%<br>Room for improvement |
| 2. Motivation | $= 0.22 * \bar{x}(F2\_1) + 0.22 * \bar{x}(F2\_2) + 0.21 * \bar{x}(F2\_3) + 0.14 * \bar{x}(F2\_4) + 0.21 * \bar{x}(F2\_5)$ | 82%<br>Positive aspect of the safety culture |
| 3. Supportive Environment | $= 0.14 * \bar{x}(F3\_1) + 0.12 * \bar{x}(F3\_2) + 0.15 * \bar{x}(F3\_3) + 0.16 * \bar{x}(F3\_4) + 0.12 * \bar{x}(F3\_5) + 0.21 * \bar{x}(F3\_6) + 0.1 * \bar{x}(F3\_7)$ | 77%<br>Room for improvement |
| 4. Safety Management System | $= 0.13 * \bar{x}(F4\_1) + 0.15 * \bar{x}(F4\_2) + 0.15 * \bar{x}(F4\_3) + 0.15 * \bar{x}(F4\_4) + 0.14 * \bar{x}(F4\_5) + 0.14 * \bar{x}(F4\_6) + 0.13 * \bar{x}(F4\_7)$ | 66%<br>Room for improvement |
| 5. Employee Participation | $= 0.2 * \bar{x}(F5\_1) + 0.27 * \bar{x}(F5\_2) + 0.27 * \bar{x}(F5\_3) + 0.26 * \bar{x}(F5\_4)$ | 76%<br>Room for improvement |
| 6. Resource Allocation | $= 0.31 * \bar{x}(F6\_1) + 0.36 * \bar{x}(F6\_2) + 0.33 * \bar{x}(F6\_3)$ | 62%<br>Room for improvement |
| 7. Safety Mindset | $= 0.17 * \bar{x}(F7_1) + 0.13 * \bar{x}(F7_2) + 0.14 * \bar{x}(F7\_3m) + 0.15 * \bar{x}(F7\_4) + 0.12 * \bar{x}(Q17\_5m) + 0.15 * \bar{x}(F7\_6m) + 0.13 * \bar{x}(F7\_7m)$ | 78%<br>Room for improvement |

| | | |
|---|---|---|
| 8. Safety Awareness | $= 0.21 * \bar{x}\ (F8\_1) + 0.18 * \bar{x}\ (F8\_2) + 0.2 * \bar{x}\ (F8\_3) + 0.2 * \bar{x}\ (F8\_4) + 0.21 * \bar{x}\ (F8\_5)$ | 82%<br>Positive aspect of the safety culture |
| 9. Work Pressure | $= 0.25 * \bar{x}\ (F9\_1) + 0.26 * \bar{x}\ (F9\_2) + 0.22 * \bar{x}\ (F9\_3) + 0.26 * \bar{x}\ (F9\_4)$ | 56%<br>Need for immediate intervention |

Note: $\bar{x}\ (FXi\_Yi)$ is the mean of responses to statement $Yi$ of the factor $Xi$

## 4.6 Discussion

The analysis and rankings of various factors influencing the safety culture within ALDOT have laid a foundation for understanding the current state of occupational health and safety from the perspectives of TMTs. The findings suggest that area differences in worker safety perceptions and experiences exist within ALDOT. It is essential for ALDOT to identify and address the underlying factors contributing to these gaps to ensure a consistent and effective approach to safety management across all areas.

The perceived risk associated with various maintenance activities among ALDOT TMTs was evaluated by asking respondents to rank activities based on their perceived hazard levels. The ranking method not only reflects the frequency of selection but also indicates the intensity of perceived risk associated with each activity. Roadway/Shoulder Maintenance, Guardrail/Cable Rail Maintenance, Mowing & Trimming, and Patching were the top high-risk activities highlighting priority areas for implementing targeted safety measures, training programs, and safety interventions. By focusing on these activities, ALDOT can address worker concerns, specific hazards, enhance safety protocols, and mitigate risks associated with critical maintenance tasks.

When investigating different safety factors, *Work Pressure* within ALDOT has emerged as a critical issue, scoring the lowest among all factors surveyed and indicating a negative impact on the organization's safety culture. Among the concerns raised, two statements stood out for receiving the most negative responses, highlighting significant areas requiring immediate attention. Pressure of completing the task on time was perceived by the majority to be one of the reasons for unsafe behavior, which emphasizes an issue where deadlines might be prioritized over safety protocols. This mentality fosters an environment prone to accidents due to rushed or neglected safety measures. The division among employees regarding the adequacy of time to follow safety guidelines suggests varying experiences within different teams or departments. This may stem from uneven workload distribution or human resources (i.e., manpower) between different areas, indicating the necessity for a standardized approach to time management in safety procedures across all areas. Similarly, believing that work pressure contributed to prior injuries by most respondents highlights the consequences of excessive work demands on employee safety. Implementing measures to alleviate work pressure, such as better workload management, stress reduction programs, and improved communication channels, could mitigate the risk of future injuries and enhance overall safety outcomes. These findings emphasize the need for ALDOT to reassess its approach to work pressure and prioritizing employees' health and well-being above time and economic constraints starting with addressing the underlying issues that lead to unsafe behavior and injuries.

Another area of concern highlighted by the survey is *Resource Allocation*, which received the second-lowest score among all assessed factors. Most respondents expressed their disagreement with the notion that sufficient workers are available to complete tasks safely. The perception of insufficient staffing levels among TMTs underscores the need for ALDOT to evaluate and potentially adjust workforce allocation strategies to ensure adequate support for safe task completion. Implementing measures to address staffing challenges, such as optimizing workforce deployment and workload management, can enhance safety outcomes and operational efficiency. Furthermore, the availability of necessary equipment to perform tasks safely always was also brought into question in Birmingham area, alongside doubts regarding whether the provided Personal Protective Equipment (PPE) is in good condition and compatible with the tasks required. Most respondents in Alexander city and Tuscaloosa area agreed that the provided PPE is adequate for required tasks, emphasizing the importance of maintaining high standards of PPE quality and suitability.

*Safety Management System* is a well-structured framework that aims to effectively manage occupational health safety and risks and should be well established and followed to ensure the working environment is safe and compliant with regulatory bodies (Tsopa et al., 2022). Feedback from respondents in Birmingham area highlights a sense of dissatisfaction with the current state of the *Safety Management System* at ALDOT. Concerns have been raised regarding the quality and practicality of safety training provided, questioning its adequacy to prepare staff for real-world hazards. Additionally, there is a notable dissatisfaction with the way managers handle hazardous situations, and the perception that management frequently overlooks employee suggestions on how to improve hazardous situations. To reinforce a safety-conscious work environment management should prioritize ongoing training programs that address specific hazards faced by TMTs and ensure effective communication channels that facilitate information sharing on safety protocols and best practices to promote a culture of safety awareness.

Disparities in satisfaction with safety training across different ALDOT areas underscore the importance of tailored training programs. The survey results highlight the critical need for evaluating and enhancing training programs, particularly in areas where satisfaction levels are low, to ensure alignment with employee expectations and job requirements. Specific training methods can significantly enhance the skill set and proficiency of maintenance workers. Examples of training methods include hands-on training, on-the-job training, classroom, E-Learning platforms, workshops and seminars. Refresher courses are essential for keeping skills sharp and staying updated on the latest maintenance practices and technologies (Wilson & Smith, 1974). TMTs can be trained in a variety of critical areas that can expand their skills, such as (1) equipment maintenance and repair, (2) safety procedures and regulations including proper PPE application, (3) risk identification and analysis (4) preventive maintenance practices, (5) communication, teamwork, and conflict resolution strategies, (6) time management, and (8) continuous improvement for new and existing employees.

While some respondents expressed satisfaction with the investigation process, a notable percentage indicated dissatisfaction or neutrality, suggesting opportunities for improvement in the handling of incidents and safety-related incidents. Improving the incident investigation process is critical for any organization to determine the roots of incidences, recommend counteractive measures, and prevent reoccurrence in the future. Some of the strategies to improve the incident investigation process include: (1) creating a proper measurement scale on how to perform incident investigation including reporting procedures, investigative team selection criterion, evidence collection and assessment process, (2) establishing a Job Hazard Analysis (JHA) system, (3) prompt reporting to enhances the validity of the results obtained from an investigation, (4) thorough documentation, (5) share lessons learned and ensuring that findings from investigations are made known to all members (Chetan S, 2023).

To address the perception of ALDOT's TMTs in Birmingham area that management frequently overlooks or outright dismisses employee suggestions, actions should be taken to foster a culture of continuous improvement and employee engagement. Some approaches to enhance the communication process include: (1) implementing an open-door policy, (2) creating regular feedback through suggestion boxes, surveys, and having designated digital platforms where employees can submit their suggestions, (3) recognize and reward workers for good suggestions that are valuable to the organization, (4) update employees on a regular basis concerning the progress of their suggestions, and (5) encourage employee participation in team meetings and workshops (Chetan S, 2023).

The survey results indicate that over half of surveyed TMTs hold either a neutral stance or disagree with the statement regarding their involvement in safety-related activities. However, it's crucial to recognize the benefits that employee participation in safety management systems brings. Employee involvement in safety related activities leads to improvements in safety performance due to better awareness and adherence to protocols, which significantly reduces workplace incidents and leads to more effective hazard identification. Furthermore, empowering employees in safety matters promotes a sense of ownership and accountability and enhances communication, leading to more effective safety measures. This positive impact increases morale and engagement in safety practices, resulting in a reduction of risks and a decrease in the probability of incidents (Shuen, 2018).

## 4.7 Conclusion and Recommendations

Based on survey results, several systematic and in-depth suggestions can be made to enhance safety practices and foster a positive safety culture within ALDOT in particular and DOTs in general. Initially, developing customized training programs that address specific safety concerns identified in the survey, particularly those related to high-risk activities, is crucial. For instance, workers expressed concerns about working in live traffic, so training should focus on traffic management and personal protective equipment (PPE) usage. Incorporating real-life scenarios from the survey responses into training modules can make the content more relatable and impactful, helping TMTs understand the practical implications of safety protocols.

Enhancing communication channels is crucial. Establishing regular feedback mechanisms, such as anonymous surveys, suggestion boxes, or safety meetings, will allow employees to voice their safety concerns and suggestions. Creating physical or digital safety bulletin boards that highlight safety tips, recent incidents, and lessons learned can keep safety at the forefront of employees' minds and encourage ongoing dialogue about safety practices. Promoting a culture of safety engagement is another essential aspect. Establishing a safety champions program, where selected employees act as safety advocates within their teams, can lead safety discussions, promote best practices, and serve as liaisons between management and workers. Implementing a recognition program that rewards teams or individuals who demonstrate exceptional commitment to safety can further encourage a proactive safety culture.

Regular safety audits and assessments should also be conducted to identify potential hazards in the work environment. These inspections should involve input from TMTs to ensure their insights are considered. Furthermore, benchmarking ALDOT’s safety practices against those of other DOTs or organizations known for their strong safety cultures can provide valuable insights into effective strategies.

Data-driven decision-making is vital for continuous improvement. DOTs should integrate safety incident data with survey results to identify trends and correlations, helping prioritize areas for improvement and tailor interventions more effectively. Establishing a system for ongoing monitoring of safety perceptions and practices will allow for regular assessment of the effectiveness of implemented safety initiatives, enabling adjustments based on feedback and emerging best practices.

The existing literature on workplace safety emphasizes the importance of a strong safety culture, employee engagement, and tailored training programs as key components in reducing workplace accidents and enhancing overall safety performance. The findings of this survey align with these principles. The identification of hazardous activities and the prioritization of safety training topics reflect a growing trend in safety management that advocates for data-driven decision-making. By integrating survey results with safety incident data, DOTs can identify trends and correlations that inform targeted interventions, a practice that is increasingly recognized as vital for continuous improvement in safety management.

## 4.8 Limitations of Study and Future Improvement

The survey of safety perceptions among ALDOT TMTs has several limitations and areas for future development. Limitations include regional variability as ALDOT operates in various regions and areas across the state. Findings highlighted from three areas in this study may not be applicable to other areas, leading to a lack of comprehensive understanding of safety perceptions across the entire organization. Another limitation is the possible response bias to certain statements concerning TMTs own mindset, awareness or participation. They may have provided socially desirable answers rather than their true perception. One other limitation is emotional bias or increased sensitivity due to experiencing a recent serious injury before taking the survey, which can create an atmosphere of anxiety that results in responding to survey questions with heightened concern about safety practices, potentially leading to more negative perceptions than under normal circumstances.

Suggested future developments of this effort include conducting longitudinal studies to track changes in safety perceptions and the effectiveness of safety interventions over time.  Expanding future research to include a wider range of ALDOT areas will enhance the generalizability of findings and ensure that safety strategies are relevant across different areas.  Performing multi-level analysis by recognizing and distinguishing between different levels of analysis (e.g., organizational, group, and individual levels) is suggested.  This ensures that the measurements taken at one level are appropriately interpreted and applied to other levels, enhancing the validity of the findings (Guldenmund, 2007).  Integrating actual safety incident data with survey results to correlate perceptions can provide a more comprehensive understanding of safety culture.

By systematically implementing these suggestions, DOTs can create a more proactive and resilient safety culture that prioritizes the well-being of its employees and effectively addresses the specific safety concerns identified in the survey.

# CHAPTER 5: CONDUCTING JOB HAZARD ANALYSIS (JHA) FOR ALDOT TMTS

A Job Hazard Analysis (JHA) is a method that examines job activities to identify the associated hazards with each step. It examines the relationships between the worker, the task, the tools, and the environment. The main purpose of JHA is to proactively address uncontrolled hazards by mitigating or eliminating them to a manageable risk level (OSHA, 2002), ensure that all workers are capable of identifying and assessing existing and potential hazards, and that they are familiar with the proper control measures to mitigate the risks (Roughton & Crutchfield, 2015). When the JHA is performed regularly and is a part of an organization's safety program, a dataset of steps to perform a task, hazards, and corresponding control measures can be documented offering guidelines for safe work practices.

## 5.1 The JHA Process

Developing a JHA for ALDOT's TMTs should be implemented using a structured approach to identify and mitigate workplace hazards effectively. Involving employees in the JHA process is fundamental since they possess firsthand knowledge and experience of the required steps to complete a task and what can go wrong. When employees are involved and encouraged to share their thoughts and recommendations, they are more likely to actively engage, implement controls, and maintain compliance with the process (Roughton & Crutchfield, 2015).

When conducting a JHA, tasks are broken down into sequential steps, each analyzed for potential hazards, with associated risks evaluated in terms of their severity and likelihood of harm. According to OSHA, conducting a JHA involves several key steps as shown in Figure 5-1. These steps include decomposing the task, identifying potential hazards, assessing the risk based on severity and likelihood, and addressing hazards most likely to cause injury. Mitigation procedures are then established for each hazard identified, followed by monitoring and training to ensure ongoing safety measures are implemented (OSHA, 2002).

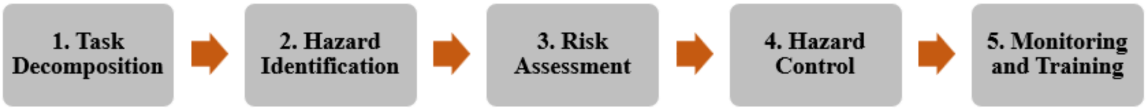


**Figure 5-1 Main JHA Steps.**

Prioritizing JHA is crucial for tasks that are associated with high injury rates, pose risks of severe harm, are prone to human error, or have recently been introduced or modified. Other tasks that that require specific instructions or are infrequent should also be examined for a JHA (OSHA, 2002).

Compiling a dataset of comprehensive JHA forms can be employed to arrange pre-task safety talks to discuss hazards and control measure with workers prior to performing scheduled tasks, which can significantly improve safety awareness and encourage workers to practice safety guidelines. Studies have shown that pre-task safety talks improve workers' safety performance by preparing them to focus their minds on the task, specific steps, and ensure awareness of hazards and risk associated (Al-Shabbani et al., 2018). The main steps involved in implementing the JHA designed for ALDOT TMTs are discussed below.

### *5.1.1 Task decomposition*

The JHA process begins with gathering details about the job or task, including a description of the task, tools and equipment used, as well as the physical demands involved. When the necessary information is collected, the task is then broken down into individual steps capturing the sequence of actions required to perform each step safely. This allows for unveiling potential hazards that could be avoided.

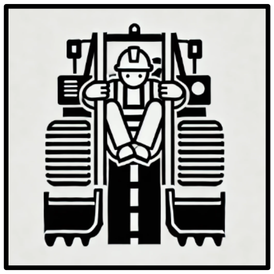
To break down a job into steps, workers who perform similar activities can discuss specific tasks and compare experiences and the sequence of steps they usually carry out to complete the task. Another method can be observing different crews performing the same task at hand while documenting the sequence of steps. This gives an opportunity to ask questions during each step and discuss possible different approaches to complete the task.

### *5.1.2 Hazard identification*

Identifying existing and potential hazards is next step in the JHA process. This entails recognizing and documenting hazards that could cause injury or harm when carrying out each step, considering factors like equipment, materials, and environmental conditions. As previously mentioned, involving workers in this phase is highly valuable. Their experience with processes, tools, and materials brings a practical perspective that helps in identifying hazards and promoting safe work practices. Common hazards faced by TMTs are shown in Figure 5-2 below.

**Traffic Hazards**
TMTs often face the risk of being hit by moving vehicles, whether from general traffic or construction-related vehicles

**Struck-by Hazards**
Struck-by incidents occur when workers face risks from flying debris, tools, or heavy machinery.

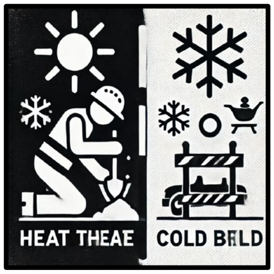


**Caught-In or Between Hazards**
In tasks involving machinery or confined spaces, workers risk being caught in or between equipment parts.

**Electrical Hazards**
For TMTs working with electrical systems like traffic signals, electric shocks or electrocution are serious risks.

**Chemical and Hazardous Material**
Exposure to chemicals like asphalt or herbicides poses a risk to TMTs.

**Noise and Vibration**
Noise from machinery or vibration can cause hearing issues over time.



**Heat and Cold Stress**
TMTs working in extreme temperatures face risks like heat stroke or frostbite.

**Manual Handling and Ergonomic Hazards**
Heavy lifting and repetitive tasks can lead to sprains and strains and back injuries

**Falling Hazards**
Working from heights like bridges or elevated platforms raises critical fall risks

**Biological Hazards**
Outdoor work exposes TMTs to biological hazards like insects or contaminated water

**Figure 5-2 Common Hazards Faced by TMTs.**

Note: 1. Images in this figure are AI-generated (Marji, 2024).

### *5.1.3 Risk Assessment*

Risk assessment is the next step, involving an evaluation of the potential harm posed by each hazard based on likelihood (or probability) and severity. OSHA assesses risks by considering the likelihood of a hazard occurring, the severity of potential harm, and existing control measures. Based on these factors, risks are then categorized as high, medium, or low, which guides the selection of control level needed to reduce or eliminate the hazard.

Assessing likelihood of a hazard is subject to judgment and personal experience, especially if the assessment is influenced by past incidents or a history of near misses which can increase the perceived likelihood of recurrence. Meanwhile, the severity of an injury considers factors like days lost, need for medical treatment, and impacts on quality of life (OSHA, 2002).

To evaluate the risks based on likelihood and severity, different designs of risk matrices are available. Regardless of the design, all matrices consider the severity of potential harm and the likelihood of occurrence. For the purposes of ALDOT TMT risk assessment, a 4 by 5 matrix design is used. While different studies define the categories of severity and likelihood differently, the following definitions are chosen as guidance for ranking (GACC, 2023);

The severity of harm is rated on a scale of 1 to 4, with 4 being the most severe as follows:

1. **Negligible:** requires only first aid or minor medical treatment, and results in little to no damage to property or the environment.
2. **Moderate**: results in hospitalization for a minor injury or a reversible illness, and minor damage to equipment, property, or the environment.
3. **Critical**: results in permanent partial disability or temporary total disability. It could also cause moderate environmental damage and extensive damage to equipment.
4. **Catastrophic**: presents imminent and immediate danger, potentially leading to death or permanent disability. It can result in major damage to property or facilities, as well as the loss of critical systems or equipment.

The likelihood of the risk occurring is rated on a scale of 1 to 5, with 5 being the most Likely as follows:

1. **Rare**: describes an event that is improbable but has happened in the past.
2. **Unlikely**: describes an event that is remotely possible but not probable.
3. **Possible:** probably will occur in time if not corrected or will occur several times.
4. **Likely**: describes an event that will occur frequently while performing the task.
5. **Almost Certain**: describes an event that is continuously experienced when performing the task.

A risk assessment matrix can be developed by combining the severity and the likelihood that allows a user to determine a task's overall risk. The intersection point in the risk assessment matrix identifies the overall risk level of a particular task under consideration (i.e., Extremely High, High, Moderate, Low) as shown in Figure **5-3**. This risk level helps prioritize risk management efforts and allocate resources effectively by identifying risks that need more urgent or strict mitigation measures.

| **Risk Assessment Matrix** | | **Probability (Likelihood of Mishap if Hazard is Present)** | | | | |
|---|---|---|---|---|---|---|
| | | **Almost Certain (5)** | **Likely (4)** | **Possible (3)** | **Unlikely (2)** | **Rare (1)** |
| **Severity (Consequences of Mishap Occurs)** | **Catastrophic (4)** | Extremely High | Extremely High | Extremely High | High | Moderate |
| | **Critical (3)** | Extremely High | Extremely High | High | Moderate | Moderate |
| | **Moderate (2)** | High | High | Moderate | Low | Low |
| | **Negligible (1)** | Moderate | Moderate | Low | Low | Low |

**Figure 5-3 Risk Assessment Matrix.**

### *5.1.4 Hazard Control*

Different control measures can have varying levels of effectiveness in reducing risk. The results of a JHA are meaningless unless control measures proposed in the analysis are applicable and integrated into each task. To ensure effective control measures are implemented, a hierarchical ranking known as the hierarchy of controls is applied (Roughton et al., 2015). This approach offers a structured method for assessing and strengthening safety protocols. The preferred order of controls is shown in Figure 5-4 below and is described as follows:

- Eliminate the hazard by removing it from the task, process, or material whenever feasible to prevent exposure.
- Substitute the hazard by limiting exposure or mitigating risks by using safer materials or methods.
- Redesign and engineer the processes, materials, equipment, or work environment to contain the hazard.
- Employ administrative controls such as establishing written procedures for safe operations, limitations on exposure periods, modifying work schedules, and training to communicate the presence of hazards and the required safety measures.
- Resort to Personal Protective Equipment (PPE) as a final solution to protect employees from hazards. (Roughton & Crutchfield, 2015).

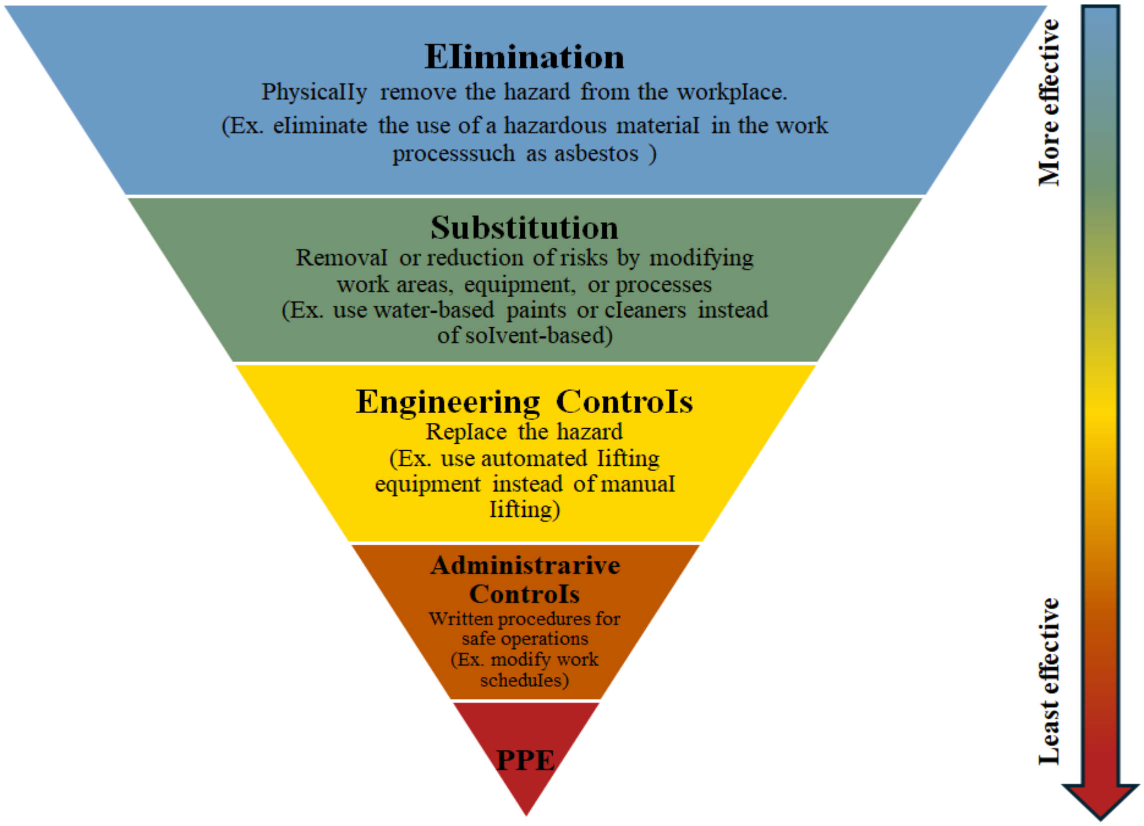


**Figure 5-4 Hierarchy of Hazard Controls (Roughton & Crutchfield, 2015).**

### *5.1.5 Monitoring and Control*

Monitoring the JHA process closely is crucial for ensuring that hazards are controlled, and safety measures are implemented. Regular review of the JHA forms maintains an ongoing, sustainable JHA program. These forms must be revised in the event of an accident or near-miss. It is recommended to review the forms periodically, to ensure that they reflect any changes in work methods, equipment, or regulations, as well as assessing the effectiveness of implemented control measures based on different safety criteria, such as improved reporting of near-misses, comparison of injury rates, costs of medical treatment, equipment and tool damage, and number of days lost due to injuries (Martin & Walters, 2001).

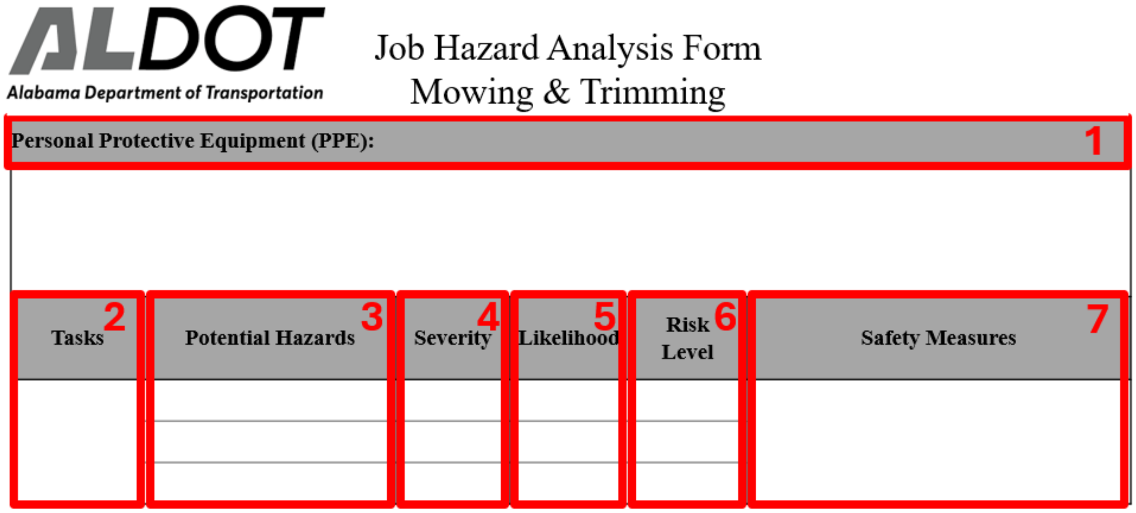
The JHA forms should be reviewed by all workers performing the tasks. These forms serve as a training reference for new workers and supervisors, as well as for infrequent job assignments. The JHA may also be a valuable tool to incorporate in incident investigation or assessing workers' safety performance. It is recommended to post hard copies of summarized JHA forms as an ongoing visual reminder to the worker performing the job. These forms are also useful for supervisors in planning and conducting safety meetings or pre-task safety talks (Morris & Wachs, 2003).

Thorough training on task specific hazards and appropriate safety protocols is essential for all TMTs. The JHA process should be framed as an ongoing, continuous practice so that workers are properly trained to recognize hazards as they arise and to report them promptly. Periodic refresher training should also be conducted to ensure that workers remain aware of new safety protocols or changes in job procedures (Roughton & Crutchfield, 2015).

With the JHA structure in place, the following step involves identifying TMT activities with the highest risk to determine the most hazardous activities for analysis.

## 5.2 ALDOT JHA Forms

This section provides clear and comprehensive instructions for completing the JHA forms. These instructions will ensure consistency, thoroughness, and accuracy in identifying and mitigating potential hazards during various work activities. The format of the JHA forms is provided in Figure 5-5 below.



ALDOT
Alabama Department of Transportation

Job Hazard Analysis Form
Mowing & Trimming

**Personal Protective Equipment (PPE):**

| Tasks | Potential Hazards | Severity | Likelihood | Risk Level | Safety Measures |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

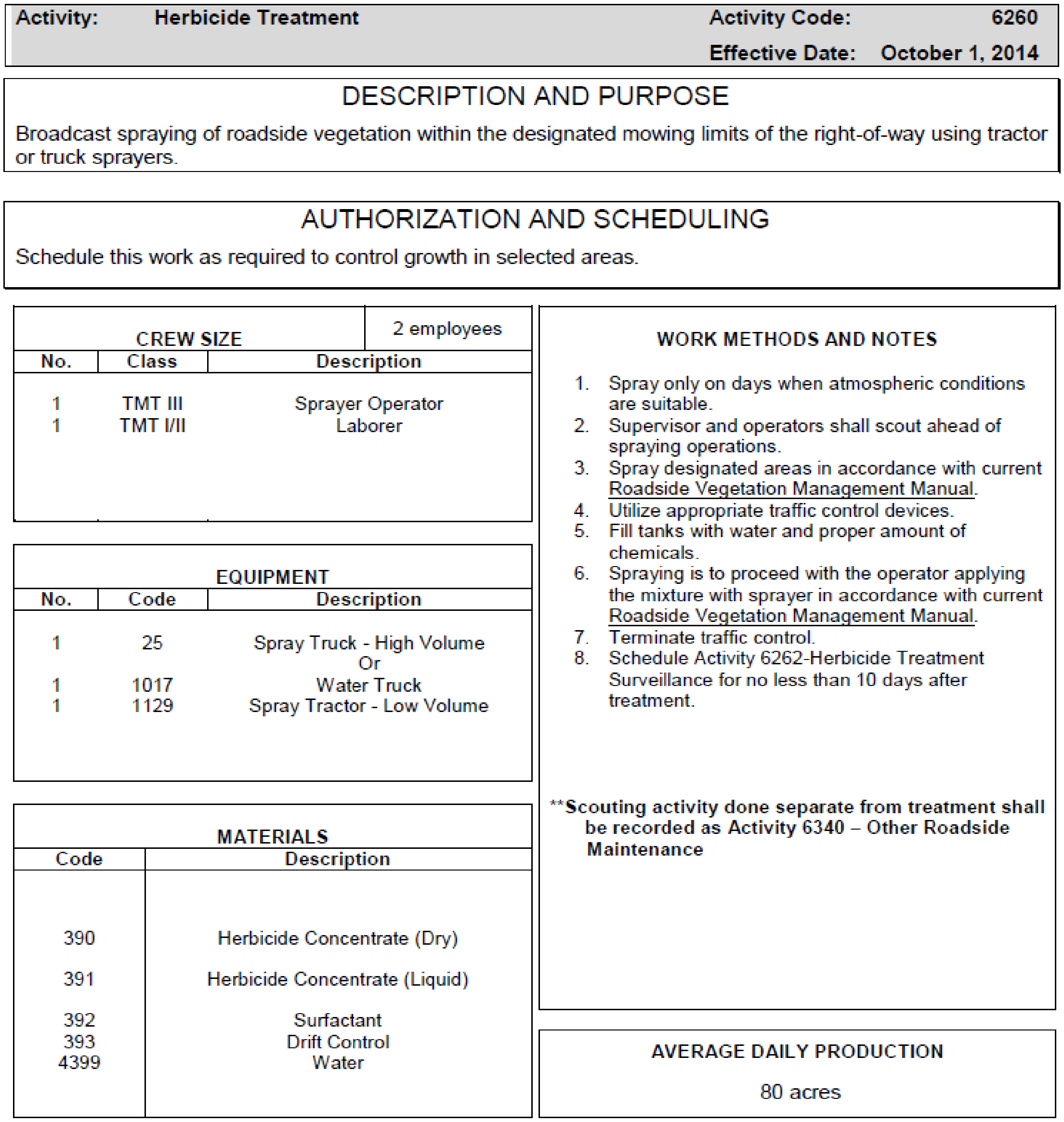
**Figure 5-5 Format of JHA Forms.**

*Step 1: Personal Protective Equipment (PPE) Requirements.* At the beginning of performing the JHA process, information related to the activity or task at hand is gathered based on the practical experience of TMTs. This information includes a brief description and identification of all tools and equipment required to perform the task.

In the first section of the JHA form on top, TMTs should list all PPE needed to perform the task safely. The type and amount of PPE is highly dependent on the nature of the task.

In this step, TMTs can refer to ALDOT task or activity Performance Guidelines, which contains information about Activity Name, Activity Code, Description and Purpose, Authorization and Scheduling, Crew Size, Equipment, Materials, Work Methods and Notes, and Average Daily

Production. An example of ALDOT Performance Guidelines for Herbicide Treatment is shown in Figure 5-6.



**Activity:** **Herbicide Treatment** **Activity Code:** **6260**
**Effective Date:** **October 1, 2014**

DESCRIPTION AND PURPOSE

Broadcast spraying of roadside vegetation within the designated mowing limits of the right-of-way using tractor or truck sprayers.

AUTHORIZATION AND SCHEDULING

Schedule this work as required to control growth in selected areas.

| CREW SIZE | | 2 employees |
|---|---|---|
| No. | Class | Description |
| 1 | TMT III | Sprayer Operator |
| 1 | TMT I/II | Laborer |

| EQUIPMENT | | |
|---|---|---|
| No. | Code | Description |
| 1 | 25 | Spray Truck - High Volume<br>Or |
| 1 | 1017 | Water Truck |
| 1 | 1129 | Spray Tractor - Low Volume |

| MATERIALS | |
|---|---|
| Code | Description |
| 390 | Herbicide Concentrate (Dry) |
| 391 | Herbicide Concentrate (Liquid) |
| 392 | Surfactant |
| 393 | Drift Control |
| 4399 | Water |

WORK METHODS AND NOTES

1. Spray only on days when atmospheric conditions are suitable.
2. Supervisor and operators shall scout ahead of spraying operations.
3. Spray designated areas in accordance with current Roadside Vegetation Management Manual.
4. Utilize appropriate traffic control devices.
5. Fill tanks with water and proper amount of chemicals.
6. Spraying is to proceed with the operator applying the mixture with sprayer in accordance with current Roadside Vegetation Management Manual.
7. Terminate traffic control.
8. Schedule Activity 6262-Herbicide Treatment Surveillance for no less than 10 days after treatment.

****Scouting activity done separate from treatment shall be recorded as Activity 6340 – Other Roadside Maintenance**

AVERAGE DAILY PRODUCTION

80 acres

**Figure 5-6 ALDOT Herbicide Treatment Performance Guidelines.**

*Source Alabama Department Of Transportation Maintenance Performance Guidelines (ALDOT, 2014)*

*Step 2: Identifying Task-Specific Steps.* In step 2, TMTs should outline the steps needed to complete the task in the first column, titled “Tasks”. The steps should be listed in sequence and detailed enough to capture all relevant work activities, tools, or materials that have the potential to expose workers to hazards. Work Methods and Notes in Performance Guidelines can be referred to as guidance for this step.

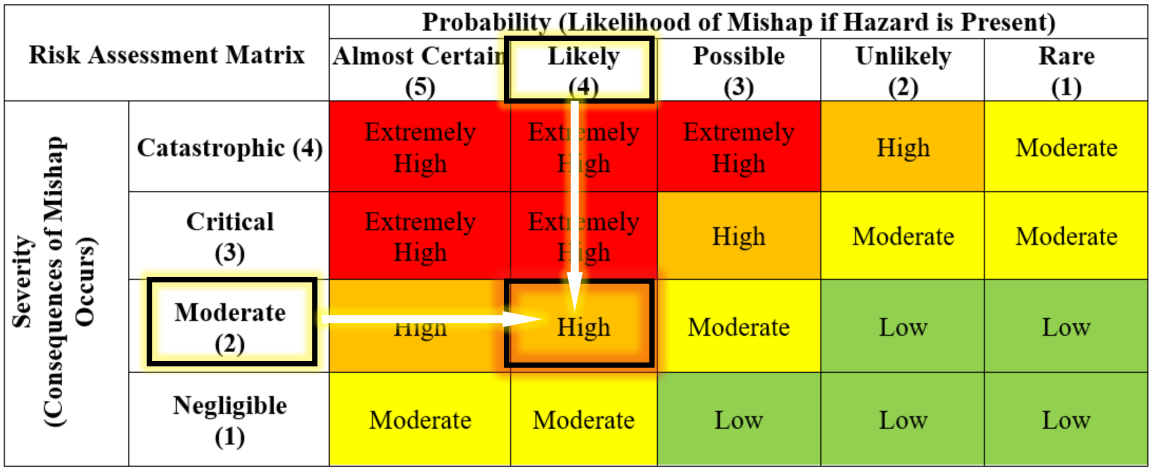
*Step 3: Identifying Potential Hazards.* In the column, titled “Potential Hazards,” workers should collaborate to identify all hazards associated with each step, taking into account the relationships between the worker, tools, and the work environment. TMTs have firsthand experience with hazards associated with their work and their input is invaluable at this stage.

*Step 4: Ranking the Severity of Hazards.* The third column, titled “Severity, “involves ranking the potential harm resulting from the hazard on a scale of 1 to 4. These assessments can be subject to personal opinion, so it is best to refer rank criteria as discussed in Risk Assessment.

*Step 5: Determining Likelihood of Occurrence. In the fourth column, titled “Like*lihood,” TMTs assess the likelihood of injury as a result of the hazard on a scale of 1 to 5. This ranking can be highly dependent on personal opinion, experience, or influence from a previous event. Therefore, it is preferable to refer to the definitions explained in *Risk* Assessment.

*Step 6: Risk Assessment.* The column, titled “Risk Level,” automatically populates the risk level in the excel sheet, based on severity and likelihood rankings. The method applied for risk assessment uses a straightforward risk assessment matrix. After understanding the effects of hazard exposure by ranking the severity and probability factors for each situation, TMTs can evaluate the associated risks using the matrix provided in Figure **5-3**. The risk level is determined by drawing a horizontal line through the severity rank, and a l vertical line through the likelihood rank. The cell where the two lines intersect represents the risk level of the combined rankings. The risk level can be low, moderate, high, or extremely high risk.

For example, if a hazard has severity rank of 2 which is moderate, and the likelihood of resulting in injury was 4 (i.e. likely); then a line from the moderate severity row is drawn to intersect with the line drawn from the Likely (4) column to give a combined ranking of high-risk level as shown in Figure 5-7.



| Risk Assessment Matrix | | Probability (Likelihood of Mishap if Hazard is Present) | | | | |
|---|---|---|---|---|---|---|
| | | Almost Certai (5) | Likely (4) | Possible (3) | Unlikely (2) | Rare (1) |
| Severity (Consequences of Mishap Occurs) | Catastrophic (4) | Extremely High | Ext emely H gh | Extremely High | High | Moderate |
| | Critical (3) | Extremely High | Ext emely H gh | High | Moderate | Moderate |
| | Moderate (2) | High | High | Moderate | Low | Low |
| | Negligible (1) | Moderate | Moderate | Low | Low | Low |

**Figure 5-7 Steps for Using the Risk Assessment Matrix.**

*Step 7: Identifying Safety Measures.* In the last column, “Safety Measures,” workers and supervisors should collaborate to list all the possible safety measures that can be implemented to eliminate or contain the hazard. Priority should be given to hazards with highest risk level. A good starting point to brainstorm possible control measures is using the hierarchy of hazard controls as shown in Figure 5-4.

Once all possible control measures are identified and documented, an action plan must be employed to resolve issues and comply with applicable controls. These plans can involve establishing priorities, deadlines, and evaluating effectiveness of safety measures.

### 5.3 Selecting Activities for Analysis

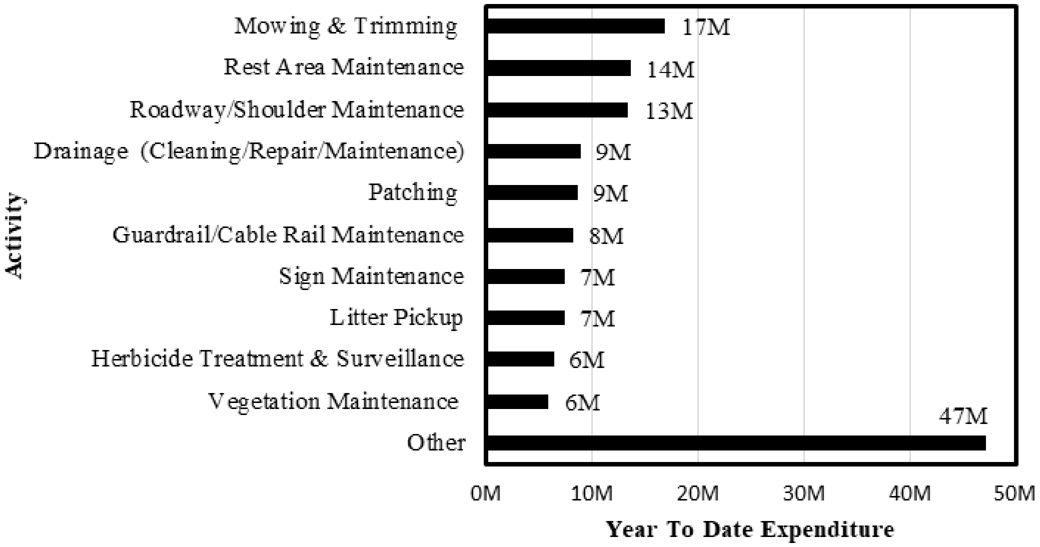
Evaluating how often TMTs are exposed to hazards while on the job is a key step in deciding which risks to tackle first and where to focus resources. As discussed earlier, the level of risk can be determined by considering two factors: (1) severity (how bad the potential harm can be), and (2) likelihood (how probable it is that the hazard will occur). To assess the likelihood, one practical approach is to consider the level of exposure. This means considering how frequently workers encounter the hazard and what safety measures are in place to mitigate the risk in check.

In this analysis, an assumption was made, that activities with higher expenditure are likely to be performed more often. As a result, these activities probably come with a higher chance of injuries, since these activities are performed more frequently.

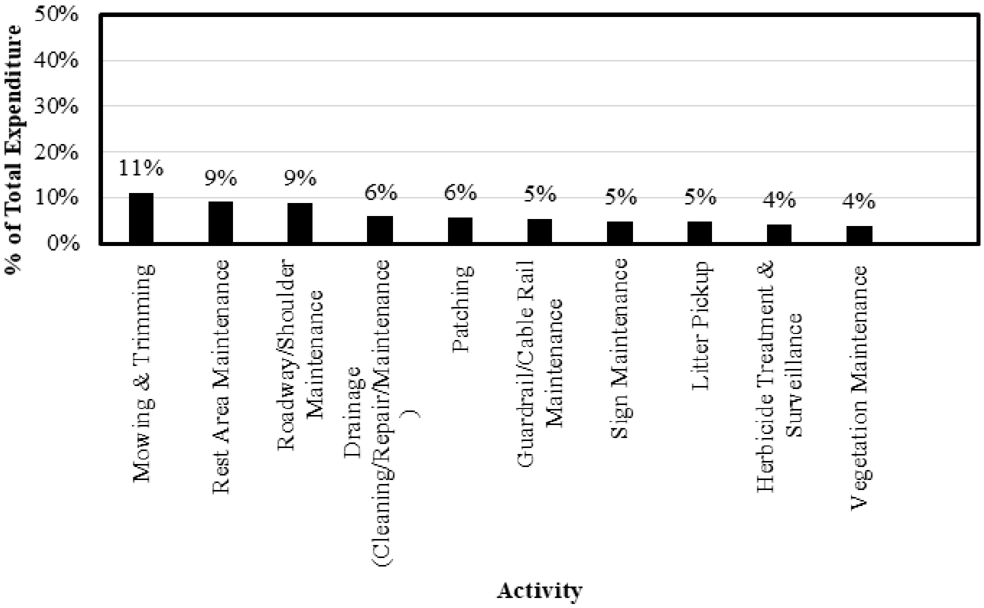
To determine worker exposure based upon maintenance activity expenditures, data was obtained from ALDOT that contained maintenance activity expenditures by area for the fiscal year (FY) 2022. Each spreadsheet contained the corresponding ALDOT Area report that provided details including Total Annual Budget, Year to Date Budget, Year to Date Expenditures, Year to Date Current Balance Status, and Total Annual Funds Remaining for each activity code sorted by District and Road Class.

Similar activity codes from different districts and road classes were grouped to examine the total 'Year to Date Expenditures' for each activity within an ALDOT Area. To examine expenditures for various maintenance activities across the state, the 10 ALDOT Area reports were listed into a single spreadsheet. Activity names were cross-referenced with their respective activity codes provided in the reports to group activities into categories that require similar methods of performance and pose similar hazards. These groupings are detailed in APPENDIX A.

The total year-to-date expenditures for all maintenance activities during Fiscal Year 2022 accounted for approximately $150.2M. The activities were ranked based on total expenditures to determine which activities incurred the highest cost as shown in Figure 5-8(a). The percent of total expenditures were plotted for top ten activities with highest cost as shown in Figure 5-8(b) below. These activities are: (1) Mowing & Trimming with $16.9M, making up 11% of all expenditures, (2) Rest Area Maintenance at $13.6M, representing 9% of total year-to-date expenditures, (3) Roadway/Shoulder Maintenance follows closely with $13.4M, and 9%, (4) Drainage at $8.9M, which accounts for 6%, (5) Patching follows with $8.6M, covering 6% of the total, (6) Guardrail/Cable Rail Maintenance with $8.2M, contributing 5%, (7) Sign Maintenance at $7.4M, also accounting for 5%, (8) Litter Pickup at $7.3M, holding the same rounded percentage of 5%, (9) Herbicide Treatment and Surveillance with $6.5M, accounting for 4%, and (10) Vegetation Maintenance rounding it up at $5.9M, covering 4% of total expenditure. These ten activities, with significant expenditures, are selected for a thorough hazard analysis to prioritize risks effectively.



(a) Year to Date Total Expenditures



(b) Percent of Total Expenditures for Top Ten Maintenance Activity Categories by Expenditure

Note: 1. Other includes all activities that were less than 4% of the FY2022 total expenditure before rouding.

**Figure 5-8 Activities Incurring Highest Expenditures.**

The analysis of ALDOT expenditure by maintenance activity allows for the identification of frequent hazard exposure which is reflected in the risk likelihood. To prioritize activities based on risk severity, the results obtained from the "*Field Survey of Alabama Department of*

*Transportation (ALDOT) Transportation Maintenance Technicians (TMTs) Perception of Worker Safety*" were used to rank activities from most hazardous to least as follows:

1. Roadway/Shoulder Maintenance
2. Guardrail/Cable Rail Maintenance
3. Patching
4. Mowing & Trimming
5. Sign Maintenance
6. Litter Pickup
7. Herbicide Treatment and Surveillance
8. Vegetation Maintenance
9. Drainage
10. Rest Area Maintenance

With a clear understanding of which tasks expose TMTs to higher risk levels, the analysis guides the selection of activities for JHA and resource allocation. The next step should involve transforming these insights into structured JHA forms. These activities along with the associated hazards were reviewed and discussed with ALDOT TMTs during visits to selected ALDOT district offices. TMT feedback was documented and incorporated into JHA forms for each of these activities.

Selected everyday tasks performed by TMTs, their associated hazards, and recommended practices to control or eliminate the risks are shown below in Table 5-1. These tasks include: (1) setting up Temporary Traffic Control (TTC), (2) lifting, (3) working in hot weather, (4) working with hazardous materials, and (5) vehicle operation. The severity and likelihood are not assessed in Table 5-1 since the frequency of exposure to the specific task can differ while performing different activities or tasks. Recommended safety measures are based on a comprehensive review of best practices implemented by state DOTs nationwide.

**Table 5-1 Hazards and Safety Measures Associated with Common TMT Tasks**

| General Task | Potential Hazards | Safety Measures |
|---|---|---|
| Setting up TTC | 1. Struck by Traffic<br>2. Flying Debris<br>3. Sun exposure<br>4. Lifting<br>5. Slip Trip, Fall | • Develop a traffic control plan.<br>• Inspect and prepare necessary traffic control devices for transport to the site.<br>• Ensure employees have appropriate PPE).<br>• Ensure flaggers are well-trained and equipped.<br>• Keep two-way radios charged and available for communication.<br>• Work facing oncoming traffic or designate a lookout if facing traffic is not practical.<br>• Stay vigilant to site hazards and identify escape routes.<br>• Avoid distractions, such as using earbuds for music or communication during work zone setup and traffic flagging.<br>• Unless actively handling traffic devices, employees should be transported in the vehicle cab.<br>• Use a truck-mounted impact attenuator for slow-moving operations or on high-speed roads whenever possible. |

| | | |
|---|---|---|
| | | • Remove signs when not necessary, especially during lunch or overnight.<br>• Utilize police support in specific cases like servicing traffic signals, notifying them promptly.<br>• Be cautious of wide or oversized loads in work zones.<br>• Do not leave equipment unattended near travel paths.<br>• Remove traffic control devices in reverse order of placement for maximum worker safety. Start with cones and end with signs. |
| Working with hazardous materials | 1. Burn<br>2. Contamination<br>3. Fire<br>4. Illness<br>5. Toxicity | • Obtain required training before handling any hazardous materials.<br>• Ensure that employees receive and are trained in the proper use of necessary personal protective equipment when handling hazardous materials.<br>• Conduct annual training sessions for employees on communicating hazards including both initial and refresher training sessions.<br>• Evaluate SDS for correct guidelines<br>• Obtain and wear appropriate PPE prior to working with hazardous materials.<br>• Ensure that the labels on hazardous materials are easily readable upon receipt and are maintained in an understandable state. Store containers in a way that keeps their warning labels visible.<br>• Supply appropriate tools and containers for the safe transfer, transportation, and storage of hazardous materials. |
| Working in hot weather | 1. Heat-related illness (i.e., heat stroke, heat exhaustion, cramps, sunburn, etc.) | • Supervisors are advised to schedule intense tasks during the cooler morning hours when feasible to minimize heat stress risks.<br>• Consider risk factors like high temperatures, humidity, physical exertion, heavy gear, and consecutive strenuous workdays when planning or revising work assignments.<br>• All staff members transitioning to hot environments should acclimate to the heat gradually before aiming for peak productivity.<br>• Before commencing work, employees are recommended to drink 2 cups of water. During each working hour, an additional 2-4 cups of water should be consumed. Avoid beverages with high caffeine or sugar content, like caffeinated and energy drinks. For activities lasting over 2 hours in hot conditions, consider replenishing electrolytes with sports drinks like Gatorade.<br>• Employees are advised to start hydrating before feeling thirsty to prevent heat-related ailments.<br>• Taking regular short breaks in shaded areas is more beneficial than infrequent long breaks.<br>• Supervisors must make sure that all teams have sufficient water supply and provide sufficient break time for hydration and recovery. |
| Manual lifting | 1. Sprains and strains<br>2. Fall, slip, trip | • Prior to executing a lift, mentally plan the entire process from start to finish and visualize the steps involved in placing the load.<br>• Consider alternative methods of moving the load (such as pushing, pulling, rolling, pouring, or pumping). If you are unable to slide the load with one foot, seek assistance.<br>• Always utilize mechanical tools if available for handling heavy loads or enlist help.<br>• Identify the optimal approach to grasp the load, utilizing available grips, or other suitable spots.<br>• Secure a strong grip on the load. |

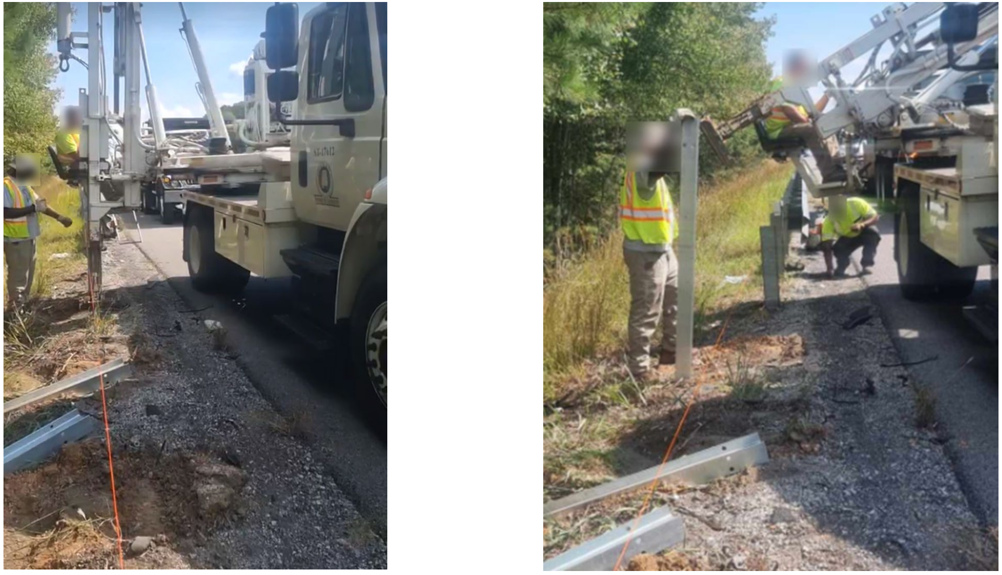
| | | |
|---|---|---|
| | | • Ensure stable footing and confirm that the standing surface is not slippery.<br>• Maintain a straight back by tucking in your chin.<br>• Engage your abdominal muscles and lift using your legs.<br>• Lift the load gradually; avoid sudden jerking movements.<br>• Minimize the space between the load and your body. Position the load near your body prior to lifting.<br>• Avoid twisting while lifting. Rotate using your feet<br>• Lower the load carefully, utilizing your legs while keeping your back as straight as possible.<br>• Ensure your fingers are clear when setting down or maneuvering the load through narrow spaces. |
| Vehicle operation | 1. Traffic accidents<br>2. Struck by | • Use of electronic devices should be minimized while driving.<br>• Loads must be secure and within manufacturer's specifications or legal limits for the vehicle.<br>• All loose items inside the vehicle must be secured to prevent injury in the event of a crash.<br>• Minimize backing whenever possible and use a spotter when backing is necessary. If no spotter is available, the operator must physically check behind the vehicle before backing.<br>• Park vehicles in the safest location possible, avoiding blind spots of other vehicles.<br>• Check for overhead power lines before working near or under them.<br>• Remove keys from unattended vehicles.<br>• For unattended running vehicles, follow specific procedures for manual and automatic transmission vehicles.<br>• Back vehicles into parking spaces whenever feasible.<br>• Keep vehicles clean and free of trash on a daily basis.<br>• Maintain vehicles according to manufacturer's specifications/recommendations, with prior approval required for any modifications.<br>• Anticipate hazards by scanning the road and checking mirrors<br>• Adjust side mirrors to minimize blind spots<br>• Expect mistakes from other drivers<br>• Avoid distractions and maintain a safe following distance<br>• Avoid conflicts with aggressive drivers<br>• Be mindful of tractor/trailers' blind spots, turning radius, and stopping distance. |

An example of a JHA form for Guardrail Repair activity is also presented in Figure 5-10. The purpose of Guardrail Repair is to “repair or replace guardrail sections, posts, and hardware due to accident damage or normal deterioration”. This activity typically requires a crew of five employees. Equipment needed is “Pick Up, a Flat Bed Dump, Post Driver, Trailer, and Arrow Board”. The materials needed include “Guardrail Sections, End Anchor Kits, and Guardrail Posts and Hardware”(ALDOT, 2014).

After gathering information about the activity, we can start listing the required PPE; which is; Safety Glasses/ Face shield, High Visibility Apparel, Gloves, Hard Hat, and Safety Boots. Each step required to complete the job is then listed. Figure 5-9 below shows illustrations of ALDOT TMTs performing main steps involved in Guardrail Repair.

(a) Removing parts that cannot be repaired

(b) Pulling out damaged posts.



(c) Setting up a stringline to position posts at the proper alignment, and spacing

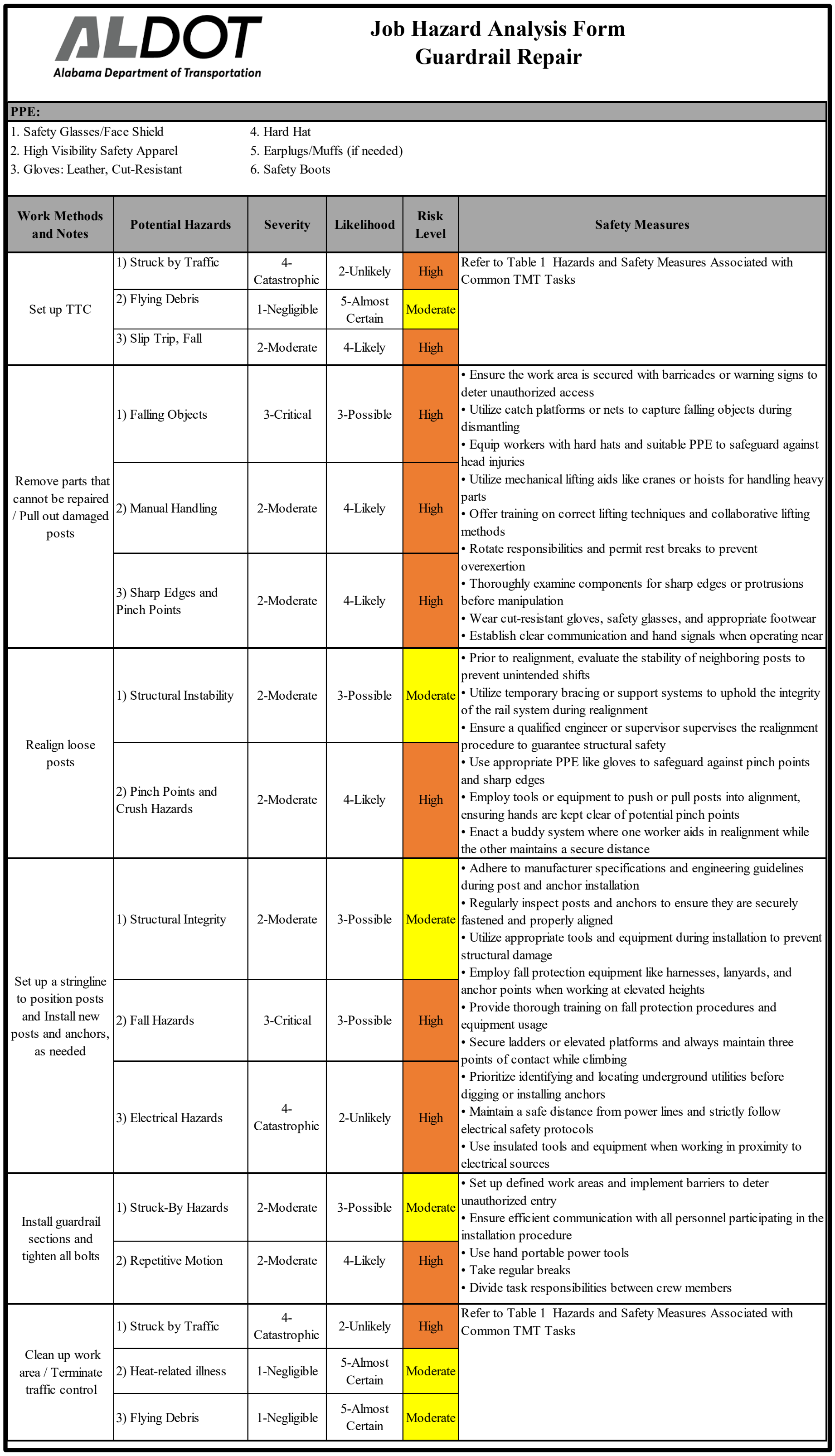
(d) Installing new posts

(e) Installing guardrail sections and tightening all bolts

**Figure 5-9 Main Steps Involved in Guardrail Repair.**

The potential hazards associated with each step should then be identified and the severity and likelihood should be assessed by TMTs. Falling objects is a hazard that is present in almost every step of Guardrail Repair, these objects can be guardrail sections, posts, or anchors. Sprains and strains are also a risk due to manual handling, lacerations and punctures can occur from sharp edges of the guardrail sections or posts. Electrical hazards are also present if installing posts near electrical sources such as underground utility lines. The most important part of the JHA comes next, which is establishing safety measures to control the hazard. Detailed safety measures can be found in Figure 5-10 below which shows a sample JHA form for Guardrail Repair.

All other JHA forms prepared for ALDOT TMTs can be found in APPENDIX B.



ALDOT
Alabama Department of Transportation

**Job Hazard Analysis Form**
**Guardrail Repair**

**PPE:**

1. Safety Glasses/Face Shield
2. High Visibility Safety Apparel
3. Gloves: Leather, Cut-Resistant
4. Hard Hat
5. Earplugs/Muffs (if needed)
6. Safety Boots

| Work Methods and Notes | Potential Hazards | Severity | Likelihood | Risk Level | Safety Measures |
|---|---|---|---|---|---|
| Set up TTC | 1) Struck by Traffic | 4-Catastrophic | 2-Unlikely | High | Refer to Table 1 Hazards and Safety Measures Associated with Common TMT Tasks |
| | 2) Flying Debris | 1-Negligible | 5-Almost Certain | Moderate | |
| | 3) Slip Trip, Fall | 2-Moderate | 4-Likely | High | |
| Remove parts that cannot be repaired / Pull out damaged posts | 1) Falling Objects | 3-Critical | 3-Possible | High | • Ensure the work area is secured with barricades or warning signs to deter unauthorized access<br>• Utilize catch platforms or nets to capture falling objects during dismantling<br>• Equip workers with hard hats and suitable PPE to safeguard against head injuries<br>• Utilize mechanical lifting aids like cranes or hoists for handling heavy parts<br>• Offer training on correct lifting techniques and collaborative lifting methods<br>• Rotate responsibilities and permit rest breaks to prevent overexertion<br>• Thoroughly examine components for sharp edges or protrusions before manipulation<br>• Wear cut-resistant gloves, safety glasses, and appropriate footwear<br>• Establish clear communication and hand signals when operating near |
| | 2) Manual Handling | 2-Moderate | 4-Likely | High | |
| | 3) Sharp Edges and Pinch Points | 2-Moderate | 4-Likely | High | |
| Realign loose posts | 1) Structural Instability | 2-Moderate | 3-Possible | Moderate | • Prior to realignment, evaluate the stability of neighboring posts to prevent unintended shifts<br>• Utilize temporary bracing or support systems to uphold the integrity of the rail system during realignment<br>• Ensure a qualified engineer or supervisor supervises the realignment procedure to guarantee structural safety<br>• Use appropriate PPE like gloves to safeguard against pinch points and sharp edges<br>• Employ tools or equipment to push or pull posts into alignment, ensuring hands are kept clear of potential pinch points<br>• Enact a buddy system where one worker aids in realignment while the other maintains a secure distance |
| | 2) Pinch Points and Crush Hazards | 2-Moderate | 4-Likely | High | |
| Set up a stringline to position posts and Install new posts and anchors, as needed | 1) Structural Integrity | 2-Moderate | 3-Possible | Moderate | • Adhere to manufacturer specifications and engineering guidelines during post and anchor installation<br>• Regularly inspect posts and anchors to ensure they are securely fastened and properly aligned<br>• Utilize appropriate tools and equipment during installation to prevent structural damage<br>• Employ fall protection equipment like harnesses, lanyards, and anchor points when working at elevated heights<br>• Provide thorough training on fall protection procedures and equipment usage<br>• Secure ladders or elevated platforms and always maintain three points of contact while climbing<br>• Prioritize identifying and locating underground utilities before digging or installing anchors<br>• Maintain a safe distance from power lines and strictly follow electrical safety protocols<br>• Use insulated tools and equipment when working in proximity to electrical sources |
| | 2) Fall Hazards | 3-Critical | 3-Possible | High | |
| | 3) Electrical Hazards | 4-Catastrophic | 2-Unlikely | High | |
| Install guardrail sections and tighten all bolts | 1) Struck-By Hazards | 2-Moderate | 3-Possible | Moderate | • Set up defined work areas and implement barriers to deter unauthorized entry<br>• Ensure efficient communication with all personnel participating in the installation procedure<br>• Use hand portable power tools<br>• Take regular breaks<br>• Divide task responsibilities between crew members |
| | 2) Repetitive Motion | 2-Moderate | 4-Likely | High | |
| Clean up work area / Terminate traffic control | 1) Struck by Traffic | 4-Catastrophic | 2-Unlikely | High | Refer to Table 1 Hazards and Safety Measures Associated with Common TMT Tasks |
| | 2) Heat-related illness | 1-Negligible | 5-Almost Certain | Moderate | |
| | 3) Flying Debris | 1-Negligible | 5-Almost Certain | Moderate | |

Figure 5-10 JHA for Guardrail Repair.

## 5.4 Conclusions

A key aspect of any successful safety program involves a proactive and continuous process for recognizing and evaluating risks in routine and non-routine tasks. The JHA is a straightforward, reliable tool to analyze and assess the work environment for potential hazards. Once potential hazards and risks are identified, the JHA is used to analyze the relationships between job steps, equipment used, work environment and the associated risks. The JHA then outlines the necessary sequence of controls needed to effectively mitigate hazards and risks. It is essential to keep monitoring job safety performance after employing safety measures and to evaluate the JHA in the event of injury or Illness incident or procedure changes regarding a specific job. Regular review of the forms ensures they are accurate and up to date.

Employee involvement is key for the process success, while improving communication, engagement, and ultimately enhancing workplace safety. The JHA process should be established as an ongoing, continuous practice to ensure workers are well-trained to identify hazards as they occur and promptly report them. Comprehensive training on task-specific hazards and appropriate safety procedures is crucial for all TMTs, as well as ensuring regular refresher training to keep workers informed of new safety protocols or changes in job procedures.

The JHA serves as the foundation for conducting on-site inspections to evaluate operations and activities. It can also be an effective tool to incorporate in pre-task safety talks and for new employee training.

ALDOT can communicate a structured plan for incident prevention and resource allocation by using risk assessments to pinpoint its most hazardous activities. The outcomes of this plan include reducing injuries and incidents’ numbers and rates, cutting workers' compensation costs, and boosting productivity amongst employees.

# CHAPTER 6: IMPROVEMENTS TO RECORDKEEPING AND INJURY REPORTING AT ALDOT

A comprehensive injury reporting system is essential for organizations aiming to improve workplace safety and reduce injuries. Retaining accurate and detailed documentation of work-related injuries is a vital component of any organization's safety program as it aids in preventing future work-related injuries by identifying patterns and prevalent risks to guide the implementation of successful safety and health initiatives. By identifying workplace health and safety issues early enables organizations to develop and execute preventive measures before various hazards increase in severity and frequency of accidents and injuries.

Injured workers benefit from workers' compensation programs, which assist in obtaining prompt medical care, avoiding prolonged disabilities, and minimizing financial setbacks through wage replacement during lost workdays. Therefore, prompt and thorough reporting that captures accurate information has significant benefits for both employers and workers (Kyung et al., 2023).

## 6.1 Addressing Common Gaps In ALDOT Injury Records

The current ALDOT reporting system has limitations that impact accurate analysis and risk assessment. These limitations restrict the ability to conduct comprehensive evaluations of injury causes and costs, impede the implementation of focused preventive actions, and limit the capacity to compare and assess corrective measures.

Information identifying the causal chain of events that resulted in the injury was insufficient in ALDOT's worker injury dataset. The dataset had two fields for describing the sequence of events, with minimal descriptions due to character limitations in the Excel cells or missing information. This creates challenges in defining appropriate preventive measures, as the focus of the analysis is to understand injury causes and prevent similar incidents from occurring.

The coding of falls is another missing element of ALDOT injury reporting system. While "Fall/Slip/Trip" is recorded under Injury Source, further coding such as fall to a lower level, same level, or downstairs, as well as the height of the fall, is not reported. Additional important information associated with fall injuries was missing, such as falling from a ladder, scaffold, collapsing structure, along with contributing elements including wind, fluids, ice, etc.

The number of hours worked by employees needed to calculate an injury rate is also not available, which prevents assessing ALDOT safety performance against other DOTs or industry standards. Injury rates are also used to evaluate the effectiveness of implemented safety measures by comparing before and after rates.

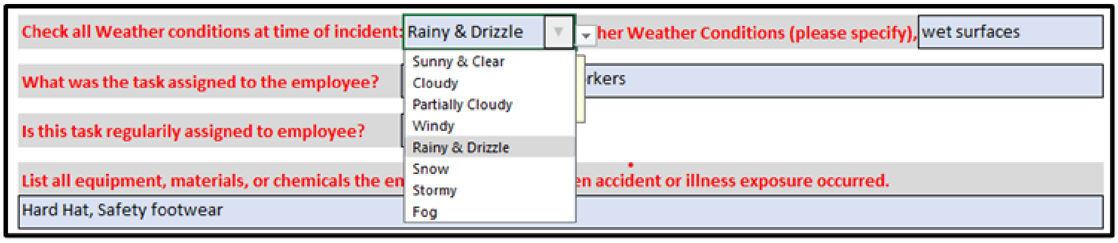
Further details associated with injuries that need to be analyzed for effective prevention plans are insufficient, including the activity performed when injury occurred, machines, tools, or materials used in the process.

To improve data collection and the quality of ALDOT's injury dataset, this chapter aims to introduce revised First Report of Injury (FROI) forms that gather detailed information about injuries, encourage near misses reporting and incident investigations to identify root causes, and recommend the incorporation of findings from incident reports and investigations into the JHA.

## 6.2 Enhancing Injury Reporting System At ALDOT

Upon evaluating ALDOT's current First Report of Injury (FROI) forms, as well as gaining an understanding of the Human Capital Management (HCM) system used to create and maintain records of worker injuries, revised FROI forms were prepared using an excel workbook with 3 sheets (Employer FROI, Employee FROI, and Injury Dataset).

The revised FROI forms for both employees and employers are designed to address the gaps in ALDOT's worker injury dataset and can be found in APPENDIX C. The sections containing red font indicate new integrated data and are intended to be detailed and easy to complete, ensuring that both direct injury characteristics and the broader contributing factors (i.e., weather conditions, equipment used, unsafe behavior, human factor(s) involved, and workplace conditions) are accurately documented. The FROI forms include drop-down lists that streamline data entry and make it easier to standardize information across reports, whilst compiling data automatically in the Injury Dataset sheet. Figure 6-1 below shows examples of dropdown lists that capture contributing factors of injuries.


Check all Weather conditions at time of incident: Rainy & Drizzle

her Weather Conditions (please specify), wet surfaces

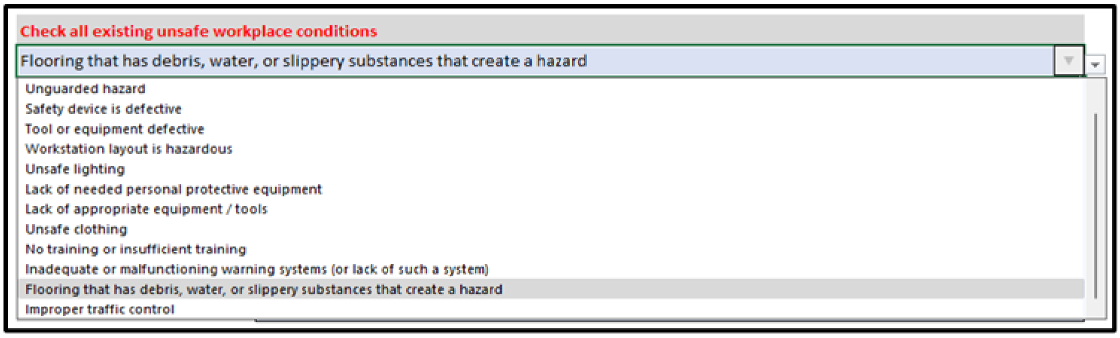
What was the task assigned to the employee? rkers

Is this task regularly assigned to employee?

List all equipment, materials, or chemicals the en … en accident or illness exposure occurred.

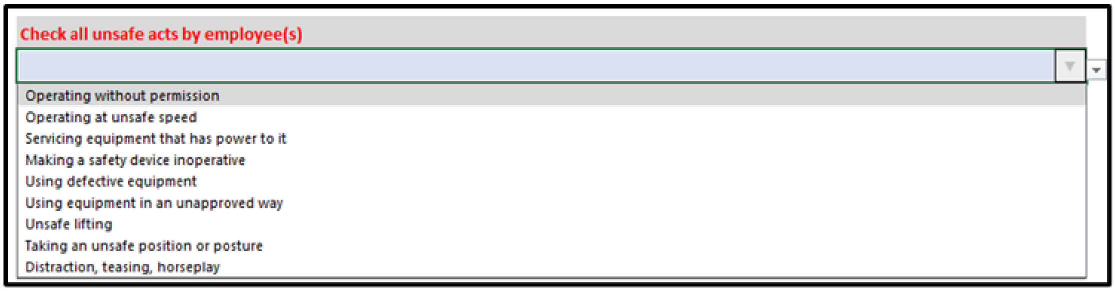
Hard Hat, Safety footwear

(a) Weather Conditions

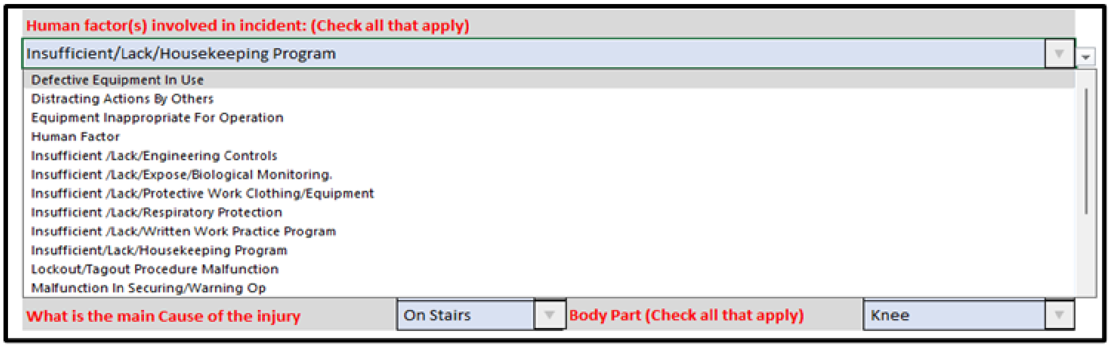

Check all existing unsafe workplace conditions

Flooring that has debris, water, or slippery substances that create a hazard

(b) Unsafe Workplace Conditions


Check all unsafe acts by employee(s)

(c) Unsafe Acts by Employee(s)

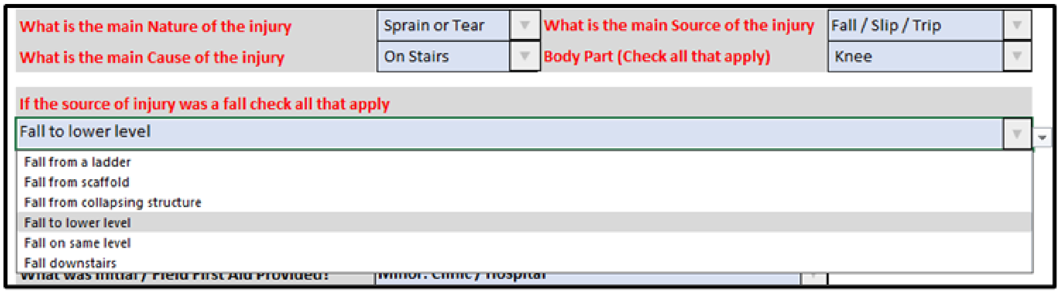

Human factor(s) involved in incident: (Check all that apply)

Insufficient/Lack/Housekeeping Program

What is the main Cause of the injury: On Stairs

Body Part (Check all that apply): Knee

(d) Human Factor(s)


What is the main Nature of the injury: Sprain or Tear

What is the main Source of the injury: Fall / Slip / Trip

What is the main Cause of the injury: On Stairs

Body Part (Check all that apply): Knee

If the source of injury was a fall check all that apply

Fall to lower level

(e) Coding of Falls

**Figure 6-1 Examples of Dropdown Lists in Revised ALDOT Employer FROI.**

Integrating FROI forms with a centralized injury dataset that compiles reports automatically enables ALDOT to track trends to pinpoint emerging hazards early. By extracting detailed and accurate data from ALDOT's system for injuries and near-misses recordkeeping, ALDOT can gain a broader understanding of workplace risks and can implement control measures before minor issues turn into serious injuries.

A recommendation to further streamline the reporting process and enhance accessibility is to use a digital injury reporting system that would let TMTs and supervisors log incidents right as they happen, ensuring details are captured accurately. A computer-based system that allows using mobile devices can be used such as the Workplace Incident Reporting Platform (WIRP), which was designed to replace old-fashioned paper-based FROIs with protected digital record-keeping platform that features many benefits including automated processing of injury reports and witness statements that are integrated with workers' compensation claims, and real time injury analysis (Alawi & Alawi, 2024).

## 6.3 Near Miss Reporting And Incident Investigation

Main components of a successful Safety Program include, accurate identification of accidents, illnesses, and injuries, documentation of all occurrences, performing thorough root cause analyses, and implementing preventive measures to avoid future incidents across the organization (INDOT, 2018). Therefore, all occurrences (i.e., crash, injury, incident, or near miss) should be documented and investigated to identify root causes, whether an injury resulted or not.

Most state DOTs do not grant open access to their incident/near miss programs or policies, making it challenging to uncover common strategies and policies. This hinders the ability to identify shared practices. However, larger states and those at the forefront of occupational safety have established and shared information about their incident/near miss reporting programs.

Some state DOTs such as NYDOT, TxDOT, PennDOT, InDOT, TDOT, and FDOT, incorporate a description of "near miss" in written policies and procedures. One obstacle to reporting stems from a lack of universal understanding and agreement on different terms. Consequently, DOTs offer standard descriptions for employee reference, with only slight variations between states.

An occurrence can be a crash, injury, incident, or near miss. Indiana DOT safety manual amongst others, establishes that the direct supervisor must perform an analysis to pinpoint main and contributing causes when investigating a safety occurrence (INDOT, 2018). Explanations of related terms include:

- Injury: requiring professional medical treatment.
- Serious Injury: leading to hospitalization.
- Incident: basic first aid is given at job site, no professional medical treatment required, or when a vehicle/heavy equipment contacts another state-owned object without resulting in monetary damage.

- Near Miss: an event that almost causes injury or contact with a vehicle, heavy equipment, or person.
- Unsafe Act: any behavior that differs from conceded safe practices or specified job procedures resulting in a crash, injury, incident, or near miss. It represents unsatisfactory conduct that significantly contributes to the occurrence. Unsafe acts can include taking shortcuts, using faulty equipment, and lack of attention.

State DOTs that incorporate incident or near miss reporting system require that all crashes, injuries, incidents, and near misses must be recorded. Certain state DOTs, like New York (NYDOT, 2018) and Texas (TxDOT, 2023), mandate that employees report incidents immediately to their supervisor, facilitating internal handling within a department. While this approach expedites addressing unsafe conditions, its verbal nature may result in numerous near misses going unreported, hindering data collection and trend identification within organizations.

On the other hand, some state DOTs, such as Pennsylvania (PennDOT, 2017) and Indiana (INDOT, 2018), depend on paper forms for incident reporting. Paper forms offer benefits like documentation, and ease of processing. However, the risk of forms getting lost and the perception of additional paperwork as time-consuming may deter employees from reporting near-miss events effectively.

In contrast, states like Florida (FDOT, 2022) and Tennessee (TDOT, 2024) have transitioned to online incident reporting tools, with some agencies developing mobile apps for reporting. These digital tools enable tracking, data collection, storage, and analysis of near misses in real time. While online reporting saves time and resources, it may pose a challenge for older or less tech-savvy employees.

Meanwhile all state DOTs with incident/near miss reporting system task supervisors with investigating each incident, identifying root causes, and making recommendations to prevent future occurrences.

The revised FROIs shown in APPENDIX C, are prepared to foster and aid in collecting needed information for incident investigations. However, adopting separate detailed forms dedicated to incident/near miss investigations is recommended.

PennDOT Investigation Guide for Accidents and Near Misses (PennDOT, n.d) states that when documenting the witness statements the following topics and questions should be addressed:

1. Set the scene for the accident or near miss:
    - What location were you in (e.g., work zone, warehouse, garage, office)?
    - How were you positioned in relation to surrounding objects or people?
    - Record the date and time.
    - Describe what was occurring around you at that moment. What activity were you engaged in?

- What specific task were you performing at that time?
- Who else was nearby? Where were they located, and what were they doing?
- Outline any environmental factors (lighting, dry or wet surfaces, weather conditions, noise levels, traffic, odors, temperature, etc.)

2. Events leading to the incident:
    - What was happening right before the accident took place?
    - Was everything still consistent with your previous responses
    - What were you doing, and where were you positioned?
    - What were others doing, and where were they located?
    - Did you notice anything unusual or out of the ordinary?
    - What was the first sign that something was amiss?
    - Describe the incident in detail: (What occurred next? What did you observe visually? What sounds did you hear? How did you respond? How did others respond? When did the incident conclude? How did the situation come to an end?)

3. Describe the outcome:
    - Was there any injury?
    - Who was injured?
    - Describe the nature of the injury.
    - What caused the injury?
    - Was any vehicle or equipment damaged?
    - What was damaged, and whose property was it?
    - Describe how it was damaged.
    - What specific part was affected?
    - What did the damage look like?
    - What caused the damage?
    - For near misses, what injury or damage was nearly sustained?

4. Debrief:
    - What aspects were as they should be?
    - What aspects were not as they should be?
    - What actions could be taken to prevent this from reoccurring?
    - What was the worst possible outcome?
    - What factors helped prevent a more severe outcome?

Different incident investigation forms used by other state DOTs can be adopted by ALDOT. An example of Mississippi DOT incident investigation form is provided in APPENDIX D.

### 6.4 Incorporating Incident Reports and Investigations Into JHA

Performing incident investigations is meaningless unless potential hazards and risk factors causing unforeseen injuries are documented, and the specific tasks associated with these risk factors are identified. This way preventative actions can be implemented before injuries occur.

Ongoing insights gained from incident reports and investigations should be constantly incorporated into the Job Hazard Analysis (JHA) forms to ensure that they reflect changes in work methods, equipment, or regulations, as well as evaluating the effectiveness of applied control measures based on different safety criteria, such as improved reporting of incidents and near-misses, comparison of injury rates, costs of medical treatment, equipment and tool damage, and number of days lost due to injuries (Martin & Walters, 2001).

This approach goes hand in hand with Step 5 of the JHA process (Monitoring and Control), which is key for maintaining an ongoing, sustainable JHA program, and updated forms. An illustration of the process is shown Figure 6-1 below. The process involves input including documented information collected from injury and incident reports followed by incident investigation. This information is then processed and analyzed for frequencies and interrelationships between different factors contributing to the risk or injury including tools and equipment used, as well as the relationship between these factors and the task performed. The risks should then be assessed and prioritized based on severity and likelihood as explained in Chapter 5. Control measures are examined with all crew members to be documented in the JHA forms for implementation as an output of the process. The deliverables include lower injury rates and number, lower workers' compensation costs, increased employee awareness, and establishing a culture of safety with ALDOT.

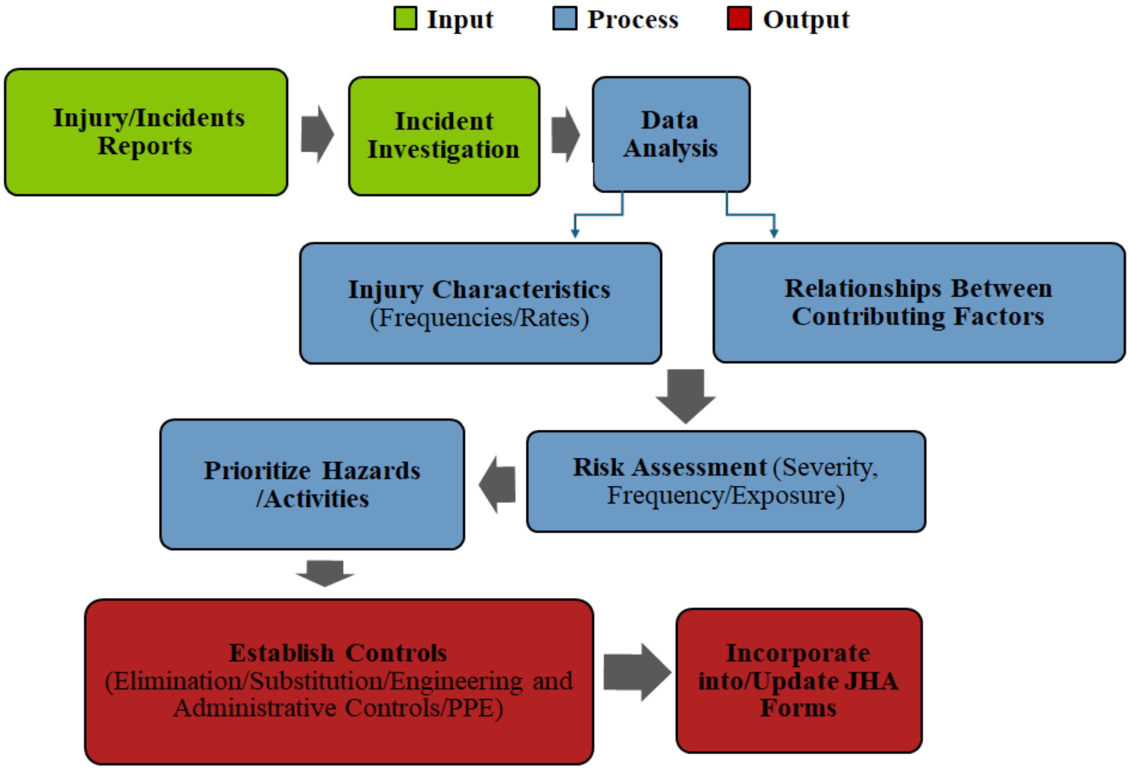


**Figure 6-2 Process Flow of Integrating Incidents Reports and Investigations into the JHA.**

## 6.5 Conclusions

This section highlights the critical role of a comprehensive injury/incident reporting and documentation system in enhancing workplace safety. Accurate, detailed documentation yields a comprehensive dataset containing all required information to identify injury trends, contributing factors, and the interrelationships between these factors. This data is essential for implementing evidence-based safety measures to prevent or reduce injuries.

ALDOT's current system for injury reporting injuries contains gaps that hinder the ability to conduct thorough analysis and assessments. To address the gaps in the data collection, revised First Report of Injury (FROI) forms were introduced using an excel workbook with 3 sheets (Employer FROI, Employee FROI, and Injury Dataset). These forms are intended to be detailed and easy to complete, ensuring that both immediate injury details and underlying factors (such as weather conditions, equipment used, and workplace conditions) are accurately documented. The FROI forms include drop-down lists that streamline data entry and make it easier to standardize information across reports. This helps better understand workplace risks and identify insights for improved safety measures.

Incidents or near-misses that do not result in injury should be viewed as opportunities to investigate root causes that led to the incident and share lessons learned to prevent future injuries. Detailed incident investigation forms yield informed findings that should be integrated into the JHA process ensuring ongoing improvement of ALDOT’s safety protocols. Integration of incident reports into the JHA process is a strategic move towards a safer workplace, with risk assessments based on real life scenarios that allows for evidence-based prioritization of control measures.

Finally, to ensure the success of the JHA process, an environment of open communication should be encouraged, whereas thorough training for workers and supervisors to grasp the importance of accurate reporting and heightened employee awareness must be offered regularly. This eventually will result in lowered injury rates, reduced compensation costs, better worker satisfaction, and fostering a safety culture within ALDOT.

# CHAPTER 7: PROPOSED ALDOT MANUAL OUTLINE FOR TMT SAFETY

A focused Alabama Department of transportation (ALDOT) Safety Manual designed for Transportation Maintenance Technicians (TMTs) provides consistent agency wide regulations to document and communicate comprehensive and clear safety measures addressing common work operations. Currently, ALDOT does not have a dedicated worker safety manual, which highlights the need for such a resource. TMTs encounter unique safety hazards that emphasize the need to equip them with specific safety protocols tailored to their tasks promoting the safe execution of their daily tasks. The Safety Manual should be provided for all existing and new TMTs, which serves as a set of guidelines for safe standardized practices.

The ALDOT Safety Manual will be a key tool for TMTs to help maintain and foster a safety focused work environment. The primary goal of a Safety Manual is to establish guidance and safety standards/requirements/policies that can be consistently applied across ALDOT with the intent of minimizing the severity and frequency of injuries sustained by ALDOT TMTs. A recommended outline of the main topics to be covered is presented in this section.

## 7.1 Literature Review

Departments of Transportation (DOTs) play a significant role in establishing safety standards and protocols to protect their employees and the public. Many state DOTs have developed detailed Safety Manuals to provide their employees with guidance regarding safety requirements. This literature review explores the content of state DOTs Safety Manuals and safe work practices.

Table 7-1 below shows selected state DOTs, links to their Safety Manuals, and a summary of the main topics covered. Common safety topics include Hazardous Materials Handling, Personal Protective Equipment (PPE), Equipment and Operational Safety, Traffic Control and Flagger Training, First Aid and Emergency Response, Incident Reporting and Investigation, Safety Training and Standards, Hazard Communication, Job Safety Analysis (JSA), Fall Protection, and Confined Space Entry.

## Table 7-1 State DOTs Safety Manual Topics

| State | Topic | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PPE | Hazardous Materials | Incident Reporting | (JHA) and Training | TTC | Confined Space Entry | Accident Prevention | Record keeping | Ergonomics | Manual Lifting | Safety Meetings | Vehicle Operations |
| Alaska (DOT & PF) | ☑ | ☑ | ☑ | ☑ | | ☑ | | ☑ | | | | ☑ |
| Arkansas (ARDOT) | ☑ | | | | ☑ | | | | | | | |
| California (Caltrans) | ☑ | ☑ | ☑ | ☑ | ☑ | | | ☑ | | | | ☑ |
| Colorado (CDOT) | | | ☑ | ☑ | ☑ | | | ☑ | | | | |
| Indiana (INDOT) | ☑ | | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | | | ☑ |
| Kentucky (KYTC) | | | ☑ | ☑ | ☑ | | ☑ | ☑ | | | | |
| Mississippi (MDOT) | | | | ☑ | | | | | ☑ | | ☑ | |
| New York (NYSDOT) | ☑ | ☑ | ☑ | | ☑ | | | ☑ | | | | ☑ |
| North Carolina (NCDOT) | ☑ | ☑ | ☑ | | | ☑ | | ☑ | | | | |
| Pennsylvania (PennDOT) | ☑ | | ☑ | | ☑ | | | | | ☑ | ☑ | |
| Tennessee (TDOT) | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ |
| Texas (TxDOT) | | ☑ | ☑ | ☑ | ☑ | | ☑ | | | ☑ | | |
| Washington (WSDOT) | ☑ | | ☑ | | | ☑ | ☑ | ☑ | ☑ | | | ☑ |

The literature review reveals a strong emphasis on training and education, equipment and operational safety, PPE, hazardous materials and hazard communication across many of the state DOTs Safety Manuals. While topics such as incident reporting and investigation, fall prevention, and sprain and strain prevention programs are present in more comprehensive and detailed state DOT safety manuals.

Differences in topics can be found where specific local hazards are present. For instance, Alaska addresses mining hazards, while California focuses on heat illness due to its climate. Variations exist in how safety programs are structured and enforced, while some states include additional topics such as daily pre-operational checklist (TDOT), near-miss reporting and investigation (NYDOT), worker suggestion program (PennDOT), and New-Hire Mentorship (MDOT).

Recurring topics across states highlight the critical nature of these safety areas. While states may tailor programs to address local needs, fundamental safety principles remain consistent. Recognizing these shared principles allows ALDOT to benchmark its program against standards, ensuring key areas are addressed and regulations are met while maintaining continuous improvement and adaptation to emerging risks to reduce accidents and foster a culture of safety.

Based on the literature review of state DOTs Safety Manuals and safety performance guidelines, an ALDOT Safety Manual tailored towards TMTs is recommended to fulfill ALDOT's short and long-term goals pertaining to worker safety.

Short term goals of the proposed safety manual include, but are not limited to:

1. Establish safety standards and demonstrate dedication to health and safety in the workplace;
2. Establish ongoing safety training;
3. Conduct and document regular safety meetings;
4. Establish a consistent commitment to resource allocation;
5. Prioritize hazard mitigation;
6. Prompt and consistent reporting of incidents and injuries;
7. Initiate and monitor corrective actions;
8. Revise safe operation guidelines; and
9. Enhance workers' safety perception and awareness. (NCDOT, 2023)

Long-term goals of the proposed safety manual include but are not limited to:

1. Decrease direct and indirect injury rate and cost (i.e., frequency, worker compensation cost, no. of lost days);
2. Procure and adapt equipment to improve safety measures;
3. Implement a comprehensive incentive and reward system;
4. Cultivate a culture of safety awareness.

The sequence of steps involved in implementing the proposed safety manual are illustrated in Figure 7-1 below.

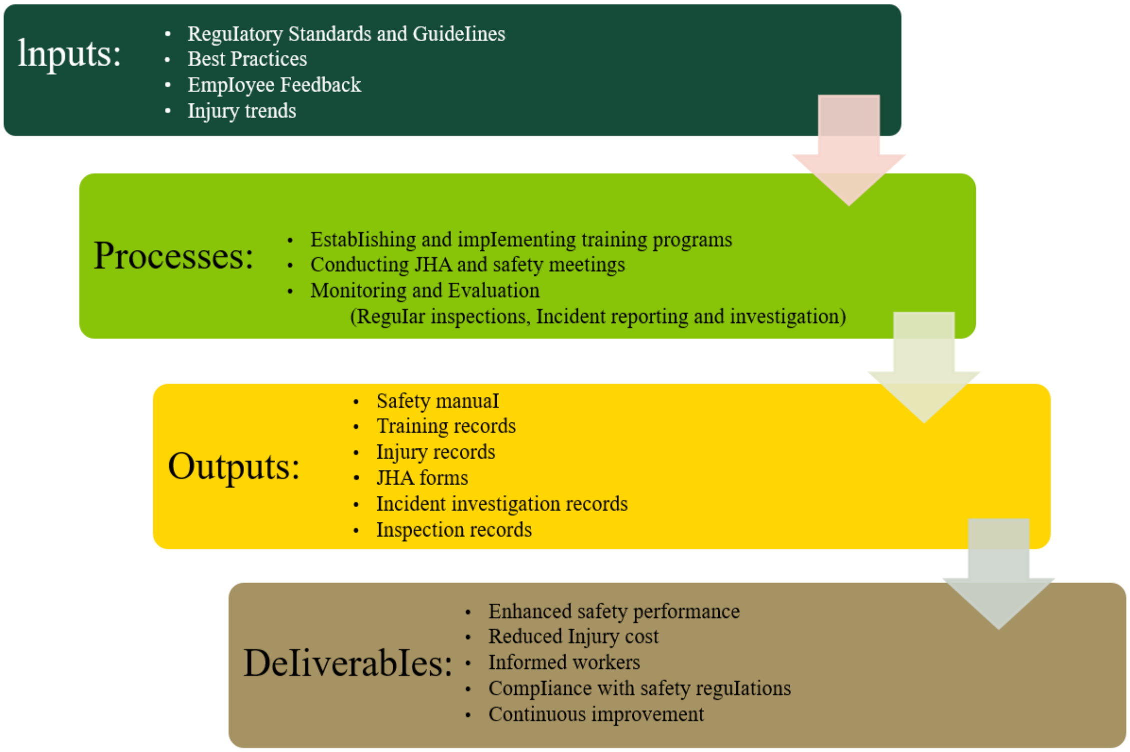


**Figure 7-1 Sequence flow of Safety Manual Implementation.**

The recommended outline of the Safety Manual can be organized into the following sections:

- Program General Information (Policy, Purpose, Responsibilities);
- Training and Education;
- TTC and Flagging Program;
- Manual Lifting/ Sprains and Strains;
- Slips, Trips, and Falls;
- Job Hazard Analysis (JHA);
- Personal Protective Equipment (PPE);
- Incident Reporting and Investigation;
- Safety Inspections and Checklists;

The following subheadings of this chapter provide a brief description of the outline.

## 7.2 Program General Information

Stating the policy, purpose, and intent of a Safety Manual as well as the organizational responsibilities related to safety within ALDOT establishes guidelines for implementing safety measures. It details the roles and responsibilities of various levels of management, supervisors, and employees so that each party is aware of their role in ensuring compliance with ALDOT safety policies and procedures.

The policy should state ALDOT's commitment to ensure that all employees work in safe and healthy environments, achieve compliance with safety guidelines, and receive proper allocation of necessary resources. Employees are entitled to their rights under the Occupational Safety and Health Act without fear of reprisal. These rights include the ability to report unsafe conditions, receive updates on complaint resolutions, and knowledge of safety standards violations (OSHA, 2023). Furthermore, employees have the right to actively participate in safety programs and be represented during safety inspections.

Supervisors' responsibilities include planning and ensuring safe operations. They are required to educate all employees on safe practices and procedures and promptly take corrective measures to prevent the recurrence of unsafe acts or conditions. Supervisors must take immediate action upon witnessing or being informed of any unsafe acts or conditions.

Employee responsibilities include following all departmental rules and regulations. They must adhere to safety and health-related laws, and any unsafe acts or conditions they observe should be promptly reported to their supervisor.

## 7.3 Training and Education

The purpose of the training and education section is to ensure that all TMTs are trained in the identification of the risks involved in their specific job assignments and ensure that they know how to perform their tasks safely. All the necessary safety training programs and minimum training requirements for TMTs, which include both initial and refresher training courses, should be established. It will also determine schedules and procedures for safety orientation for new hires and refresher courses for existing employees, documentation of training, and resources for workers seeking additional information about training requirements. New hires, promoted or transferred workers must be trained in safety practices required for their assignments. It is highly recommended that all workers participate in weekly toolbox safety training/meetings that cover specific safety topics related to their current activities.

A report prepared for Kentucky Transportation Center (KYTC) lists recommended safety training resources for construction and maintenance personnel (G. Dadi et al., 2022). Training topics associated with common TMT tasks and suggested sources are found in Table 7-2 below. All listed sources can be accessed electronically.

**Table 7-2 Training Sources for Selected Topics (G. Dadi et al., 2022)**

| Title | Source |
|---|---|
| Equipment/Jobsite Hazards Awareness | Click Safety: Working Around Mobile Equipment Awareness For Construction<br>Click Safety: Electrical Hazard Recognition & Control For Construction<br>OSHAcademy: Heavy Equipment Safety |
| | OSHA Heavy Equipment Safety Awareness |
| | T2 Work Zone Courses |
| | ARTBA PPE Training |

| | |
|---|---|
| | ARTBA Preventing Runovers and Backovers |
| | ARTBA Scaffolds, Steps & Ladders |
| | TC3 Job Hazard Analysis |
| | TC3 Construction Safety: Recognition and Avoidance of Unsafe Conditions |
| Hand/Portable Power Tools | Click Safety Hand and Power Tools for Construction |
| | OSHAcademy Hand and Power Tool Safety |
| | OSHA Education Center Hand and Power Tools Online Course |
| | SafetySkills Hand and Power Tool Safety |
| | HSI Hand and Power Tools |
| | HSI Hand and Portable Power Tools |
| | HSI Hand and Power Tool Safety Overview |
| Machine/Machine Guarding | National Safety Council Machine Guarding Training |
| | Machine Safety Specialists Machine Guarding Training |
| | National Safety Education Center Machine Guarding Course |
| | USFOSHA Machine Guarding Compliance Training |
| | OSHAcademy Introduction to Machine Guarding |
| | eSafety Machine Guarding |
| | HSI Machine Guarding |
| | University of Washington Environmental Health & Safety Machine Guarding |
| | HSI Machine Guarding |
| General Energy Control - LO/TO | Click Safety Working Safely with Electricity for Construction |
| | Click Safety Electrical Safety Awareness for Construction |
| | Click Safety and LOTO for General Industry |
| | Click Safety Electrical Hazard Recognition & Control for Construction |
| | Virginia Tech Environmental Health and Safety Lockout/Tagout Awareness |
| | HSI Lockout/Tagout |
| | eHazard NFPA 70E Training |
| Welding, Cutting, Brazing | National Safety Council Welding, Cutting and Brazing Training |
| | OSHAcademy Welding, Cutting, and Brazing Safety |
| | USFOSHA Welding and Cutting Safety Training |
| | NASP Welding Cutting Brazing |
| | Virginia Tech Welding and Cutting Safety |
| | Welding, Cutting and Brazing |
| Defensive Driving | NSC Defensive Driving Course |
| | Defensive Driving Course |

Note: 1. Written consent by authors to include this table was granted.

Sources that received high ranking by KYTC employees in terms of content value, applicability, duration, and delivery method are MACROM-Ergonomics (although not entirely maintenance/construction oriented, but can be applied to related tasks), MARCOM-Electrical Safety, MARCOM-Hand and Power Tool Safety, MARCOM-Machine Guard Safety, and MARCOM-Respiratory Protection and Safety (G. Dadi et al., 2022).

The American Association of State Highway and Transportation Officials (AASHTO) Transportation Curriculum Coordination Council (TC3) is a technical service initiative aimed at creating training materials for technical personnel in construction, maintenance, and materials. TC3 has a state sharing program created to provide employees of participating states free access to course material that can be integrated in their DOT's internal system (AASHTO, n.d.). Participating states include but are not limited to (Arizona, Florida, Louisiana, Michigan, Missouri, Ohio, Tennessee, West Virginia). Recommended TC3 courses base on ALDOT TMT needs and other state DOTs' recommendations include:

- Flagger Training - WEB-BASED: This is a fundamental course in the field of flagger training for entry level. It can also serve as a refresher for all employees. This training does not address the training or certification prerequisites in individual states.
- Guardrail Maintenance and Repair: This course offers guidance on the proper methods for maintaining and repairing guardrails. The intended audience for this course includes TMTs and workers engaged in the installation, inspection, and maintenance of guardrails.
- Inspection Safety for Bridges: Three topics are addressed in this course; safety accountability, PPE, and possible hazards in bridge inspection. This training is for entry-level workers conducting bridge inspections at entry-level, but also serves as a valuable refresher for all levels.
- Job Hazard Analysis: Explains what a JHA entails and the reasons for conducting it. This course specifically outlines the information that needs to be recorded during a JHA and presents example tasks along with possible hazards that could be faced. This training is intended for all supervisors and workers involved in highway maintenance activities.
- Maintenance of Traffic for Technicians: This training offers details regarding the positioning of TTC necessary for highway maintenance, in addition to creating traffic control plans for work zones and flagger operations. This training is intended for TMTs and inspectors.
- Recognizing Roadside Weeds (Southeastern States): Establishing a suitable weed management plan requires recognizing the weed species. This training specifically targets southeastern states and intended for beginners in vegetation management.
- TTC and Safety in Short-term Work Zones: This course addresses factors of short duration work zones, including hazards and best practices associated with TTC and the safety of workers and road users. The target audience are mainly TMTs
- Working Safely in Work Zones: The training identifies safety hazards in highway work zones, and the primary categories of injuries that take place. It also discusses types and classes of safety apparel. TMTs are the main target audience for this training.

It is recommended that ALDOT participates in the state sharing program offered by the Transportation Curriculum Coordination Council and includes the abovementioned courses in minimum training requirements for TMTSs.

## 7.4 Temporary Traffic Control Flagging Program

The purpose of the Temporary Traffic Control (TTC) Flagging Program is to lay down procedure and regulations for ALDOT TMTs in order to be licensed as TTC Flaggers and to establish the required qualifications and responsibilities. Supervisor's responsibilities and general precautions must be clearly established and communicated. Supervisor's responsibilities include managing the components of the TTC flagging program; determining necessary personnel, training, and equipment requirements, offer assistance, guidance, and support through consultations. General precautions can include standards for temporary traffic control devices and relevant requirements regarding size, shape, color, intended use, and reflectivity of TTC devices (KTC, 2018).

All temporary traffic control procedures must adhere to the Manual on Uniform Traffic Control Devices (MUTCD); however, guidelines should be tailored to the specific needs of ALDOT's maintenance operations. ALDOT Division 700 supplemental guidance; "Procedure for Traffic Control through Construction Work Zones" offers guidance for TTC procedures for construction and maintenance activities, including training, improvement program, implementation, TTC quality guide, and work zone safety (ALDOT, 2024b). ALDOT also issued a memorandum for on-line TTC training course that is recommended for all ALDOT TMTs (ALDOT, 2024a).

The MUTCD Part 6:Temporary Traffic Control, offer guidelines for proper and safe work practices that can be practiced by TMTs including detailed descriptions of procedures necessary for the safe maneuvering of road users around work zones, while protecting workers and equipment. It contains guidelines for implementing effective temporary traffic control plans and the proper use of barriers, cones, and signs to mitigate risks associated with workers and the public. It also highlights the need for worker training to ensure compliance with all standards and regulations.

The length of time and location of operations that require TTC and flagging are important factors in determining the quantity and kinds of TTC devices. Maintenance operations are usually divided into three different categories; (1) Short-term stationary work, (2) Short-duration work, and (3) Mobile work (ATSSA, 2010). The Manual should determine the requirements for each category.

Short-term stationary work involves staying at one location for more than one hour during a single work shift. Cones and portable signs are available as choices for traffic control devices in these areas. Short-duration tasks take place in a spot for a maximum of one hour. Portable traffic control devices can be utilized as well as signs or arrow panels can help direct vehicles. Shadow vehicles could also be utilized to ensure the safety of workers. Mobile work can either move sporadically or constantly. The devices and vehicles used for mobile work can also be utilized for brief operations. No matter the category of the operation is, it is important to note that *"Safety in short-duration or mobile operations should not be compromised by using fewer devices simply because the operations will frequently change its location."*(MUTCD, 2009). Specific training for short duration maintenance work is provided in the TC3 training course Temporary Traffic Control and Safety in Short-term Work Zone.

## 7.5 Manual Lifting / Sprains and Strains

Sprains and strain mainly affecting the back have contributed to 314 days away from work annually for ALDOT TMTs alone. Sprain and strain or ergonomics injuries have consistently been at the top of ALDOT's burdens over the year as the physical demands faced by their workers are unavoidable. Therefore, the need for an ergonomic program is essential to reduce the severity as well as the likelihood of these injuries by raising awareness amongst ALDOT's employees. Education and training are essential for workers to effectively recognize sprain and strain risk factors in their work environment and to apply appropriate control measures.

Topics should cover repetitive motion, working in awkward positions, manual lifting, material handling and movement (i.e., carrying, holding, pulling, and pushing, body vibration, and working in confined areas) (Wang et al., 2017). Recommended training sources for ALDOT TMTs include: NIOSH Simple Solutions-Ergonomics for Construction Workers, CPWR-Roadway Safety Awareness (includes an overview of a different roadway hazards, such as electrical, falls, slips and trips and ergonomics), CPWR-Preventing MSDs in Construction Workers, CPWR- Ergonomics Awareness Training, and NIOSH-Manual Material Handling.

This training program can be delivered individually or in groups, utilizing a combination of oral presentations, videos and online content, handouts, and hands-on demonstrations with equipment and work practices.

Common causes of strains and strains that can be recognized by employees should be clearly communicated, as well as symptoms including numbness, burning, and swelling. The section should also identify minimum training requirements and managers' responsibilities in implementing administrative and engineering controls such as tools and equipment required to minimize the risk and rotating assignments.

## 7.6 Slips, Trips, and Falls

Slips, Trips, and Falls are one of the most common sources of injuries suffered by ALDOT TMTs accounting for 19% of all Source Descriptions. TMTs often work in environments with uneven surfaces, wet or slippery conditions, and obstacles, that pose a risk of these injuries. Falls from heights are the main cause of severe injuries, especially when performing activities that require aerial devices with attached man buckets such as bridge repair, sign installation and repair, and facility inspections. Therefore, policies, applicable standards, training, and prevention methods to reduce slip, trip, and fall Injuries should be highlighted in the Safety Manual.

Personal fall protection programs should emphasize different fall arrest systems, requirements, inspection procedures and checklists as well as ensuring thorough training. Tennessee DOT (TDOT) provides a checklist designed to assess the safety conditions of Personal Fall Protection systems including checks for cleanliness, absence of damage, proper alignment, positioning, and integrity of the system (TDOT, 2023). North Carolina DOT (NCDOT, ) provides a written policy for elevated working and walking surfaces including ladders and scaffolds. The policy includes training requirements, possible hazards, inspection, maintenance, as well as responsibilities for supervisors and employees.

While slips, trips and falls on the same level result in less severe injuries, they occur instantly and without warning, therefore having guidelines to raise awareness of possible hazards, control measure, and steps to be taken after a related injury occurs, can significantly reduce the likelihood and/or severity of such injuries. Guidelines outlined in Pennsylvania Employee Safety & Health Manual, PUB 445M (5-23), Protocol 12 include: field housekeeping practices, maintaining three points of contact, appropriate footwear, situational awareness, falling techniques, and safety practices such as placing drums or cones on temporary elevation changes to draw attention to the hazard, using suitable methods of lighting (flashlight, light towers, etc.) when necessary, and taking small steps when walking on slippery surfaces while pointing the toes a tad to the side (PennDOT, 2017). Other DOTs (NYDOT, WSDOT, UDOT, etc.) include guidelines to control ground level slips, trips, and falls within their housekeeping policy which involve warning signs, signals, barricades, and storage areas.

### 7.7 Job Hazard Analysis (JHA)

Offering reference forms of TMT-related activities serves as a great tool for new workers and supervisors training, as well as for infrequent job assignments. These forms will include descriptions of each activity, hazards associated, and control measures to be reviewed by TMTs prior to performing scheduled tasks.

Tennessee DOT (TDOT) Safety Manual includes links to relevant programs and guidelines related to employee safety in each activity form based on the hazards associated with activity. An Example of links included in TDOT activity JHA forms is shown in Figure 7-2.

SUMMARY OF HIGHWAY MAINTENANCE ROADWAY REPAIR

The Highway Maintenance Division consists of various maintenance activities on Tennessee State roadways. Roadway repair activities can include pothole patching, crack sealing, pavement resurfacing or overlay, road milling, roadway construction, shoulder repair, culvert repair, guardrail and barrier repair, and roadway marking. Roadway repair activities are an ongoing process throughout the state to ensure the longevity and functionality of the State's transportation infrastructure. The maintenance of State routes is integral to the safe transportation and commerce throughout the state and nation.

TOP 5 HAZARDS

1. Contact with Vehicles / Traffic
2. Contact/Crush by Construction Equipment
3. Ergonomic / Soft Tissue Injury
4. Lacerations
5. Weather Exposure and contact with biting insects, animals and poisonous plants

OHS SHAREPOINT

STANDARD PPE FOR GENERAL HIGHWAY MAINTENANCE ROADWAY REPAIR

APPLICABLE TDOT OHS PROGRAMS

- OHS-001 Vehicle and Mobile Equipment Securement LOTO Program
- OHS-002 Hazard Communication Program
- OHS-003 Facility Lockout Tagout Program
- OHS-006 Personal Fall Protection Systems
- OHS-007 Powered Industrial Truck Operation Program
- OHS-008 Walking Working Surfaces
- OHS-009 Injury and Property Damage Reporting
- OHS-010 Hot Work Program
- OHS-012 Confined Space Entry Program
- 305-01 PPE Policy
- 305-02 Bloodborne Pathogens Program
- 305-03 Motor Vehicle Utilization
- Auto Accident Reporting Information
- TDOT PIT Daily Pre-Op Checklist
- Guidance for Voluntary Respirator Use- General
- Emergency Action Plans (EAPs)
- Memorandum - Lane Crossing
- 4-Us Checklists
- TTC Inside Shoulder
- Winter Equipment
- Tailgate Procedures
- TMA Operator Reference Guide
- Truck and Trailer Mounted Attenuator Manual
- Chainsaw Checklists

RELATED PROGRAMS AND REFERENCES

- TDOT Work Zone Field Manual
- Winter Equipment Operations SOG
- TDOT Fleet Vehicle Conspicuity
- Standard Specs for Road and Bridge Construction

Clickable Links

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Figure 7-2 Clickable Links in TDOT JHA Forms (TDOT, 2023).

The usefulness of TDOT manual lies in its flexibility, allowing workers to either access it online or print specific information related to their chosen work activity or topic (TDOT, 2023).

## 7.8 Personal Protective Equipment (PPE)

ALDOT Guidelines For Operation (GFO) 1-5 was revised in 2018 to update the GFO to ensure all high visibility safety apparel is compliant with either ANSI/ISEA 107-2010 or ANSI/ISEA 107-2015 on their tags.

Workers wearing high-visibility safety gear are required to carry a department-approved whistle that is easily accessible. This whistle is used to warn coworkers of potential hazards, such as unexpected vehicles entering the work area or dangers from construction equipment. For workers in loud environments where whistles might not be effective, personal safety horns are an option.

Additional emphasis has been placed on providing workers with properly sized apparel, available in sizes from Small to 6X Large. It also stated that it is important that the front of the safety gear is securely fastened, whether by zipper, velcro, or buttons. Apparel should be replaced if it becomes dirty or worn out, or if it has exceeded its recommended number of washes (ALDOT, 2018).

ALDOT should expand on other PPE including Eye Protection, Face Protection, Respiratory Protection, Hand Protection, Hearing Protection, Foot Protection, Fall Protection Devices, and Skin Protection. Furthermore, details about the types of PPE required for different tasks should be stated as well as providing instructions for workers on how to wear and maintain their PPE properly.

## 7.9 Incident Reporting and Investigation

Injury reporting is practiced across all state DOTs. Maintaining precise and comprehensive records of work-related injuries constitutes a crucial element of any organization’s safety program, as it allows for mitigating similar work-related injuries by recognizing trends and common hazards. The steps and requirements for reporting injuries, accidents, and near-misses should be clearly addressed. Standardized written procedure for completing the First Report of Injury (FROI) for both employee and supervisor form as discussed in Chapter 5 should be provided, where to find FROI forms or any further information regarding injury reporting. Guidelines should emphasize the need to provide a specific description of the incident, including any root causes and other factors that may have caused or contributed to the incident, possible corrective actions and opportunities for continual improvement. It should also emphasize the importance of communicating preventative actions and lessons learned.

Reporting near-misses is crucial to control hazards before injuries occur. ALDOT should encourage all workers to report near-misses, provide a clear definition of what constitutes a near-miss, how to report them, and ensure employees feel comfortable reporting near misses knowing that their input is valued without fear of assigning blame or negative repercussions.

Incident investigation is the next step that begins once the FROI is completed and submitted. In cases where this form is not mandated, such as a near miss, the supervisor or a designated ALDOT safety employee will reach out to the worker(s) directly involved, and document all information as the worker(s) details the events leading up to the incident. Incident investigations should address (1) the context of the incident (date, time, location, specific task, workers involved), (2) the event leading to the incident, (3) the description of the event, (4) consequences if any (injuries, damages to property or equipment), (5) worst possible outcomes, (6) corrective measures (PennDOT, n.d). APPENDIX D provides an example of Mississippi DOT incident investigation form that can be adopted by ALDOT.

## 7.10 Safety Inspection and Checklists

Safety inspections are normally performed on site or prior to performing the task. Checklists can be created based on the framework of the JHA to ensure preventative measures are implemented and hazards are controlled. Establishing a schedule for safety inspections to be performed regularly can significantly reduce injuries, especially if workers are involved in these inspections. It is important to note that inspections must be carried out by a competent person who has the knowledge, skills, experience and the authority to take corrective actions (OSHA, n.d.). Safety inspections can include but are not limited to; work area and traffic control, PPE, equipment and machinery, hazardous materials, fall protection, training and compliance, and emergency preparedness.

It is recommended to document workplace conditions daily in addition to maintaining the necessary temporary traffic control plans and logs. Documentation can be done using inspection forms that list items of work zone safety checklists. ALDOT daily inspection of traffic control devices forms can be found following the link below: https://www.dot.state.al.us/publications/Construction/pdf/Forms/English/C-25.pdf.

More examples of inspection checklists are provided in Colorado DOT Work Zone Best Practices Safety Manual (CDOT, 2008) as shown in Table 7-3 below.

**Table 7-3 Example of Inspection Checklist Items (CDOT, 2008)**

| Yes | NO | N/A | Checklist Item (Flagging Procedure) |
|---|---|---|---|
| | | | STOP/SLOW paddle applied as main signaling device |
| | | | Paddles are 8-sided, 18 in. minimum (24 in. for high speeds) |
| | | | Minimum 5 ft. staff length, 6 ft. preferred |
| | | | Flags are in good shape for emergencies |
| | | | Flags, are 24 in., red color, solid material |
| | | | Flagger practice per MUTCD, accurately practiced |
| | | | All flaggers are qualified |
| | | | Flaggers wear safety attire reflectorized at night—per ANSI/ISEA 107-2010 or ANSI/ISEA 107-2015 |
| | | | Flagger station remote from operations and other workers |

|  |  |  |  |
|---|---|---|---|
|  |  |  | sufficient sight-distance to flagger station |
|  |  |  | Flagger has suitable escape path |
|  |  |  | Flagger placed on shoulder or within lane closure as traffic approaches |
|  |  |  | Flagger retains eye contact until vehicle comes to stop |
|  |  |  | Regular breaks given to all flaggers |
|  |  |  | Flagger sign taken off as soon not required anymore |
|  |  |  | Other warning signs used according to MUTCD |
|  |  |  | Additional signs/devices to slow down traffic on high-speed roads prior to flagger |
|  |  |  | Flagger station lit at night (streetlights are inadequate for good illumination) |

| Yes | NO | N/A | Checklist Item (Roadway Surface Conditions) |
|---|---|---|---|
|  |  |  | Bumps or holes and rough pavement are repaired or marked quickly. |
|  |  |  | Advance warning signs are provided for uneven surfaces. |
|  |  |  | Milled or grooved pavement includes warning signs, with pavement markings restored. |
|  |  |  | Pavement debris is regularly cleaned, and dust is controlled on unpaved surfaces. |
|  |  |  | Unpaved roads are maintained through grading and compaction, with drop-offs marked. |
|  |  |  | Walkways are kept clear and smooth. |
|  |  |  | Bumps or holes and rough pavement are repaired or marked quickly. |
|  |  |  | Advance warning signs are provided for uneven surfaces. |
|  |  |  | Milled or grooved pavement includes warning signs, with pavement markings restored. |

| Yes | No | N/A | Checklist Item (Temporary Barriers/Roadside Safety) |
|---|---|---|---|
|  |  |  | Roadside hazards are removed or protected, and materials stored outside the clear zone. |
|  |  |  | Workers' vehicles are parked safely, and barriers protect roadside hazards. |
|  |  |  | Worker protection includes safety gear, high-visibility clothing, and appropriate signage. |
|  |  |  | Channelizing devices or delineators are used to mark roadside hazards if not removed or protected. |
|  |  |  | Temporary barriers such as portable concrete barriers are deployed to protect hazards where needed. |
|  |  |  | Safety fencing or barricades protect pedestrian hazards, installed according to standards. |
|  |  |  | Joint connections and pavement connections are provided where required. |
|  |  |  | Buffer space and channelizing devices are used before barriers. |
|  |  |  | Standard connections between different barrier types are maintained. |
|  |  |  | Delineators or steady-burn lights are placed on barriers near curves. |
|  |  |  | Barrier ends are treated with turndown or crash cushions to prevent vehicle impact. |
|  |  |  | Channelizing devices or delineators are used to mark roadside hazards if not removed or protected. |

| Yes | No | N/A | Checklist Item (Worker and Vehicle Protection) |
|---|---|---|---|
|  |  |  | Safe access is ensured for both workers and vehicles. |
|  |  |  | Workers wear high visibility apparel in compliance with ANSI/ISEA 107-2004. |
|  |  |  | All workers must wear hardhats. |
|  |  |  | Vests and hardhats are reflectorized for nighttime or low-visibility conditions. |
|  |  |  | Vehicles and equipment are equipped with revolving amber lights. |
|  |  |  | Reflective tape is used on vehicles and equipment. |
|  |  |  | Escort vehicles guide slow-moving equipment through active traffic areas. |
|  |  |  | Warning signs are posted at worker and vehicle/equipment entrances to ensure safety. |

| Yes | No | N/A | Checklist Item (Bridge and Road Closures) |
|---|---|---|---|
|  |  |  | Type III barricades are used to close off roadways or bridges. |

|  |  |  |  |
|---|---|---|---|
|  |  |  | Flashing warning lights are placed on barricades for visibility. |
|  |  |  | A ROAD/BRIDGE CLOSED regulatory sign is displayed above the barricade. |
|  |  |  | Advance warning signs notify drivers of closures or detours ahead. |
|  |  |  | Detour route guidance is provided as necessary. |
|  |  |  | Safety fencing is installed to secure the worksite and ensure pedestrian safety. |

### 7.11 Conclusions

ALDOT needs a clear communication strategy for communicating safety responsibilities across all organizational levels. An ALDOT TMT Safety Manual aims to improve workplace safety through detailed and practical guidance. Every employee, supervisor, and manager should have access to the Safety Manual and understand the role he/she plays in putting it into action.

Implementing guidelines from successful state DOT safety programs and tailoring them to ALDOT’s specific needs and local hazards such as extreme heat and unique roadway conditions, enhances the effectiveness and adaptability of ALDOT's guidelines.

Ease of access to training resources and further education should be offered, ensuring that training sessions are consistently evaluated through employee feedback and practical assessments to verify the employment of all safety practices. Both online and practical TTC and flagging certification programs that meet ALDOT maintenance operation requirements should be made available for all TMTs, reinforcing compliance with safety protocols.

Furthermore, the implementation of an ergonomics program and a slip, trip, and fall prevention policy, by providing hazard awareness training and guidelines, can help reduce the biggest physical toll on employees and financial burden on management.

To promote a proactive safety culture, consistent incident reporting and investigation procedures should be established by providing access to forms and encouraging prompt reporting of hazards, which enhances overall workplace safety.

Finally, a clear policy for routine safety inspections should be established, incorporating checklists derived from JHA elements. These inspections should encompass all safety areas, such as work zone setup, PPE, handling of hazardous materials, equipment and machinery, fall protection, housekeeping, and emergency preparedness.

# CHAPTER 8: CONCLUSIONS AND LIMITATIONS OF RESEARCH

The research project entitled " Development of ALDOT's Worker Safety Assessment, Risk Identification, and Control Program," aimed to prioritize high-hazard accident types and recommend future preventative actions that may lead to reduce the frequency and severity of ALDOT TMT injuries by uncovering injury trends and contributing factors.

The research offers novel insights for ALDOT by offering data driven analysis over a 16-year period to pinpoint specific safety trends and gaps as well as recommendations. The research also provides a foundation for ALDOT to implement new methodologies to address data gaps, ensuring continuous improvement in their safety culture and having meaningful implications for future safety protocols and policies.

## 8.1 Conclusions

For any safety program to be effective, it should be based on data driven decision making procedures. Therefore, it is essential to analyze ALDOT's injury records periodically. The current analysis of ALDOT's injury records shows that sprains and strains, mainly affecting the back, shoulders, and knees, are predominant contributors to TMT injuries, resulting in approximately 314 days away and $820K in total incurred compensation costs per year, for TMTs alone (National Safety Council, 2024). Introducing task-specific ergonomic interventions and stretching programs holds the potential to decrease these injuries and their severity by enhancing flexibility. Tailored stretch-and-flex routines targeting injury-prone areas, including the lower back, shoulders, and wrists, prepare muscles for lifting or bending. Such programs can significantly reduce sprain and strain injuries associated with repetitive motion and awkward posture (Choi et al., 2017).

Back injuries, accounting for approximately 75 days away and $217K per year in workers' compensation costs for TMT injuries, necessitate a strong emphasis on safe lifting practices. Training in proper lifting techniques such as bending the knees while keeping the spine neutral plays a significant role in injury prevention. Performing tasks with a partner, consistent training in handling heavy materials, and utilizing mechanical aids are essential strategies to minimize back injuries. Additionally, it is recommended to schedule regular mini-breaks (every 15-20 minutes) to stretch the back, shoulders, and hands (Griffin, 2014).

Properly designed tools with ergonomic handles reduce the risk of injuries related to hand and arm vibrations. Ergonomic handles enhance grip and decrease the physical effort required, thereby reducing the risk of injury associated with lifting and pushing/pulling activities. When operating vibrating tools, TMTs should be encouraged to take frequent breaks and wear anti-vibration gloves to minimize strain and vibration exposure, preventing related injuries. Good fitting anti-slip footwear with adequate ankle support and cushioning for shock absorption, should be supplied to all TMTs to reduce the strain on the foot, muscles, and joints and provide adequate grip on slippery or uneven surfaces.

The general recommendations to reduce sprains and strain involve (1) engineering enhancements such as reorganizing, altering, redesigning, supplying, or changing tools, equipment, workplaces, procedures, or materials, in addition to (2) managerial improvements that include reviewing how various workers accomplish the same tasks to gain a better understanding of enhancing work procedures or coordinating the work. Following this, supervisors of ALDOT TMTs should consider the following:

- Rotate heavy assignments with light assignments;
- Offer diversity in tasks to eliminate or decrease repetition;
- Alter work schedules, work speed, or work procedures;
- Provide adequate work breaks;
- Amend work procedures so that employees operate over the knees, beneath the shoulders, and close to the body;
- Allow for workers to take turns for tasks that use different muscles, limbs, or positions;
- Implement programs intended to enhance worker's fitness, (i.e., stretch and flex plans);
- Implement combinations of the abovementioned tactics.

OSHA has published recommendations to help employers and employees reduce the risk and occurrence of sprains and strains affecting back injuries (Occupational Safety and Health Administration (OSHA), n.d). General OSHA recommendations for dealing with high risk factors are summarized in Table 8-1 below .

**Table 8-1 Factors Related to Back Injuries and Recommendations**

| Main Factor | Recommendation |
|---|---|
| Awkward posture | • Work close to elbow elevation to avert too much bending<br>• Avoid operating overhead and bending you knees when possible<br>• Where uncomfortable positions are inevitable, alter tasks, stretch, and take brief breaks regularly |
| Lifting | • Ensure size and weight of object to allow for a squat lift with bent legs and a straight back<br>• Keep the object close to your body<br>• Lift within the knuckle-to-shoulder height range<br>• Avoid bending or twisting while lifting<br>• Limit repetitive lifting |
| Force | • Use the appropriate tools / motorized instruments for the task at hand<br>• Ensure that the use of a motorized device does not produce further force concerns |
| Repetitive movement | • Use power instruments when accessible<br>• Alter assignments, stretch, or take frequent breaks from recurring movements<br>• Adhere to job rotation strategies when possible – efficient job rotation replaces muscle groups among consecutive job tasks |
| Vibration | • Use tools/equipment equipped with cushioned grips with a compressible exterior<br>• Use gel packed gloves to reduce the hand-transmitted vibration exposures from machines and powered hand tools<br>• Choose tools/equipment equipped with damping systems (i.e., springs/hydraulics) |

Early identification of musculoskeletal injuries including pain, numbness, or fatigue can hinder progression to severe injury (California Department of Industrial Relations, 2000). Implementing regular assessments or ergonomic check-ins could encourage TMTs to report discomfort early, allowing for timely interventions.

To assess an ergonomic program and interventions ALDOT's management can follow the following recommendations (WSDOT, 2024):

- Address ergonomics related issues promptly, as needed;
- Make sure that the worker and incident receive adequate attention;
- Make sure that education and training have been provided and interventions have been implemented;
- Keep in touch with the relevant worker during the evaluation process and period of intervention;
- Conduct additional assessments to confirm the success of the intervention;
- Communicate information about successful interventions implemented throughout the organization.

The recommended training resources to raise awareness and reduce sprains and strains and associated back injuries include NIOSH Simple Solutions-Ergonomics for Construction Workers, CPWR-Roadway Safety Awareness, CPWR-Preventing MSDs in Construction Workers, CPWR-Ergonomics Awareness Training, and NIOSH-Manual Material Handling.

Ergonomic interventions should be incorporated into safety protocols such as ergonomic guidelines in Job Hazard Analysis (JHA). This provides TMTs with actionable guidance on minimizing physical strain during tasks and allows for evaluating ergonomic risks before commencing work, which heightens TMTs' awareness of these hazards.

Comprehensive forms for injury and near miss reporting can highlight specific hazards and similar patterns over time. The recommended forms provided in APPENDIX C are designed to cover weather conditions, type of task, equipment or tools used. Datasets that contain every aspect of the incident (who, what, when, where, why and how it might be avoided) lay down the foundation for control methods to handle underlying causes.

The implementation of JHA has shown effectiveness as it relates to the safety of workers and safety awareness among TMTs (Al-Shabbani et al., 2018). Ongoing monitoring and control of the JHA process to evaluate its effectiveness with respect to TMT safety performance should be prioritized. In the event of an incident, injury or near miss, task specific forms must be reviewed and updated as appropriate to incorporate the information collected from the incident. Improvements in incident reporting, rates of injury, cost of medical treatment, damage to equipment and tools and number of days lost due to injury can be assessed to measure the effectiveness of the JHA process and control measures implemented.

Employee participation should be promoted to ensure workers’ buy-ins. When regular feedback is implemented, TMTs can voice their concerns to guide ALDOT’s safety efforts through suggestion boxes, or safety meetings, while supporting a culture of safety engagement.

Tailored and updated training programs offered to TMT on a regular basis are essential, as well as refresher courses. Training topics should address safety concerns and high-risk hazards including working in live traffic, field ergonomics, and any new hazards that arise from adjustments to job tasks or procedures. It is recommended that ALDOT incorporates the above-mentioned ergonomic training resources into pretask safety toolbox talks as well as engages in the state sharing initiative provided by the Transportation Curriculum Coordination Council to provide easily accessible training courses for TMTs focusing on the following topics: Flagger Training - WEB-BASED, Guardrail Maintenance and Repair, Inspection Safety for Bridges, Job Hazard Analysis, Maintenance of Traffic for Technicians, TTC and Safety in Short-term Work Zones.

Another recommendation involves preparing a Safety Manual for TMTs to address their specific risks and promote a proactive safety environment. This manual functions as an essential tool to keep all workers safe and healthy, offering clear written instructions on avoiding hazards, safe work methods, PPE, reporting incidents and ensuring ongoing improvement. The Safety Manual should be handed to all existing and new TMTs to promote a consistent safety approach and control measures across all ALDOT areas and districts.

Encouraging a culture of safety by rewarding safe behavior can also be beneficial. For example, Maine DOT began the “Safety Idea Incentive Program” in 2012 to encourage workers in participating as teams to develop a safety program inspired by safety meetings. Each month, safety suggestions are gathered and assessed to identify the most valuable and relevant idea. Each winner of the team gets 50 points, which is equal to $25. This initiative ran from 2012 to 2015 and led to the adoption of numerous safety protocols that are now being followed with minimal interference from supervisors, as they have the approval of the workers. Even though the program only lasted for three years, it resulted in the implementation of various safety measures, including the creation of a guide for poisonous plants, supplying tick removal kits in first aid kits, and marking sidewalks where snow and ice might fall (Gambatese et al., 2017). North Dakota established the "Leading Indicators Initiative," in which the state DOT monitored and evaluated various safety factors, including worker involvement in self-inspections, first aid training, and worker suggestion programs. Worker involvement in safety inspections was examined as another important factor. The primary goal of this initiative is to embrace a different safety mindset that focuses on proactive measures. A benefit of this program is that it resulted in a half decrease in insurance premiums (Gambatese et al., 2017).

## 8.2 Limitations

While the research provides valuable insights and recommendations for improving worker safety within ALDOT, several limitations must be acknowledged to guide future research efforts.

ALDOT worker safety dataset had several limitations that affect the accuracy and comprehensiveness of the analysis. Significant gaps in injury reporting were present, with missing records for specific months and years, such as October, November, and December of 2019, and various months in 2020, 2023, and 2024. This incomplete data limits the ability to perform a fully comprehensive trend analysis over the years and may affect the reliability of conclusions drawn about injury patterns and trends.

The dataset also lacked detailed descriptions of incidents due to limited characters in the Injury Description fields or missing information altogether. Important details such as the sequence of events leading to injuries, further classification of falls (e.g., fall from a ladder, fall to lower level), severity of injuries, number of hours worked, and contributing factors like age, years of experience, time of day, race, or gender were not available. Lack of these details hinder the ability to perform in-depth risk assessments and develop targeted interventions.

Inconsistent coding and vague descriptions in the dataset, such as "Injury," "Multiple Injuries," and "No Injury," without further context or classification, limit the utility of the data for analysis and recommendation development. The absence of standardized injury classification criteria, lack of detailed incident investigations, and unavailability of work hours number per year needed to calculate injury rates complicates comparative analyses and benchmarking against industry standards.

Lack of information on direct and indirect costs, such as lost productivity, training replacement workers, and reduced workforce efficiency, as well as direct costs like medical and compensation expenses, impedes a full understanding of the financial impact of injuries on ALDOT. Without this information, it is challenging to perform a comprehensive cost-benefit analysis of proposed safety interventions.

The two surveys of state DOTs' safety efforts and TMT safety perception faced challenges related to sample size and diversity of samples. Smaller sample sizes limit the applicability of the results to all DOTs or all ALDOT areas. Different areas within ALDOT provided mixed results, therefore, findings from one area might not fit others, causing incomplete understanding of safety views across the agency. Few respondents of state DOTs were not aware of injury or fatality rates, hinting at knowledge gaps that might affect the accuracy of responses.

Possible bias in answers exists, as participants might give responses they believe are more socially accepted. Emotional bias or heightened sensitivity from a recent serious injury prior to taking the survey can also affect responses, causing more anxiety about safety conduct.

Appendix E provides a recommended schedule for achieving the strategic implementation of ALDOT safety program starting April 2025 and lasting three years. The phases include initial planning, assessment, and leadership efforts to improve reporting systems, implement job hazard analysis (JHA), and create broad training and education programs. It also includes the development of a safety manual, a safety incentive program, and a review and revision stage to evaluate and improve the program. Each phase has a specific timeline that outlines suggested start and end date as well as the tasks to be accomplished and goals to be achieved. The recommended timeline aims to help in monitoring the progress and ensure the implementation of all necessary steps to achieve a safer work environment for ALDOT maintenance workers.

### 8.3 Future Research

Current limitations, shown by study results, indicate important areas for future exploration. Better data collection and reporting procedures at ALDOT remain important, to gather full details and fix current gaps. Ensuring data accuracy in injury/incident reports supports informed decisions; while including factors such as work hours, employee backgrounds, environmental factors and existing circumstances increases the potential for deep and complete risk evaluations.

The representativeness of these findings could be improved by conducting long-term studies and collecting survey responses across more areas of ALDOT. With this broader scope, results are more meaningful, likely enabling tailored safety intervention to be successfully implemented across areas and districts. The combination of a multi-layered study that considers the organization level and individual level adds depth to findings.

Larger sample sizes in future studies give more reliable statistics, which helps to identify key patterns or differences. Thorough information from interviews or group discussions gives more depth to the knowledge about safety culture and worker experiences, showing details that numbers alone might miss.

This dissertation highlights the need for a comprehensive safety program within the Alabama Department of Transportation (ALDOT) directed to Transportation Maintenance Technicians (TMTs). This investigation supports improved injury prevention strategies, enhanced safety culture, and improved data collection through extensive historical injury analysis and comparison to practices in multiple state DOTs. The results indicate that risk management can be greatly improved by implementing a Job Hazard Analysis (JHA) in a well-structured way, perform better recordkeeping, and subsequently create a tailored safety manual. However, because of partial years of data; and no data on work hours, it is not possible to calculate precise injury rates or perform complete assessments of safety outcomes. These data gaps should be targeted in future research along with the deployment of more ergonomic training and further adaptive and proactive safety practices around changing workplace hazards. Implementing the recommendations of this study can lead to a safer work environment, improved productivity, improved job satisfaction for ALDOT TMTs, and reduced financial costs.

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# APPENDIX A: ALDOT ACTIVITY GROUPING

**Bridge Painting**

- 0B23 Bridge Painting - Spot
- 0B24 Bridge Painting - Partial
- 0B25 Bridge Painting Complete

**Guardrail/Cable Rail Maintenance**

- 6381 Guardrail Maintenance
- 6382 Cable Rail Maintenance

**Herbicide Treatment & Surveillance**

- 6260 Herbicide Treatment
- 6262 Herbicide Treatment Surveillance
- 6310 Spot Herbicide Treatment

**Litter Pickup**

- 6300 Litter Pickup (Full Width)
- 6301 Litter Pickup (Spot)

**Minor & Major Deck Repair**

- 0B05 Minor Deck Repair - Steel
- 0B06 Minor Deck Repair - Concrete
- 0B07 Minor Deck Repair - Timber
- 0B08 Major Deck Repair - Steel
- 0B09 Major Deck Repair - Concrete
- 0B10 Major Deck Repair – Timber

**Mowing & Trimming Activities**

- 6251 Mowing (Interstate)
- 6252 Mowing (Non-Interstate)
- 6253 Boom Mowing
- 6254 Line Trimming

**Pavement Preservation Activities**

- 6050 Concrete Joint/Crack Maintenance
- 6060 Crack Sealing - Asphalt Pavement
- 6070 Pavement Planning

**Patching Activities**

- 6010 Spot Premix Patching
- 6020 Major Premix Patching
- 6021 Major Premix Patching w/Planer
- 6030 Skin Patching
- 6040 Strip Patching
- 6090 Patching Unpaved Shoulders

**Pavement Markings and Legends**

- 6360 Centerline and Edgeline Painting
- 6370 Pavement Markings and Legends
- 6400 Raised Pavement Marker Maintenance

**Standby Time**

- 6830 Standby Time-District
- 6831 Standby Time-Division

**Rest Area Maintenance Activities**

- 6740 Rest Area Maintenance

**Roadway/Shoulder Improvement**

- 6560 Roadway/Shoulder Improvement
- 6570 Roadside Improvements

**Concrete Pavement Repair**

- 6130 Concrete Pavement Repair

**Roadway/Shoulder Maintenance**

- 6100 Blading Unpaved Shoulders
- 6140 Other Roadway and Shoulder Maintenance
- 6340 Other Roadside Maintenance

**Super/Sub Structure Member Repair (SMR)**

- 0B11 Minor Super SMR - Steel
- 0B12 Minor Super SMR - Conc
- 0B13 Minor Super SMR - Timber
- 0B14 Major Super SMR - Steel
- 0B15 Major Super SMR – Conc
- 0B16 Major Super SMR - Timber
- 0B17 Minor Sub SMR - Steel
- 0B18 Minor Sub SMR - Concrete
- 0B19 Minor Sub SMR - Timber
- 0B20 Major Sub SMR - Steel
- 0B21 Major Sub SMR - Con
- 0B22 Major Subs SMR – Timber

**Sign Maintenance**

- 6352 Sign Maintenance

**Drainage Activities (Cleaning/Repair/Maintenance)**

- 6160 Ditching
- 6170 Cleaning Minor Drainage Structures
- 6180 Repairing Minor Drainage Structures
- 6190 Other Drainage Maintenance

**Attenuator Barrier Rail Maintenance**

- 6230 Impact Attenuator Maintenance
- 6240 Concrete Barrier Rail Maintenance

**Vegetation Maintenance Activities**

- 6270 Brush and Tree Cutting
- 6280 Erosion Control
- 0B46 Vegetation Control

**Open/Sealed Joint Repair**

- 0B03 Joint Repair - Open
- 0B04 Joint Repair - Sealed

# APPENDIX B: JHA FORMS OF ALDOT TRANSPORTATION MAINTENANCE OPERATIONS

ALDOT
Alabama Department of Transportation

# Job Hazard Analysis Form
# Mowing & Trimming

**PPE:**

| | |
|---|---|
| 1. Safety Glasses/Face Shield | 4. Hard Hat |
| 2. High Visibility Safety Apparel - Class 2 or Class 3 | 5. Earplugs/Muffs |
| 3. Gloves: Leather, Cut-Resistant | 6. Safety Boots |

| Work Methods and Notes | Potential Hazards | Severity | Likelihood | Risk Level | Safety Measures |
|---|---|---|---|---|---|
| Assign mowers to roads and Utilize appropriate traffic control devices | 1) Struck-by traffic or equipment | 4-Catastrophic | 3-Possible | Extremely High | • Wear appropriate PPE<br>• Establish work zone safety measures<br>• Use warning signs<br>• Maintain a safe distance from moving equipment<br>• Wear slip-resistant footwear<br>• Maintain a clean work area<br>• Use caution on slopes, and provide fall protection where needed |
| | 2) Slips, Trips, and Falls | 1-Negligible | 4-Likely | Moderate | |
| | 3) | | | | |
| Utilize appropriate traffic control devices | 1) Traffic Hazards | 4-Catastrophic | 3-Possible | Extremely High | • Use flaggers or traffic control devices<br>• Provide worker training on traffic safety<br>• Maintain situational awareness |
| | 2) | | | | |
| | 3) | | | | |
| Operate mowing and trimming equipment according to manufacturer guidelines | 1) Flying Debris, rocks or objects | 2-Moderate | 3-Possible | Moderate | • Protect your eyes and face by wearing a protective eyewear<br>• Use a face shield<br>• Stay out of traffic lanes and maintain visibility when operating machines<br>• Train on machinery operation<br>• Conduct pre-use inspections<br>• Follow lockout/tagout procedures<br>• Wear hearing protection<br>• Shorter duration of exposure to noisy equipment<br>• Conducted hearing conservation training |
| | 2) Contact with Machinery | 3-Critical | 3-Possible | High | |
| | 3) Noise Exposure | 1-Negligible | 4-Likely | Moderate | |
| Collect and dispose of mowed or trimmed vegetation | 1) Falling Objects | 3-Critical | 3-Possible | High | • Wear head protection<br>• Remove any overhead clutter in work areas<br>• Secure loose objects<br>• Provide emergency response items (e. g., first aid supplies, eyewash station, emergency shower) available at the workplace<br>• Develop a generative, plant-based safety ergonomics program<br>• Provide shade or shelter<br>• Dress for the weather<br>• Stay hydrated<br>• If Weather Forecast Peeking Up, Alter Work Timings |
| | 2) Exposure to Hazardous Plants | 1-Negligible | 3-Possible | Low | |
| | 3) Exposure to extreme temperatures | 1-Negligible | 5-Almost Certain | Moderate | |
| Terminate traffic control | 1) Traffic Hazards | 4-Catastrophic | 3-Possible | Extremely High | • Develop a clear plan for terminating traffic control<br>• Create communication standards among workers, flaggers and drivers<br>• Employ advance warning for changes in traffic conditions<br>• Wear high-visibility clothing |
| | 2) | | | | |
| | 3) | | | | |

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# Job Hazard Analysis Form
# Roadway/Shoulder Maintenance

**PPE:**

1. Safety Glasses/Face Shield
2. High Visibility Safety Apparel - Class 2 or Class 3
3. Gloves: Leather, Cut-Resistant
4. Hard Hat
5. Earplugs/Muffs
6. Safety Boots

| Work Methods and Notes | Potential Hazards | Severity | Likelihood | Risk Level | Safety Measures |
|---|---|---|---|---|---|
| Disc shoulder if necessary to loosen material | 1) Working around moving equipment (Struck by) | 3-Critical | 3-Possible | High | • Employees are required to use of high visibility clothes<br>• Verify that backup alarms on equipment are functioning<br>• Develop Plan of Communication from technicians to the Equipment Operator<br>• Stay aware of the surroundings<br>• Train team members on tool usage<br>• Guards and barriers are used on machines<br>• Conduct pre-use inspections<br>• Adhere to lockout/tagout procedures |
| | 2) Contact with Machinery | 3-Critical | 3-Possible | High | |
| | 3) | | | | |
| Peel off sod and topsoil with motor patrol and windrow along pavement edge | 1) Working around moving equipment (Struck by) | 3-Critical | 3-Possible | High | • Workers must wear high visibility apparel to ensure they are conspicuous to motorists and equipment operators<br>• Ensure equipment backup alarms are functional<br>• Develop communication plan with equipment operator<br>• Keep alert to surroundings |
| | 2) | | | | |
| | 3) | | | | |
| Cut excess material off shoulder and windrow | 1) Overturning Equipment | 3-Critical | 3-Possible | High | • Train equipment operators on safe operating practices, including proper speed, depth adjustment, and turning techniques<br>• Examine work area for obstructions overhead hazards and soil stability<br>• Ensure that employees wear proper PPE including goggles, gloves, ear protection and reflective attire |
| | 2) Slips, Trips, and Falls | 1-Negligible | 4-Likely | Moderate | |
| | 3) Flying Debris | 2-Moderate | 4-Likely | High | |
| Load excess material into trucks and dump at designated areas | 1) Improper lifting; sprains and strains | 1-Negligible | 5-Almost Certain | Moderate | • Size up the load<br>• Always lift with your legs and not your back<br>• Try not to twist while lifting anything<br>• Lift with a plan in place and as a backup<br>• Ask for assistance or use a hoist to reduce the loads on your back<br>• Minimize length of reaching distance or use ladders to prevent overhead reaching |
| | 2) Reaching or overextending limbs | 1-Negligible | 5-Almost Certain | Moderate | |
| | 3) Carrying too much weight | 1-Negligible | 5-Almost Certain | Moderate | |
| Spread sod and topsoil back on shoulder with motor patrol | 1) Equipment Hazards | 3-Critical | 3-Possible | High | • Check the motor patrol equipment to make sure it is safe and operational before use<br>• Train equipment operators on safe operating practices<br>• Implement clear signals, protocols and guidelines for communication between the operator of the equipment and ground personnel to coordinate movements and ensure worker safety |
| | 2) | | | | |
| | 3) | | | | |
| Make additional passes as necessary to obtain proper slope for drainage | 1) | | | | |
| | 2) | | | | |
| | 3) | | | | |
| Terminate traffic control | 1) Traffic Hazards | 4-Catastrophic | 2-Unlikely | High | • Develop a clear plan for terminating traffic control<br>• Create communication standards among workers, flaggers and drivers<br>• Employ advance warning for changes in traffic conditions<br>• Wear high-visibility clothing |
| | 2) | | | | |
| | 3) | | | | |

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# Job Hazard Analysis Form
# Concrete Pavement Repair

**PPE:**

1. Safety Glasses/Face Shield
2. High Visibility Safety Apparel - Class 2 or Class 3
3. Gloves: Leather, Cut-Resistant
4. Hard Hat
5. Earplugs/Muffs (if needed)
6. Safety Boots

| Work Methods and Notes | Potential Hazards | Severity | Likelihood | Risk Level | Safety Measures |
|---|---|---|---|---|---|
| Remove broken sections of concrete pavement | 1) Manual Handling | 1-Negligible | 4-Likely | Moderate | • Workers must wear the proper PPE such as gloves, safety goggles, hard hats, hearing protection and respiratory protection<br>• Lift planned, proper footing, knees bent, good grip, lift with legs not back, no twist in body during lift, smooth movement no jerking, set down gently<br>• Water suppression of dust and / or dust extraction systems to reduce airborne particle exposure |
| | 2) Exposure to Dust and Fumes | 2-Moderate | 4-Likely | High | |
| | 3) | | | | |
| Repair base, sub-base, and reinforcing steel as required | 1) Manual Handling | 1-Negligible | 4-Likely | Moderate | • Use mechanical equipment to help in lifting heavy objects e.g. hoist or forklifts<br>• Work areas shall be kept clean and orderly, barricades or warning signs shall be posted for hazards<br>• Provide PPE as gloves, respirators and eye protection |
| | 2) Slips and Trips | 1-Negligible | 4-Likely | Moderate | |
| | 3) Exposure to Hazardous Materials | 2-Moderate | 3-Possible | Moderate | |
| Provide proper construction joints by sawing or trimming existing pavement | 1) Noise Exposure | 1-Negligible | 3-Possible | Low | •Provide hearing protection (earplugs or earmuffs) for workers operating sawing equipment<br>•Wear respiratory protection (e.g., dust masks or respirators) to prevent inhalation of airborne particles<br>•Job rotation, anti-vibration gloves, regular inspections of equipment |
| | 2) Exposure to Dust and Debris | 2-Moderate | 4-Likely | High | |
| | 3) Hand-Arm Vibration | 3-Critical | 4-Likely | Extremely High | |
| Pour concrete (fast setting, if applicable), finish joint, and apply sealer | 1) Chemical Exposure | 2-Moderate | 3-Possible | Moderate | •Wear suitable PPE – gloves, long-sleeves, and chemical-resistant boots<br>•Utilize anti-slip footwear not to mention word of caution signs kept tidy work areas<br>•Provide shaded rest areas, hydration filling stations, rotating work schedules to cooler times of day |
| | 2) Slippery Surfaces | 1-Negligible | 4-Likely | Moderate | |
| | 3) Heat Stress | 1-Negligible | 5-Almost Certain | Moderate | |
| Allow for sufficient curing time | 1) | | | | |
| | 2) | | | | |
| | 3) | | | | |

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# Job Hazard Analysis Form
# Drainage (Cleaning/Maintenance/Repair)

**PPE:**

| | |
|---|---|
| 1. Safety Glasses/Face Shield | 4. Hard Hat |
| 2. High Visibility Safety Apparel - Class 2 or Class 3 | 5. Earplugs/Muffs |
| 3. Gloves: Leather, Cut-Resistant | 6. Safety Boots |

| Work Methods and Notes | Potential Hazards | Severity | Likelihood | Risk Level | Safety Measures |
|---|---|---|---|---|---|
| Remove dirt and debris with excavator and load in trucks | 1) Strain and Sprain | 1-Negligible | 4-Likely | Moderate | • Provide manual handling training, use lifting aids, and encourage proper ergonomics<br>• Identify and mark underground utilities, maintain safe distances from power lines, and use insulated tools<br>• Conduct a hazard assessment, provide appropriate PPE, and follow proper disposal procedures for hazardous materials |
| | 2) Electrical Hazards | 4-Catastrophic | 3-Possible | Extremely High | |
| | 3) Exposure to Hazardous Materials | 3-Critical | 3-Possible | High | |
| Re-establish uniform flow line, taking care to avoid low spots which will accumulate water | 1) Cave-ins or Collapses. | 4-Catastrophic | 2-Unlikely | High | • Implement trench safety measures, such as sloping, shoring, or shielding, conduct soil assessments, and ensure proper trenching practices<br>• Ensure proper grading to promote water flow, install drainage systems as needed, and monitor water accumulation during and after work |
| | 2) Water pooling (Slip Hazards and Potential Flooding) | 2-Moderate | 2-Unlikely | Low | |
| | 3) | | | | |
| Dress and shape foreslopes and backslopes. Avoid creating steep slopes when possible | 1) Erosion Hazards | 3-Critical | 2-Unlikely | Moderate | • Implement erosion control measures, such as vegetation, erosion blankets, or retaining structures, to stabilize slopes and prevent erosion<br>• Use warning signs, flaggers, and high-visibility clothing to enhance visibility on slopes and in the work area |
| | 2) Visibility Hazards | 2-Moderate | 3-Possible | Moderate | |
| | 3) | | | | |
| Haul waste material to designated area | 1) Overloading | 1-Negligible | 4-Likely | Moderate | • Adhere to weight limits, monitor load capacity, and ensure proper distribution of weight within the vehicle<br>• Properly label hazardous materials, use spill containment measures, and have spill response procedures in place |
| | 2) Spills or Leaks of Hazardous Waste Materials | 3-Critical | 3-Possible | High | |
| | 3) | | | | |
| Remove debris and undesirable vegetation from inlet and outlet channels | 1) Sharp Objects | 2-Moderate | 4-Likely | High | • Wear cut-resistant gloves and clothing, use tools with safety guards, and inspect debris before handling<br>• Use chemical-resistant gloves when necessary<br>• Use respiratory protection if needed, wash hands thoroughly after handling debris, and seek medical attention for any allergic reactions<br>• Identify and mark underground utilities, maintain safe distances from power lines, and use insulated tools when working near electrical hazards |
| | 2) Biological Hazards | 2-Moderate | 3-Possible | Moderate | |
| | 3) Electrical Hazards | 4-Catastrophic | 3-Possible | Extremely High | |
| Clean out silted material from culvert or pipe | 1) Confined Spaces | 4-Catastrophic | 3-Possible | Extremely High | • Implement a confined space entry program, use gas detectors, have a rescue plan in place, and provide confined space training to workers<br>• Conduct a structural assessment before cleaning, shore up unstable areas, and use proper bracing or supports during cleaning<br>• Monitor water levels and flow rates, use barriers to control water ingress, and have rescue equipment readily available |
| | 2) Collapse Hazards | 4-Catastrophic | 2-Unlikely | High | |
| | 3) Water Hazards | 4-Catastrophic | 2-Unlikely | High | |
| Repair damage to minor drainage structures as required | 1) Structural Instability | 4-Catastrophic | 2-Unlikely | High | • Conduct a thorough assessment of the structure's stability, use temporary supports if needed, and follow safe work practices to prevent structural failures<br>• Use barricades or warning signs to secure the work area, wear hard hats for head protection, and implement a clear debris removal plan<br>• Identify and mark underground utilities, maintain safe distances from power lines, use insulated tools, and follow electrical safety protocols |
| | 2) Falling Objects | 3-Critical | 3-Possible | High | |
| | 3) Electrical Hazards | 4-Catastrophic | 2-Unlikely | High | |

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# Job Hazard Analysis Form
# Patching Activities

| **PPE:** | |
|---|---|
| 1. Safety Glasses/Face Shield | 4. Hard Hat |
| 2. High Visibility Safety Apparel - Class 2 or Class 3 | 5. Earplugs/Muffs (if needed) |
| 3. Gloves: Leather, Cut-Resistant | 6. Safety Boots |

| Work Methods and Notes | Potential Hazards | Severity | Likelihood | Risk Level | Safety Measures |
|---|---|---|---|---|---|
| Clean the surface failure area and square up depressions and edges | 1) Sharp Objects | 2-Moderate | 4-Likely | High | • Avoid distractions<br>• Keep alert to surroundings<br>• Avoid walking backwards<br>• Train employees in correct lifting methods and encourage them to take scheduled breaks to avoid overexertion<br>• Conduct inspection of work areas for sharp objects, supply cut-resistant gloves, and exercise caution when working with tools or materials |
| | 2) Slips, trips, and falls on uneven pavement surfaces | 1-Negligible | 4-Likely | Moderate | |
| | 3) Manual Handling | 1-Negligible | 4-Likely | Moderate | |
| Apply tack coat of liquid asphalt/ Spread bituminous material | 1) Exposure to Chemicals | 3-Critical | 3-Possible | High | • Ensure appropriate personal protective equipment like gloves and goggles is provided, ensure access to proper handwashing facilities, and educate workers on chemical handling procedures<br>• Supply heat-resistant gloves and clothing, designate specific areas for managing hot materials, and train workers on safe handling practices<br>• Utilize anti-slip footwear, promptly address spills, place warning signs in slippery areas, and uphold good housekeeping standards |
| | 2) Burn Hazards | 3-Critical | 3-Possible | High | |
| | 3) Slippery Surfaces | 2-Moderate | 3-Possible | Moderate | |
| Compact material with hand tamper, truck wheels, or roller | 1) Repetitive motions | 1-Negligible | 5-Almost Certain | Moderate | • Rotate employees regularly to reduce exposure risks, supply anti-vibration gloves, and perform routine health checks on employees<br>• Foster transparent communication between operators and ground staff, create defined work areas, and utilize warning signals during equipment use<br>• Train operators in equipment handling, carry out pre-use checks, and refrain from operating on steep or unstable ground |
| | 2) Getting Caught Under Eequipment or Between Materials | 3-Critical | 3-Possible | High | |
| | 3) Overturn of Equipment | 4-Catastrophic | 2-Unlikely | High | |
| Dump premix from trucks and spread with motor patrol | 1) Equipment Operation Hazards | 3-Critical | 3-Possible | High | • Offer equipment operation training, perform pre-use checks, and restrict machinery handling to qualified operators<br>• Supply heat-resistant gloves and attire, schedule tasks during cooler hours, and allow frequent breaks in shaded spots |
| | 2) Heat Exposure | 1-Negligible | 5-Almost Certain | Moderate | |
| | 3) | | | | |
| Hand rake excess premix over butt joints and feather the edges before rolling | 1) Hand Injuries | 2-Moderate | 3-Possible | Moderate | • Supply cut-resistant gloves, inspect rakes for good condition, and advocate for safe handling procedures<br>• Provide suitable personal protective equipment (PPE) like gloves and long sleeves, and establish skin-cleansing stations for staff<br>• Utilize anti-slip footwear, administer anti-skid coatings to slippery zones, and uphold proper housekeeping protocols |
| | 2) Chemical Exposure | 3-Critical | 3-Possible | High | |
| | 3) Slippery Surfaces | 1-Negligible | 3-Possible | Low | |
| Roll each layer of premix immediately | 1) Equipment Operation Hazards | 3-Critical | 3-Possible | High | • Offer equipment operation training, perform pre-use checks, and restrict machinery handling to qualified operators<br>• Train operators in equipment handling, carry out pre-use checks, and refrain from operating on steep or unstable ground<br>• Supply heat-resistant gloves and attire, schedule tasks during cooler hours, and allow frequent breaks in shaded spots |
| | 2) Overturn of Equipment | 4-Catastrophic | 2-Unlikely | High | |
| | 3) Heat Exposure | 1-Negligible | 5-Almost Certain | Moderate | |
| Remove broken sections of concrete pavement | 1) Manual Handling | 1-Negligible | 5-Almost Certain | Moderate | • Utilize mechanical assistance such as wheelbarrows or forklifts, educate workers on safe lifting practices, and promote teamwork for handling heavy loads<br>• Supply anti-vibration gloves, limit the duration of exposure to vibrating tools, and implement regular health check-ups for employees<br>• Establish and mark designated work zones, maintain adequate lighting, and ensure clear pathways free of obstacles<br>• Implement dust control techniques like water suppression, provide respiratory protective gear when needed, and guarantee proper ventilation in the work environment |
| | 2) Trip and Fall | 1-Negligible | 3-Possible | Low | |
| | 3) Exposure to Dust and Fumes | 3-Critical | 3-Possible | High | |

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# Job Hazard Analysis Form
# Sign Maintenance

**Personal Protective Equipment (PPE):**

1. Safety Glasses/Face Shield
2. High Visibility Safety Apparel - Class 2 or Class 3
3. Gloves: Leather, Cut-Resistant
4. Hard Hat
5. Earplugs/Muffs (if needed)
6. Safety Boots

| Work Methods and Notes | Potential Hazards | Severity | Likelihood | Risk Level | Safety Measures |
|---|---|---|---|---|---|
| Utilize appropriate traffic control devices | 1) Struck-by Hazards | 4-Catastrophic | 2-Unlikely | High | • Appropriate traffic control measures should be implemented to reduce the risk of struck-by hazards, such as barricades or flaggers |
| | 2) | | | | |
| | 3) | | | | |
| fix cracks, chips, or other damages to the sign | 1) Electrical Hazards | 4-Catastrophic | 2-Unlikely | High | • Disconnect signs from power sources before repair, utilize insulated tools, and assign qualified personnel to handle electrical components<br>• Utilize fall protection gear like harnesses and guardrails, adhere to ladder safety protocols, and perform routine inspections of elevated work zones<br>• Supply cut-resistant gloves, teach proper handling methods, and safely dispose of sharp objects |
| | 2) Falls | 4-Catastrophic | 3-Possible | Extremely High | |
| | 3) Sharp Objects | | | | |
| Sign cleaning | 1) Chemical Exposure (Cleaning Agents) | 2-Moderate | 4-Likely | High | • Issue appropriate personal protective equipment (PPE) such as gloves and eye protection, employ chemical-resistant materials, and adhere to safety data sheet (SDS) instructions |
| | 2) | | | | |
| | 3) | | | | |
| Replacements | 1) | | | | |
| | 2) | | | | |
| | 3) | | | | |
| Sign support installation | 1) Fall Hazards | 3-Critical | 3-Possible | High | • Utilize fall protection gear like harnesses, guardrails, or safety nets, adhere to correct ladder safety protocols, and perform routine checks of elevated work zones<br>• Follow appropriate lifting methods, don gloves for hand protection, and exercise caution when dealing with bulky or unwieldy materials<br>• Ensure the correct grounding of metal sign supports, keep a safe distance from power lines, and assign qualified individuals to manage electrical connections |
| | 2) Pinch Points and Crush Injuries | 2-Moderate | 3-Possible | Moderate | |
| | 3) Electrical Hazards | 4-Catastrophic | 2-Unlikely | High | |
| Sign Removal | 1) Fall Hazards | | | | • Use fall protection equipment such as harnesses, guardrails, or safety nets, ensure proper ladder safety practices, and conduct regular inspections of elevated work areas<br>• Use proper tools for dismantling signs, wear gloves to protect hands, and be cautious when handling heavy or sharp materials<br>• Ensure signs are properly disconnected from power sources before removal, use insulated tools, and have qualified personnel handle electrical components |
| | 2) Pinch Points and Crush Injuries | | | | |
| | 3) Electrical Hazards | | | | |

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# Job Hazard Analysis Form
## Litter Pickup

**Personal Protective Equipment (PPE):**

1. Safety Glasses/Face Shield
2. High Visibility Safety Apparel - Class 2 or Class 3
3. Gloves: Leather, Cut-Resistant
4. Hard Hat
5. Earplugs/Muffs (if needed)
6. Safety Boots

| Work Methods and Notes | Potential Hazards | Severity | Likelihood | Risk Level | Safety Measures |
|---|---|---|---|---|---|
| Pick up large items and place directly on truck | 1) Flying Debris | 1-Negligible | 3-Possible | Low | • Wear safety glasses and a face shield<br>• Provide manual handling training to workers on proper lifting techniques<br>• Use team lifting or mechanical aids (e.g., dollies, carts) for heavy items<br>• Encourage workers to take regular breaks and rotate tasks to prevent overexertion<br>• Provide workers with cut-resistant gloves and other appropriate PPE<br>• Inspect items before handling to identify and safely manage sharp objects<br>• Implement proper disposal procedures for hazardous materials |
| | 2) Manual Handling | 1-Negligible | 4-Likely | Moderate | |
| | 3) Sharp Object Injuries | 1-Negligible | 3-Possible | Low | |
| Collect small litter in litter bags or buckets | 1) Environmental Hazards | 1-Negligible | 3-Possible | Low | • Provide workers with appropriate protective clothing for weather conditions<br>• Conduct regular safety briefings on environmental hazards and emergency procedures<br>• Dispose of hazardous materials according to regulations and guidelines<br>• Maintain clear pathways and remove obstacles to prevent tripping hazards<br>• Wear appropriate footwear with slip-resistant soles<br>Use caution when navigating uneven terrain or wet surfaces |
| | 2) Slips, Trips, and Falls | 1-Negligible | 3-Possible | Low | |
| | 3) | | | | |
| Place filled litter bags or buckets along the shoulder | 1) Slips and trips | 1-Negligible | 3-Possible | Low | • Avoid distractions<br>• Keep alert to surroundings<br>• Avoid walking backwards<br>• Provide manual handling training to workers on proper lifting techniques<br>• Use team lifting or mechanical aids for heavy or bulky items<br>• Encourage workers to take breaks and rotate tasks to prevent overexertion<br>• Provide workers with appropriate protective clothing for weather conditions<br>• Schedule work during favorable weather conditions when possible<br>• Ensure workers stay hydrated and take breaks in shaded areas during hot weather |
| | 2) Overexertion and Musculoskeletal Hazards | 1-Negligible | 4-Likely | Moderate | |
| | 3) Tempreture Extremes | 1-Negligible | 4-Likely | Moderate | |
| Truck driver empties litter onto truck | 1) Improper lifting | 1-Negligible | 4-Likely | Moderate | • Size up the load<br>• Preplan the lift before attempting it<br>• Get help from others or use a lifting device for heavier loads<br>• Reduce the reaching distance to items, or use ladders to reduce reaching overhead |
| | 2) | | | | |
| | 3) | | | | |
| Dispose of litter at designated dumping areas | 1) Sharp Objects | 1-Negligible | 3-Possible | Low | • Maintain clear pathways and remove obstacles to prevent tripping hazards<br>• Wear appropriate gloves and footwear with slip-resistant soles<br>• Use caution when navigating uneven surfaces and watch for potential trip hazards<br>• Inspect litter bags for sharp objects before handling and dispose of them safely<br>• Implement proper disposal procedures for hazardous materials<br>• Follow proper waste disposal guidelines and regulations for different types of litter<br>• Educate workers on the importance of proper waste disposal practices |
| | 2) Slips, Trips, and Falls | 1-Negligible | 3-Possible | Low | |
| | 3) Incorrect disposal of litter or hazardous materials | 1-Negligible | 3-Possible | Low | |

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# Job Hazard Analysis Form
## Herbicide Treatment & Surveillance

**Personal Protective Equipment (PPE):**

1. Safety Glasses/Face Shield
2. High Visibility Safety Apparel - Class 2 or Class 3
3. Gloves: Chemical, Cut-Resistant
4. Hard Hat
5. Earplugs/Muffs (if needed)
6. Safety Boots

| Work Methods and Notes | Potential Hazards | Severity | Likelihood | Risk Level | Safety Measures |
|---|---|---|---|---|---|
| Supervisor and operators shall scout ahead of spraying operations | 1) Environmental Hazards | 1-Negligible | 3-Possible | Low | • Instruct scouts on recognizing protected species, fragile habitats, and environmentally sensitive areas to prevent accidental harm<br>• Create a contingency plan detailing steps for wildlife encounters and equip scouts with a comprehensive first aid kit<br>• Set up effective communication channels between scouts and the spraying team for sharing survey results, environmental updates, and safety issues |
| | 2) Encounters with Wildlife | 2-Moderate | 3-Possible | Moderate | |
| | 3) Communication Risk | 2-Moderate | 3-Possible | Moderate | |
| Spray designated areas | 1) Skin Contact, Inhalation, or Ingestion of herbicides | 3-Critical | 3-Possible | High | • Provide employees with suitable PPE such as coveralls, gloves, goggles, and respirators to reduce skin contact and inhalation of chemicals<br>• Ensure comprehensive training on proper handling and application techniques<br>• Utilize drift-reducing nozzles, maintain adequate buffer zones, and take into account weather conditions to minimize drift and avoid contamination of non-target areas<br>• Regularly inspect spraying equipment, offer training on equipment usage, and keep backup equipment on hand in case of breakdowns<br>• Establish shaded resting areas, promote hydration, schedule work for cooler times of the day, and educate workers on identifying and managing heat-related illnesses |
| | 2) Equipment Malfunction | 3-Critical | 3-Possible | High | |
| | 3) Heat Stress | 1-Negligible | 4-Likely | Moderate | |
| Fill tanks with water and proper amount of chemicals | 1) Chemical Exposure | 3-Critical | 3-Possible | High | • Use appropriate personal protective equipment (PPE) such as gloves, goggles, and coveralls to shield skin and eyes from chemical splashes<br>• Manage chemicals in well-ventilated spaces to reduce the risk of inhalation exposure<br>• Employ specified equipment and tools for precise measurement and mixing of chemicals<br>• Ensure spill containment kits are easily accessible for prompt spill response<br>• Label chemical containers and storage areas correctly to prevent mishaps and confusion<br>• Train workers on spill response protocols and proper cleanup methods<br>• Prevent cross-contamination by using separate equipment for handling different chemicals<br>• Adhere to manufacturer guidelines for chemical mixing to prevent reactions between incompatible substances<br>• Thoroughly rinse equipment after use to prevent any residual contamination |
| | 2) Spills and Leaks | 2-Moderate | 3-Possible | Moderate | |
| | 3) Chemical Contamination | 3-Critical | 3-Possible | High | |
| Continuously monitor the spray to ensure that it's being applied at the correct rate | 1) Slips and Trips | 1-Negligible | 3-Possible | Low | • Avoid distractions<br>• Keep alert to surroundings<br>• Avoid walking backwards |
| | 2) | | | | |
| | 3) | | | | |

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# Job Hazard Analysis Form
# Vegetation Maintenance and Control

**Personal Protective Equipment (PPE):**

| | |
|---|---|
| 1. Safety Glasses/Face Shield | 4. Hard Hat |
| 2. High Visibility Safety Apparel - Class 2 or Class 3 | 5. Earplugs/Muffs (if needed) |
| 3. Gloves: Leather, Cut-Resistant | 6. Safety Boots |

| Work Methods and Notes | Potential Hazards | Severity | Likelihood | Risk Level | Safety Measures |
|---|---|---|---|---|---|
| Cut brush and trees on right-of-way | 1) Falling Objects (Branches, Debris, etc.) | 2-Moderate | 3-Possible | Moderate | • Use appropriate PPE like hard hats, eye protection, and gloves for protection against falling objects<br>• Reduce the reaching distance to items, or use ladders to reduce reaching overhead<br>• Define a clear work zone boundary and ensure that workers maintain a secure distance from falling branches or debris<br>• Employ warning signs or barriers to notify pedestrians or drivers of the work zone<br>• Identify the positions of overhead power lines before commencing work and uphold a safe distance to prevent accidental contact<br>• Utilize insulated tools and equipment when working in proximity to power lines<br>• Enforce a "spotter" system to oversee clearance from power lines during tree cutting operations |
| | 2) Reaching or Overextending Limbs | 1-Negligible | 4-Likely | Moderate | |
| | 3) Contact with Power Lines | 4-Catastrophic | 2-Unlikely | High | |
| Dispose of brush and trees on right-of-way if there is sufficient room | 1) Sharp Objects and Splinters | 1-Negligible | 3-Possible | Low | • Wear cut-resistant gloves, long sleeves, and appropriate footwear<br>• Inspect tools for sharp edges or damage before use<br>• Provide first aid kits and training on wound care procedures<br>• Create well-organized piles to ease removal or processing<br>• Ensure clear access paths and stable stacks to prevent potential hazards<br>• Establish a composting area dedicated to organic materials like leaves, small branches, and tree trimmings<br>• Adhere to composting guidelines to enhance decomposition and nutrient recycling |
| | 2) Slips and Trips | 1-Negligible | 4-Likely | Moderate | |
| | 3) Environmental Impact | 1-Negligible | 3-Possible | Low | |
| Haul brush and trees to disposal area if there is not sufficient room for disposal on the right-of-way | 1) Manual Handling | 1-Negligible | 4-Likely | Moderate | • Provide training on proper lifting techniques and use of mechanical aids<br>• Use teamwork to distribute the weight of heavy objects and reduce individual strain<br>• Rotate tasks to prevent overexertion and allow for rest periods |
| | 2) | | | | |
| | 3) | | | | |
| Apply fertilizer and seed | 1) Chemical Exposure | 3-Critical | 3-Possible | High | • Conduct training sessions on the appropriate handling, storage, and application of chemicals<br>• Ensure personnel wear the necessary personal protective equipment (PPE), such as gloves, goggles, and respiratory protection<br>• Maintain proper ventilation in enclosed areas where chemicals are stored or used<br>• Adhere to recommended application rates and methods to reduce runoff<br>• Refrain from applying chemicals close to water bodies or sensitive ecosystems<br>• Utilize erosion prevention techniques to control soil erosion and sediment buildup<br>• Establish access to clean drinking water and handwashing facilities<br>• Encourage employees to take breaks in well-ventilated locations<br>• Implement routine health checks for individuals exposed to chemical risks<br>• monitor wind speed and direction when applying liquid chemicals before and during the application process |
| | 2) Environmental Impact | 1-Negligible | 3-Possible | Low | |
| | 3) Prolonged Exposure to Chemicals or Dust | 3-Critical | 4-Likely | Extremely High | |

## APPENDIX C: REVISED FIRST REPORTS OF INJURY (FROIs)

# EMPLOYER'S FIRST REPORT OF INJURY OR OCCUPATIONAL DISEASE

## EMPLOYEE INFORMATION

| Name of Injured Employee | SSN | Gender | Date of Birth (mm/dd/yyyy) | Date of Hire | Ethnicity |
|---|---|---|---|---|---|
| **John Doe** | 123-45-6789 | Male | 9/13/88 | 1/1/2013 | Hispanic |

**Employee Contact Information**

| | |
|---|---|
| No. and Street: | Alexandar street |
| City or Town: | Birmingham |
| Zip Code: | 35205 |
| State: | Alabama |
| Email Address: | XXXX@gmail.com |

**Employee Phone**

| | |
|---|---|
| Home: | (205) 511-1111 |
| Work: | (205) 511-1112 |
| Cell: | (205) 511-1113 |

| Job Description | Employee Number | Employment Status | | Hours Worked | | |
|---|---|---|---|---|---|---|
| ENGINEERING ASSISTANT II | 20324 | Full Time | From | 8 | To: | 5 |

**Years od Experience in Job Position** 8-10 years

**Days Worked (Select all that apply)** Mon-Fri

| ALDOT Region | ALDOT Area | County | City | Zip Code |
|---|---|---|---|---|
| **West Central** | Tuscaloosa | Tuscaloosa | Tuscaloosa | 35405 |

## INCIDENT/ACCIDENT INFORMATION

| Date of Incident (mm/dd/yyyy) | Time of Incident (hh:mm) | AM/PM | Time Employee Began Work | AM/PM | Date Employer Notified | On Agency Premises |
|---|---|---|---|---|---|---|
| 10/1/2018 | 10:25 | AM | 8:00 | AM | 10/1/2018 | Yes |

**Exact location where Incident occurred. Include street address, building, room, parking lot etc., if possible.**

| | |
|---|---|
| Project Number: | 123 |
| No. and Street: | 123 University BLv |
| City or Town: | Tuscaloosa |
| Zip Code: | 35405 |
| State: | Alabama |

**Names and phone numbers of witnesses (if any):**

| Witness Name | Witness Phone Number |
|---|---|
| Rosa R. Poulin | (607) 429-4289 |
| Ida J. Hill | (310) 003-5298 |
| James M. Falcone | (601) 461-8786 |
| | |
| | |

**Was injury caused by a motor vehicle accident?** (If YES, provide copy of police report to SEICTE) **No**

**Describe in detail what the injured employee was doing and how the accident occurred.**

Employee was walking down stairs, trip on a piece of debris, fell and injured his left knee

| | | | |
|---|---|---|---|
| **Check all Weather conditions at time of incident:** | Rainy & Drizzle | **Other Weather Conditions (please specify)** | wet surfaces |

**What was the task assigned to the employee?** Supervise Technical workers

**Is this task regularly assigned to employee?** Yes

**List all equipment, materials, or chemicals the employee was using when accident or illness exposure occurred.**

Hard Hat, Safety footwear

**Could this incident have been prevented?** Yes **If yes, please elaborate below**

If debris were removed from stairs

**Check all existing unsafe workplace conditions**

Flooring that has debris, water, or slippery substances that create a hazard

**Other (please specify)**

**Check all Unsafe acts by employee(s), Check all unsafe acts by employee(s)**

**Other (please specify)** N/A

**Human factor(s) involved in incident: (Check all that apply)**

Insufficient/Lack/Housekeeping Program

**Other (please specify)**

## INJURY DESCRIPTION AND CATEGORIZATION

**Describe the injury(ies) received. Indicate if cut, bruise, sprain,strain, twist, pull, etc. (Give details below):**

The Employee sprained his left knee falling down the stairs

| | | | |
|---|---|---|---|
| **What is the main Nature of the injury** | Sprain or Tear | **What is the main Source of the injury** | Fall / Slip / Trip |
| **What is the main Cause of the injury** | On Stairs | **Body Part (Check all that apply)** | Knee |

**If the source of injury was a fall check all that apply**

Fall to lower level

**If applies, specify the height of the fall** **1** **ft** **2** **in**

## INJURY TREATMENT

**What was Initial / Field First Aid Provided?** **Minor: Clinic / Hospital**

**Medical Facility Name:** **UAB Hospital**

**Facility Address:** **1802 6th Ave s**

**Treating Doctor's Name:** **Robert Doe**

| | | | |
|---|---|---|---|
| **Was the employee placed on Restricted Duty?** | No | If yes, please specify the Work Restrictions | |
| **Was the employee placed on No Work Status?** | Yes | If yes, please specify Number of Days Away | 3 |

**Did the employee seek any unauthorized medical treatment for this injury?** No

**I am the supervisor of the employee making the claim for SEICTF benefits and have filled out this First Report of Injury based on the information that has been reported to me. I certify that the above information is true and correct to the best of my knowledge**

| **Signature of supervisor reporting incident** | **Print name** | **Daytime phone** | **Date** |
|---|---|---|---|
| | | | |

ALABAMA DEPARTMENT OF TRANSPORTATION

# EMPLOYEE'S FIRST REPORT OF INJURY OR OCCUPATIONAL DISEASE

## EMPLOYEE INFORMATION

I am reporting a work related:

Have you informed your supervisor about this injury/near miss?

| Date of Incident (mm/dd/yyyy) | Time of Incident (hh:mm) | AM/P | Today's Date (mm/dd/yyyy) | Time Employee Began Work (hh:mm) | AM/PM | Date Employer Notified (mm/dd/yyyy) | On Agency Premise | On Break or Lunch at Time of Incident? |
|---|---|---|---|---|---|---|---|---|
| 8/2/2022 | 6:25 | AM | | | | | | |

| Name of Employee | Name of Supervisor | SSN | Gender | Date of Birth (mm/dd/yyyy) | Date of Hire (mm/dd/yyyy) | Ethnicity |
|---|---|---|---|---|---|---|
| | | | | | | |

**Employee Contact Information**

No. and Street:

City or Town:

Zip Code:

State:

Email Address:

**Employee Phone**

Home:

Work:

Cell:

Preferred method of contact by SEICTF:

| Job Description | Employee Number | Employment Status | Hours Worked |
|---|---|---|---|
| Select | | | From: To: |

Years of Experience in Job Position

Days Worked (Select all that apply)

Describe the specific activity you were performing at the time the injury/accident occurred including exactly what happened to cause injury/accident.

At the time of the injury/accident, were you using any protective equipment (ex. Latex gloves, eye protection)?

If yes, list equipment use

What is the main Nature of the injury

What is the main Source of the injur

What is the main Cause of the injury

Body Part (Check all that apply)

Have you previously had pain, treatment, diagnostic testing (x-rays, MRI, etc.) or injury to the same body part(s)?

If yes, enter body part affected, date(s) of injuries and name(s) and address(es) of treatment provider(s).

| | Body Part Affected | Date of Injury | Name of Treatment Provider | Address of Treatment Provider |
|---|---|---|---|---|
| 1) | | | | |
| 2) | | | | |
| 3) | | | | |
| 4) | | | | |
| 5) | | | | |

Exact location where Incident occurred. Include street address, building, room, parking lot etc., if possible.

Project Number:

No. and Street:

City or Town:

Zip Code:

State:

Names and phone numbers of witnesses (if any):

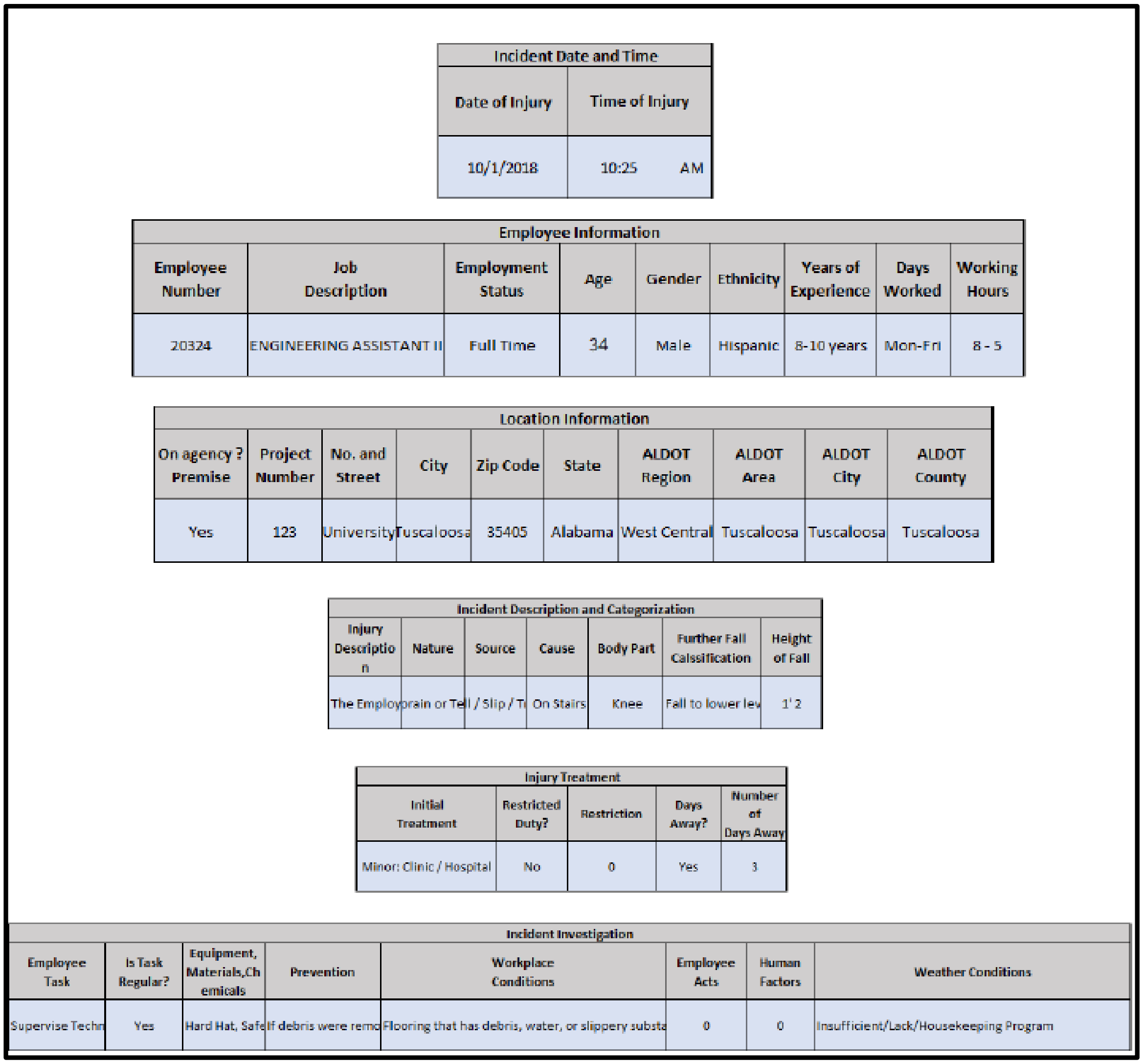
| | Witness Name | Witness Phone Number |
|---|---|---|
| 1) | | |
| 2) | | |
| 3) | | |
| 4) | | |
| 5) | | |

Was injury caused by a motor vehicle accident? (If YES, obtain a copy of the police report of accident and submit to supervisor as soon as possible. )

I understand the intentional reporting of false information will disqualify me from receiving further SEICTF benefits and could expose me to penalties or criminal charges. I certify all information is correct to the best of my knowledge. I further understand that non-compliance with SEICTF Rules (i.e. failure to attend medical appointments as scheduled, failure to respond to requests for contact, failure to provide signed medical authorization forms, failure to cooperate with SEICTF staff, failure to comply with your physician's medical treatment plan, etc.) will progressively lead to suspension and/or termination, per

| Signature of employee | Print name | Daytime phone | Date |
|---|---|---|---|
| | | | |
| **Signature of supervisor reporting incident** | **Print name** | **Daytime phone** | **Date** |
| | | | |

# Injury Dataset (Example)



| Incident Date and Time | |
|---|---|
| Date of Injury | Time of Injury |
| 10/1/2018 | 10:25 AM |

| Employee Information | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Employee Number | Job Description | Employment Status | Age | Gender | Ethnicity | Years of Experience | Days Worked | Working Hours |
| 20324 | ENGINEERING ASSISTANT II | Full Time | 34 | Male | Hispanic | 8-10 years | Mon-Fri | 8 - 5 |

| Location Information | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| On agency ? Premise | Project Number | No. and Street | City | Zip Code | State | ALDOT Region | ALDOT Area | ALDOT City | ALDOT County |
| Yes | 123 | University | Tuscaloosa | 35405 | Alabama | West Central | Tuscaloosa | Tuscaloosa | Tuscaloosa |

| Incident Description and Categorization | | | | | | |
|---|---|---|---|---|---|---|
| Injury Description | Nature | Source | Cause | Body Part | Further Fall Calssification | Height of Fall |
| The Employ | prain or Te | ll / Slip / T | On Stairs | Knee | Fall to lower lev | 1' 2 |

| Injury Treatment | | | | |
|---|---|---|---|---|
| Initial Treatment | Restricted Duty? | Restriction | Days Away? | Number of Days Away |
| Minor: Clinic / Hospital | No | 0 | Yes | 3 |

| Incident Investigation | | | | | | | |
|---|---|---|---|---|---|---|---|
| Employee Task | Is Task Regular? | Equipment, Materials,Chemicals | Prevention | Workplace Conditions | Employee Acts | Human Factors | Weather Conditions |
| Supervise Techn | Yes | Hard Hat, Safe | If debris were remo | Flooring that has debris, water, or slippery substa | 0 | 0 | Insufficient/Lack/Housekeeping Program |

## APPENDIX D: SUGGESTED INCIDENT INVESTIGATION FORM

*Source: Mississippi Department of Transportation (Mississippi Department of Transportation (MDOT), 2019)*

**Mississippi Department of Transportation**
**Incident Report # _______**

Incident Overview
- Date of Incident: ___________________________________________
- Time of Incident: ___________________________________________
- Location of Incident: ___________________________________________
- Job Function at Time of Incident: ___________________________________________

Incident Details
*(If no injury, mark N/A for name of injured; however, include crew involved, particularly in the case of a near miss.)*
- Name of Injured or Involved Person: ___________________________________________
- Assigned Crew: ___________________________________________
- Injury Sustained: ___________________________________________
- Person Reporting Incident: ___________________________________________
- Date Reported: ___________________________________________
- Crew Leader: ___________________________________________
- Date Report Completed: ___________________________________________

Witness(es) of Incident
- Name(s) and Job Title(s): *(Include if statement from witness is attached.)*

Full Description of Incident Events
*Briefly describe what happened, including the sequence of events, who was involved, conditions present, what was involved, what activity (if any) was taking place prior to and at the time of the incident. Include hazards the injured was exposed to and/or those hazards that may have contributed to the incident. Investigate the scene of the incident or near miss when needed.*

Equipment
- Were the proper tools and equipment being used?
  If not, why? ___________________________________________
- Were the tools and equipment inspected before use?
  If not, why? ___________________________________________
- Did tools and equipment function as designed?
  If not, why? ___________________________________________
- Were safety devices working properly?
  If not, why? ___________________________________________
- Were hazardous substances involved?
  If yes, list: ___________________________________________
- Was PPE being used?
  If not, why? ___________________________________________

Environment
- Weather/Temperature: ___________________________________________
- Housekeeping: ___________________________________________
- Noise: ___________________________________________

- Particles (e.g., gas, dust, fumes) present: ____________________________________________
- Was terrain (e.g., uneven ground, hills) an issue? ______________________________________
- Lighting: ____________________________________________
- Ventilation: ____________________________________________

Employee

- Were worker(s) experienced with the task being done? _________________________________
- Were worker(s) properly trained? ____________________________________________
- Were safety procedures being used? ____________________________________________
- Were shortcuts taken? ____________________________________________
- Worker(s) tired? ____________________________________________
- Under stress? ____________________________________________

Management

- Was a safety huddle conducted by the crew leader prior to beginning the task that resulted in this incident? ____________________________________________
- Were safety rules/procedures communicated and enforced? _________________________
- Was there adequate supervision? ____________________________________________
- Were enough workers on hand to complete the task? _________________________________
- Did worker understand the task being performed? ____________________________________
- Had job hazards been previously identified? ______________________________________
- Were job hazards addressed and unsafe conditions corrected? ___________________________
- Did production take priority over safety? ____________________________________________
- Had the employee completed all safety training? ___________________________________
- Was maintenance of equipment completed in a timely manner? ____________________

Immediate and Contributing Cause(s)
*(that may have been a factor in the incident)*

- Has this type of incident occurred in your crew or district previously? _______________
- What preventative action could have been taken? _________________________________
- If all proper procedures are followed and risk considered and mitigated, what is the likelihood this incident will occur again? ____________________________________________

Root Cause(s)
*(e.g., missing or lacking policies, procedures, processes, planning)*
*Questions may include why unsafe conditions were present, procedures not followed, worker in a hurry, etc.*

Corrective Action Recommendations

- Investigator's Recommendation:
- Person Responsible for Action: ____________________________________________
- Deadline for Completion: ____________________________________________

Investigator's Name: ______________________________________
Date: __________________
Attachments: ________________________________________________________________

Corrective Action Implementation

- Date Implemented: _______________________________________________
- Action Taken: _______________________________________________
- Person Responsible: _______________________________________________
- Review Date: _______________________________________________

## APPENDIX E: ALDOT SAFETY PROGRAM IMPLEMENTATION TIMELINE

# ALDOT Safety Program Implementation Timeline

**Program start:** **2025-03-31**

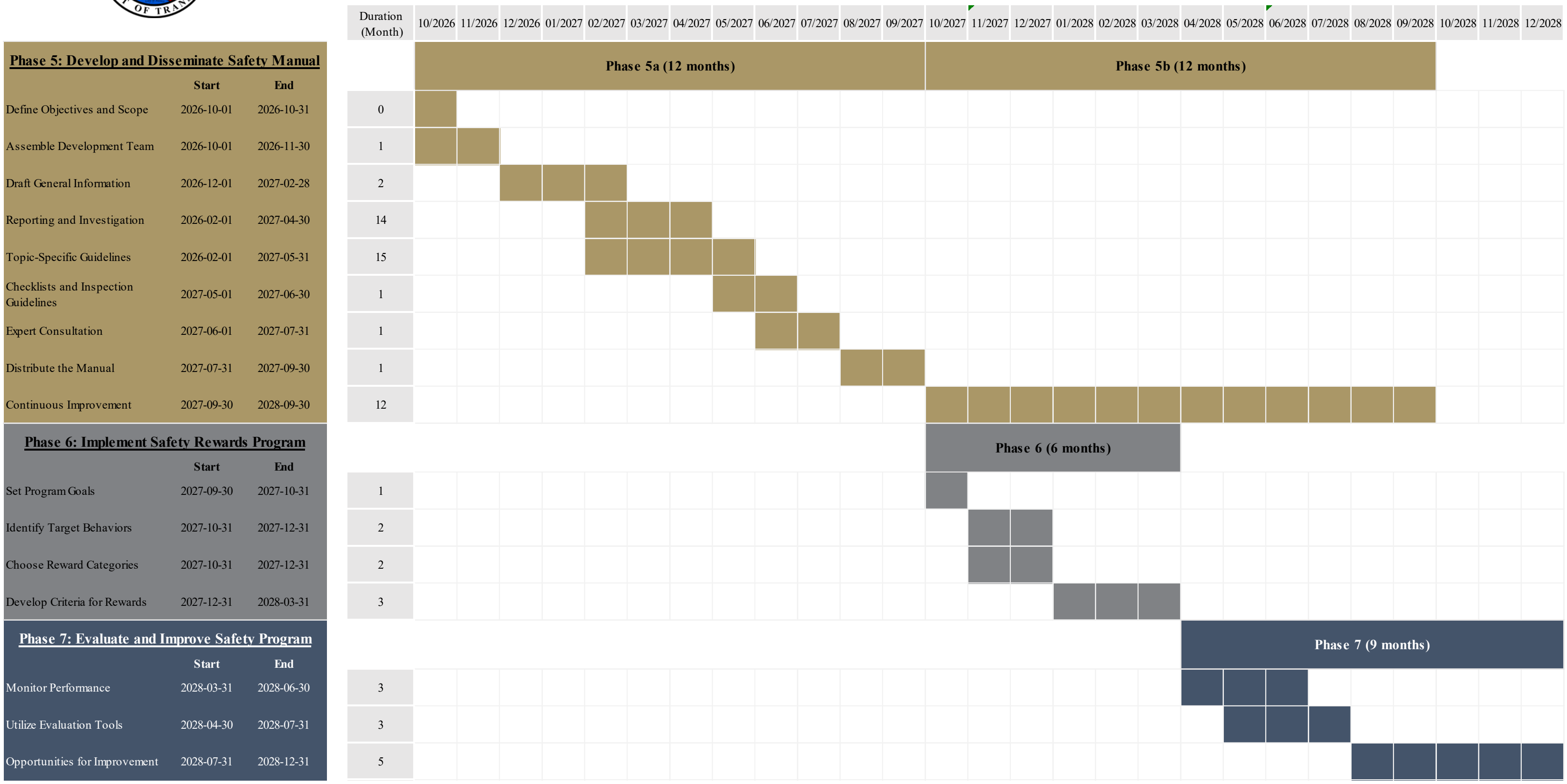
**Program end:** **2028-12-31**

| | Start | End | Duration (Month) | 04/2025 | 05/2025 | 06/2025 | 07/2025 | 08/2025 | 09/2025 | 10/2025 | 11/2025 | 12/2025 | 01/2026 | 02/2026 | 03/2026 | 04/2026 | 05/2026 | 06/2026 | 07/2026 | 08/2026 | 09/2026 | 10/2026 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Phase 1: Preparation and Assessment** | | | | **Phase 1 (3 months)** | | | | | | | | | | | | | | | | | | |
| Form a Safety Committee | 2025-03-31 | 2025-07-01 | 3 | 🟩 | 🟩 | 🟩 | | | | | | | | | | | | | | | | |
| Communicate Motivations | 2025-03-31 | 2025-07-01 | 3 | 🟩 | 🟩 | 🟩 | | | | | | | | | | | | | | | | |
| Define Clear Objectives | 2025-03-31 | 2025-07-01 | 3 | 🟩 | 🟩 | 🟩 | | | | | | | | | | | | | | | | |
| Develop Training Calendar | 2025-03-31 | 2025-07-01 | 3 | 🟩 | 🟩 | 🟩 | | | | | | | | | | | | | | | | |
| **Phase 2: Enhance Reporting Systems** | | | | | | | **Phase 2 (3 months)** | | | | | | | | | | | | | | | |
| Revise FROI Forms | 2025-07-01 | 2025-09-30 | 3 | | | | 🟩 | 🟩 | 🟩 | | | | | | | | | | | | | |
| Define Reportable incidents | 2025-07-01 | 2025-09-30 | 3 | | | | 🟩 | 🟩 | 🟩 | | | | | | | | | | | | | |
| Communicate the Process | 2025-07-01 | 2025-09-30 | 3 | | | | 🟩 | 🟩 | 🟩 | | | | | | | | | | | | | |
| **Phase 3: Implement Job Hazard Analysis** | | | | | | | **Phase 3 (10 months)** | | | | | | | | | | | | | | | |
| Customize JHA Forms | 2025-07-01 | 2025-09-30 | 2 | | | | 🟩 | 🟩 | 🟩 | | | | | | | | | | | | | |
| Train JHA Usage | 2025-07-01 | 2025-12-31 | 5 | | | | 🟩 | 🟩 | 🟩 | 🟩 | 🟩 | 🟩 | | | | | | | | | | |
| Monitor JHA Effectiveness | 2025-09-30 | 2026-01-31 | 4 | | | | | | | 🟩 | 🟩 | 🟩 | 🟩 | | | | | | | | | |
| Expand JHA Coverage | 2025-10-31 | 2026-03-01 | 4 | | | | | | | | 🟩 | 🟩 | 🟩 | 🟩 | | | | | | | | |
| Integrate into Daily Operations | 2025-12-31 | 2026-03-31 | 3 | | | | | | | | | | 🟩 | 🟩 | 🟩 | | | | | | | |
| Incorporate Incident Investigations | 2026-01-01 | 2026-04-30 | 4 | | | | | | | | | | 🟩 | 🟩 | 🟩 | 🟩 | | | | | | |

# ALDOT Safety Program Implementation Timeline

**Program start:** 2025-03-31

**Program end:** 2028-12-31



| | Start | End | Duration (Month) | 10/2026 | 11/2026 | 12/2026 | 01/2027 | 02/2027 | 03/2027 | 04/2027 | 05/2027 | 06/2027 | 07/2027 | 08/2027 | 09/2027 | 10/2027 | 11/2027 | 12/2027 | 01/2028 | 02/2028 | 03/2028 | 04/2028 | 05/2028 | 06/2028 | 07/2028 | 08/2028 | 09/2028 | 10/2028 | 11/2028 | 12/2028 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Phase 5: Develop and Disseminate Safety Manual** | | | | Phase 5a (12 months) | | | | | | | | | | | | Phase 5b (12 months) | | | | | | | | | | | | | | |
| Define Objectives and Scope | 2026-10-01 | 2026-10-31 | 0 | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Assemble Development Team | 2026-10-01 | 2026-11-30 | 1 | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | |
| Draft General Information | 2026-12-01 | 2027-02-28 | 2 | | | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | |
| Reporting and Investigation | 2026-02-01 | 2027-04-30 | 14 | | | | | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | |
| Topic-Specific Guidelines | 2026-02-01 | 2027-05-31 | 15 | | | | | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | |
| Checklists and Inspection Guidelines | 2027-05-01 | 2027-06-30 | 1 | | | | | | | | ■ | ■ | | | | | | | | | | | | | | | | | | |
| Expert Consultation | 2027-06-01 | 2027-07-31 | 1 | | | | | | | | | ■ | ■ | | | | | | | | | | | | | | | | | |
| Distribute the Manual | 2027-07-31 | 2027-09-30 | 1 | | | | | | | | | | | ■ | ■ | | | | | | | | | | | | | | | |
| Continuous Improvement | 2027-09-30 | 2028-09-30 | 12 | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| **Phase 6: Implement Safety Rewards Program** | | | | | | | | | | | | | | | | Phase 6 (6 months) | | | | | | | | | | | | | | |
| Set Program Goals | 2027-09-30 | 2027-10-31 | 1 | | | | | | | | | | | | | ■ | | | | | | | | | | | | | | |
| Identify Target Behaviors | 2027-10-31 | 2027-12-31 | 2 | | | | | | | | | | | | | | ■ | ■ | | | | | | | | | | | | |
| Choose Reward Categories | 2027-10-31 | 2027-12-31 | 2 | | | | | | | | | | | | | | ■ | ■ | | | | | | | | | | | | |
| Develop Criteria for Rewards | 2027-12-31 | 2028-03-31 | 3 | | | | | | | | | | | | | | | | ■ | ■ | ■ | | | | | | | | | |
| **Phase 7: Evaluate and Improve Safety Program** | | | | | | | | | | | | | | | | | | | | | | Phase 7 (9 months) | | | | | | | | |
| Monitor Performance | 2028-03-31 | 2028-06-30 | 3 | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | | | | | | |
| Utilize Evaluation Tools | 2028-04-30 | 2028-07-31 | 3 | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | | | | | |
| Opportunities for Improvement | 2028-07-31 | 2028-12-31 | 5 | | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ |

ALDOT Safety Program Implementation Timeline

Program start: 2025-03-31

Program end: 2028-12-31

Duration