



Safety Concepts for Workers from an OSHA Perspective

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Kentucky Transportation Center
College of Engineering, University of Kentucky Lexington, Kentucky

in cooperation with
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Commonwealth of Kentucky

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Kentucky Transportation Center • University of Kentucky
176 Raymond Building • Lexington KY 40506 • 859.257.6898 • www.ktc.uky.edu



Research Report
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Safety Concepts for Workers from an OSHA Perspective

Zamaan Al-shabbani
Research Associate

Roy E. Sturgill, Jr., P.E.
Research Engineer

and

Gabriel B. Dadi, Ph.D., P.E., LEED AP
Professor of Civil Engineering

Kentucky Transportation Center
College of Engineering
University of Kentucky
Lexington, Kentucky

In Cooperation With
Kentucky Transportation Cabinet
Commonwealth of Kentucky

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16. Abstract Highway construction and maintenance workers face numerous hazards on job sites, many of which are unique by industry standards. Despite the exposure of state transportation agency employees and contractors to these hazards, there are few safety standards, regulations, programs that directly target the sector aimed at prevention and mitigation. To help the Kentucky Transportation Cabinet (KYTC) improve employee safety, researchers at the Kentucky Transportation Center (KTC) analyzed the frequency and causes of workplace injuries for 10 essential Cabinet maintenance operations. Most incidents were attributable to human factors or ergonomics. Based on this analysis, the leading causes of incidents, and a review of best practices related to workplace safety, KTC designed and built a pre-task safety tool applicable to the 10 KYTC maintenance operations. Developed in Microsoft Excel, the tool is straightforward and intuitive, addresses the most frequent hazards encountered on jobs sites, and can potentially be expanded to encompass all maintenance operations (once sufficient data are available). The tool contains three sections: 1) an introductory sheet with user instructions; 2) statistical summaries of previous injuries suffered by KYTC maintenance workers for each operation; and 3) examples of incidents that have resulted from each of the most frequent causes of injury and recommended safety practices to minimize or eliminate potential hazards. Site foremen or supervisors can use the tool to develop a pre-task safety talk on scheduled workday activities, their associated hazards, and specific measures to prevent or mitigate those hazards. KTC researchers delivered the pre-task safety tool to KYTC separately.			
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Executive Summary

Dangerous work environments permeate the construction industry. The many risks found on jobsites have led to the adoption of safety standards, regulations, and programs. Highway construction and maintenance workers encounter hazards that are unique by industry standards. Even though state departments of transportation (DOT) and contractors working in highway construction and maintenance are exposed to many hazards — both those associated with their work and those unrelated to adjacent traffic — few safety standards, regulations, and programs directly target the sector. Highway site safety remains an understudied topic, with safety research and programs receiving insufficient attention. This study focused on work-related hazards present, specifically those for highway maintenance workers.

As part of its continuing efforts to improve employee safety, the Kentucky Transportation Cabinet (KYTC) asked researchers at the Kentucky Transportation Center to create a data driven pre-task safety-talk tool. Researchers developed the tool after analyzing incident data on KYTC maintenance workers that covered a 10-year period (2005–2015). The tool applies to 10 common operations identified in the Cabinet’s Field Operations Guide. It will improve the safety performance of KYTC maintenance crews by 1) increasing workers’ knowledge and awareness of potential worksite hazards, and 2) introducing safety controls that can be adopted to prevent or minimize the likelihood of encountering such hazards. The easy-to-use tool will help foremen or supervisors prepare a pre-task safety talk specific to the upcoming workday’s activities before they commence. The talk will focus on potential hazards that workers can expect on the jobsite and specific measures to mitigate them. This tool can be expanded to cover other KYTC maintenance operations once data are available and can be improved based on safety performance.

Background & Scope of Work

Introduction

The construction industry is fraught with dangers. Workers on construction projects are exposed to many different hazards. Within the industry, highway construction and maintenance is often viewed as being more dangerous than other types of construction. Work taking place in locations adjacent to traffic passing at high speeds can endanger workers, while the large construction and maintenance equipment, massive amounts of material, and extreme environmental conditions found on highway work sites are hazardous as well. These conditions increase workers' exposure to different hazard types; the nature of this highway work and its associated hazards are unique compared to other types of construction. In fact, hazardous conditions at these work sites often make the job of maintaining safe working conditions more challenging than performing the highway work itself.

Maintaining a safe work environment is the responsibility of all project stakeholders, from top management to the labor workforce. In highway construction and maintenance work, this responsibility extends from the field staff to state departments of transportation (DOT) executives. Workers, supervisors, and all other individuals on the jobsite should be well-trained and knowledgeable, enough so to recognize potential hazards. At the management level, leadership should express a commitment to providing a safe work environment, with the goal of having zero fatalities and injuries. However, this goal is not easy to achieve. While DOTs have taken significant steps to improve safety performance and provide safe working environments for their employees, highway construction and maintenance is still marred by high rates of injuries and fatalities. With over 20,000 worker injuries and 133 fatalities recorded in work zones in 2012, the industry is still far from achieving its safety goal (FHWA, 2016).

State DOTs have dedicated numerous resources and implemented a variety of safety controls to create safe work environments for their employees. Based on study and analysis of worker injuries and fatalities, state DOTs attempt to understand the nature of workplace hazards, the root causes of incidents, incident types and their associated outcomes, and strategies for preventing incidents. Therefore, reporting and archiving data on worker injuries and their causes is a core pillar of most safety improvement programs. With any safety initiative of this type, data on injuries and fatalities are the main source for understanding safety issues and establishing or improving safety controls. Data-driven safety controls have proven effective in states across the country.

As part of the Kentucky Transportation Cabinet's (KYTC) efforts to improve employee safety, researchers at the Kentucky Transportation Center (KTC) were asked to create a data-driven design for a pre-task safety-talk tool. The tool KTC developed is based on previous incident data of KYTC maintenance workers, making it relatable and true-to-form for KYTC. The tool is intended for use prior to any workday task encompassing 10 of the typical work operations of KYTC maintenance workers listed in the Cabinet's Field Operations Guide. The goal of this safety tool is to improve safety performance of KYTC maintenance crews by increasing workers' awareness of — and capacity to anticipate — potential worksite hazards and introduce safety controls to prevent or minimize the possibility of encountering such hazards.

Problem Statement

There is significant room for improvement in the highway construction industry's safety culture, especially in the southeast region. Complacency abounds in an environment rife with uncontrollable hazards. Other states and regions have lower incidents rates than Kentucky, which suggests a learning opportunity exists for Kentucky's highway industry. This project synthesizes elements of safety performance and compiles best practices from numerous sources to establish guidance that will improve

the safety of highway work sites. This research does not represent an additional study in work zone traffic control safety, as attention has recently been focused on this area. This study focuses on the safety practices of workers who perform highway maintenance and construction work. It emphasizes Occupational Safety and Health Administration (OSHA) and Kentucky Occupational Safety and Health Program (KYOSH) standards. This reason for this is that four of the five worker fatalities that have occurred in KYTC work zones in the past several years were work-related, not traffic-related.

Every year the United States sees tens of fatalities and thousands of injuries in the highway construction industry. The hazardousness of work sites coupled with working near high-speed traffic are two principal reasons for the high injury and fatality numbers. Workers on highway construction and maintenance jobsites include contractor workforce and state DOT employees. State DOTs are responsible for maintaining a safe environment in highway construction and maintenance work zones for the public and their employees. Contractors are also responsible for providing safe jobsites; state DOTs should take an active role in maintaining the safety at these jobsites since their employees are also present. State DOTs have dedicated significant resources to create and improve safety controls that minimize personnel exposure to construction and maintenance work hazards, although there is always room for improvement if they are to achieve the goal of zero incidents. Health and safety data sources are used to create and implement preventive measures and improve existing safety practices. Because each state's transportation system is unique, many state DOTs have opted for individualized approaches to improving jobsite safety.

KYTC supervises the development and maintenance of over 27,000 miles of the state's transportation system. With approximately 4,800 employees, KYTC works to provide a "safe, efficient, environmentally sound and fiscally responsible transportation system that delivers economic opportunity and enhances the quality of life in Kentucky" (KYTC Mission Statement). With more than 2,000 maintenance employees, the Cabinet regularly performs a variety of maintenance operations across the state, exposing maintenance workers to different hazard types, which could easily lead to incidents. While the Cabinet has significantly bolstered its safety performance, it continues to work on improving its safety performance to provide safe working environments. In a July 2016 safety report, KYTC reported that its total recordable cases (TRC) declined from 5.5% in 2010 to 4.2% in 2015, total days away from work dropped 20%, worker compensation claims fell 30%, and the total number of claims decreased 43%. In addition to the safety performance improvement, spending on worker compensation claims fell \$2.5 million — from \$ 4 million to \$1.5 million per year (KYTC Annual Safety Report, 2016). However, KYTC realized that safety performance was not achieving its desired goals. While the Cabinet aims for a TRC of 5% or less, its latest report revealed a TRC rate above 15% when focused on field staff, which is appropriate since most of the work injuries reported come from maintenance employees. In 2015, 316 KYTC maintenance workers were injured during work operations (KYTC Annual Safety Report, 2016).

After carefully examining employee incident data, KYTC realized that it still needs to address safety hazards to achieve its safety performance goals. This motivated development of this project, the goal of which was to address the problem by 1) dedicating resources to analyze and understand the available data, and 2) creating safety measures to prevent and minimize similar injuries in the future. By increasing workers' awareness of potential safety hazards and outlining the proper safety measures to address them, KYTC will improve its safety performance.

Study Scope and Objectives

Originally, the project scope asked KTC researchers to analyze worker safety both within the KYTC construction contracting community and KYTC maintenance operations. However, obtaining data on construction safety practices and incidents in the contracting community proved difficult. In response, researchers modified the scope, refocusing the study strictly on maintenance operations, analyzing incidents within those operations, and identifying practices to mitigate incidents, where possible. Under

the revised work plan, the objective of this research was to provide guidance that would improve the safety performance of KYTC-managed construction and maintenance projects, with a focus on OSHA and KYOSH standards. It focused on safety measures used by KYTC and within the Kentucky highway industry, and on cataloguing guidance and benchmarks from surrounding states and other sources to chart a path toward lower incident rates. The purpose of this study was to improve the safety performance of KYTC maintenance workers by 1) increasing their awareness of potential hazards within their work environments, and 2) reviewing available best practices to prevent or minimize the possibility of incidents associated with such hazards.

The following tasks were undertaken to achieve the project's objectives:

- 1) Review literature and other DOT safety programs to identify effective safety measures to facilitate design of a safety tool.
- 2) Analyze historical health and safety data (2005–2015) on KYTC maintenance workers to understand the nature of hazards, incidents, their consequences, and potentially incident causes.
- 3) Determine best practices to address the hazards identified from data analysis.
- 4) Design a pre-task safety tool that can be used before the start of any workday operation to increase worker awareness of potential hazards and preventive safety controls.

The implementation of the final objective in delivering a pre-task safety tool would result through review of the tool by operation supervisors and be communicated to maintenance staff through pre-task safety talks. The previous tasks led to the development and delivery of the pre-task safety tool described in following sections of this report. The implementation of this tool will potentially be monitored through future research efforts.

Literature Review

The literature review focuses on highway worker safety and hazards research, including studies conducted at the national and local level. Researchers also investigated practices that minimize or eliminate employee safety hazards.

Overview

For decades, workers in the construction industry have experienced high injury and fatality rates. Highway construction and maintenance, while also characterized by high rates of injuries and fatalities, are considered especially hazardous. According to the Bureau of Labor Statistics, 844 worker fatalities occurred in road work zones between 1995 and 2002 (Pegula, 2004), 962 fatalities were recorded between 2003 and 2010 (Pegula, 2013), and 609 fatalities took place between 2011 and 2015 (Bureau of Labor Statistics, 2017). Road worker fatalities consistently account for 2% of all work-related fatalities in the United States, with no downward trend. These numbers do not capture those workers who survived or experienced close calls.

Kentucky has relatively high work zones incident rates. In the 2013 annual safety issue of *Transportation Builder*, an article stated that USDOT Region 4, which includes KYTC, has some of the highest work zone incident rates in the nation (Black, 2013). Recently, the KYTC Annual Employee Safety Report and Recommendations stated that the agency's safety performance fails not meet its desired goals (KYTC, 2016). Although KYTC initially appeared to meet its overall TRC target of 5% or less, it reassessed its findings after realizing more than 60% of KYTC employees work in an office setting and that most incidents are reported by maintenance employees. Further analysis led KYTC to conclude that its TRC rate for 2015 was likely more than 15%, which prompted the agency to identify and develop to safety controls to improve this figure.

Previous studies have addressed safety issues for KYTC employees. Hopwood and Palle (2004) reviewed KYTC safety issues related to construction activities for both Cabinet and contractor personnel. After interviewing KYTC resident engineers, as well as surveying and interviewing district safety coordinators, the authors recommended creating new safety programs and training initiatives, partnering with contractors and the Kentucky Department of Labor (including KYOSH), promoting changes in the KYTC policies, and increasing the role and support of safety coordinators. Hancher et al. (2007) sought to address research questions with more of a focus on hazards associated with work zones and vehicular traffic. Using surveys and focus group discussions, the authors examined safety concerns and identified best safety practices for highway maintenance workers. The survey elicited ideas and feedback from KYTC as well as private highway construction and maintenance workers. Based on feedback, recommendations were provided, such as adopting closed-cab tractors for mowers, placing LED stop signs on work sites, and using additional lighting for nighttime work. These projects helped inform and refine the current study.

Federal and Statewide Safety Standards and Practices

The federal government has introduced nationwide policies and standards to minimize risks presented to the public and workers in roadway construction and maintenance work zones. The *Manual on Uniform Traffic Control Devices* (MUTCD) outlines the mandatory work zone practices (FHWA, 2009). These standards include guidance on topics like setting up temporary traffic controls in work zones. Federal standards associated with highway construction and maintenance are focused on controlling traffic in work zones due to the high number of fatalities associated with vehicular accidents. Improving vehicle-worker interactions to reduce the risk faced by workers and drivers in highway work zones is a trend in highway construction safety research in general. OSHA establishes standards and regulations for the

overall construction industry, although few specifically target highway operations. These standards also apply to state DOTs but do not always cover all the work involved in highway construction and maintenance. To date, 21 states have developed state-specific safety and health plans that cover local and state government workers, including DOT employees (Gambatese et al., 2017). In Kentucky this body is KYOSH. However, many of its policies are not specifically addressed to the highway construction and maintenance industry. There are few federal safety standards and practices that directly attend to the safety of highway construction and maintenance workers. As a result — and due to the uniqueness of each state transportation system — state DOTs often develop individualized safety programs and practices.

A recent National Cooperative Highway Research Program (NCHRP) synthesis study reviewed existing state DOT safety programs. Researchers interviewed personnel from six states (California, Maine, North Dakota, Oregon, South Carolina, and Washington) to identify effective safety controls and programs. State safety programs were explored and discussed to highlight examples of safety improvements and draw attention to elements of these programs viewed as effective (Gambatese et al., 2017).

For example, California has introduced the “Safety for Safety Initiative,” a data-driven program focused on using data to identify issues that need improvement and inform landscape architects and engineers of problems they might need to address in the design phase. This is a proactive approach that helps minimize the risk of potential hazards in work zones. The program also solicits ideas and feedback from maintenance workers and communicates them to designers to help them better understand which actions can improve safety performance.

Maine initiated its “Safety Idea Incentive Program” in 2012, which encourages DOT employees to collaborate with fellow crew members on the development of the safety program by taking part in safety discussions. Each month, safety ideas were collected and evaluated to determine those most valuable and applicable. Members of the winning crew received 50 points, the equivalent of \$25. This program was in place from 2012 to 2014 and resulted in the adoption of many safety best practices. Less management-level intervention has been necessary given that the ideas received buy-in from work crews.

North Dakota created the “Leading Indicators Initiative,” where the state DOT records and analyzes different leading indicators (e.g., employee participation in self-inspections, first aid training, employee suggestion programs). Other leading indicators, such as employee participation in safety audits, are evaluated through employee activity in safety programs. The program’s main objective is to foster a new culture that proactively implements policies to improve safety rather than counting the consequences or evaluating lagging indicators.

A common thread among these practices is their data-driven approach to decision making. Most existing state programs are based on some combination of past health and safety data and feedback or ideas from employees, which highlights the importance of using accurate information to guide future decision making. In fact, data-driven decision approaches have been emphasized even at the federal level. FWHHA has made data-driven approaches to decision making a policy priority (Gambatese et al., 2017), which is evidenced by the agency’s overhaul of the Highway Safety Improvement Program (HSIP). The Fixing America’s Surface Transportation (FAST) Act transformed this into a much more data-driven decision program. It can be concluded that data driven decision making is an effective approach to designing safety control to improving safety performance, as is the case of this study.

Methodology

This goal of this study was to develop a tool that would improve the safety of KYTC maintenance operations. The expectation was that analysis of recordable incident data would indicate areas in which safety improvements are needed. The literature review offered some insights into best practices to mitigate those safety problems. The aim of the tool was to present this information succinctly and clearly. After reviewing guidance from the tool, employees would begin their workdays knowledgeable about 1) the hazards typically associated with the operations they were slated to perform, and 2) techniques to prevent or mitigate those hazards. As a starting point, KTC researchers collected and analyzed KYTC incident data on maintenance operations. Data were grouped according to typical maintenance operations; best practices were organized based on the hazards present for typical operations. The following sections further elaborate on the methodology and analysis, which informed development of a comprehensive tool that could be used with KYTC maintenance employees.

Data Collection

KYTC works with the Risk Management Services Company to collect and track recordable incidents along with their associated severity, lost time, and costs. KYTC recordable incident data were gathered for a 10-year period (2005–2010) and pared down to include only KYTC maintenance employee incidents. Data were categorized according to the code of the National Council of Compensation Insurance (NCCI), resulting in 3,876 claims. The dataset included claimant information (e.g., age, work title) and incident information, (e.g., incident location, its date and time, incident causes, incident description). Some data entries were missing information. Where possible, researchers reviewed such data to determine whether to include them in the ensuing analysis. After removing records with incomplete data, over 3,000 remained. The lack of detailed descriptions of incidents within the data was a leading factor in recommending an improved process and requirements for incident data collection and reporting.

Data Mining and Analysis

Data were analyzed in a three-phase process to work toward development of the safety tool. The data were first analyzed for trends regarding the maintenance operations during which incidents occurred. Incidents were further analyzed to identify their main causes within separate operations. Finally, effective safety practices were aligned with these causes and incidents to present methods for hazard mitigation.

Phase I: Incident Categorization by Maintenance Operation

KYTC's Field Operations Guide for Maintenance states that the Cabinet has approximately 17 maintenance work operations. Phase I analysis categorized incident data according to these 17 work operations. Doing so helped KTC work toward the design of a tool that would provide best practices to KYTC maintenance workers according to their maintenance work operations. Unfortunately, the incident data lacked systematic references that linked the claim to the work operation it stemmed from. Therefore, the research team categorized the injuries according to work operations by carefully examining the details of the incident data, such as the incident description and causes, incident location, and claimant work title. The incident description and causes were especially helpful for this intensive data analysis.

Because some claims were missing information, and due to the inaccuracies introduced during collection and recording of the data, there appeared to be data available aligning with only 10 of the 17 KYTC typical maintenance work operations (Table 1). Because there was not information about the seven remaining operations, the final tool does not apply to them. This highlights the importance of further standardizing incident recording and reporting practices and potentially establishing *operation* as a field for incident data.

Categorizing the data let researchers convert some qualitative aspects of the incident data into quantitative data. The frequency of incidents related to the 10 operations was then calculated. Categorizing the data let researchers identify the most frequent causes of incidents for each work operation.

Table 1 Selected KYTC Maintenance Work Operations

1- Concrete repairs and Bridge maintenance
2- Equipment maintenance
3- Guardrail maintenance
4- Litter and debris removal
5- Mowing
6- Pipe / drain clearing and replacement
7- Road and Shoulder repairs
8- Sign inventory and replacement
9- Snow and ice removal
10- Tree and brush trimming

Phase II: Identification of Leading Incident Causes

After categorizing and organizing the data according to the 10 applicable maintenance operations, the research team worked to identify the most frequent causes of incidents for each of the selected operations. Causes were classified using NCCI codes. Some similar causes, such as lifting, holding or carrying, and object being lifted were combined because they represent similar activities and are associated with similar injuries. For each operation, 5–6 of the most frequently cited causes were identified. In total, 12 causes were identified as the most frequent incident catalysts. These 12 causes and their annual frequency (averaged over the data period, 2005-2015) are shown in Table 2.

Some incident causes, such as lifting, appear in all the operations and rank at the top of this list with the highest frequency (64.1 incidents/year). Many of the incidents were caused by human factors and ergonomics. For example, most of the incidents caused by falling from a different level (ranked third) were triggered by exiting a vehicle or getting into or out of a truck bed. In these incidents, human factors, such as expectancy, were key contributors to workers’ behavior. This is a critical finding, as there a few practices that currently address human factors and ergonomics for such scenarios. OSHA requires workers to use fall protection when working from a height of more than six feet, however, most of the fall incidents observed in this study occurred from a height of less than six feet. These incidents caused varying types of injuries with varying levels of severity. While OSHA guidance may be effective at preventing more severe incidents at heights greater than six feet, the findings of this study suggest that human factors and ergonomics should be addressed, possibly through considerations in the design phase.

Table 2 Overall Top Frequent Incident Reasons

Top Frequent incident causes	Frequency
1- Object being lifted or handled	641
2- Falling or flying objects	313
3- Fall from different level	239
4- Hand tool or machine in use	189
5- Pushing or pulling	149
6- Foreign matter in the eye	143
7- Fall on ice or wet floor	141
8- Chemicals, liquids, or vapors	115
9- Vehicle upset	106
10- Animal or insect	99
11- Stationary or sharp objects	62
12- Hot object and temperature extreme	47

Phase III: Identifying Safety Best Practices

As noted in the literature review, states develop individualized safety programs to address issues unique to their transportation systems. Federal regulations and standards offer little to address the issues revealed in this study. There is a significant knowledge gap in standardized effective safety practices directly applicable to specific highway maintenance operations, especially related to human factors and ergonomics. To compensate for this, the research team collected and reviewed safety practices resources based on the following criteria:

- 1- Practices addressing specific frequent safety issues (operation-specific when possible)
- 2- Safety resources produced through academic research
- 3- Safety practices presented in industry guidance
- 4- Government regulations and standards

Based on these criteria, the following resources were identified for collecting effective safety practices:

- 29 CRF 1926 OSHA regulations
- OSHA ergonomics E tool
- Safety tool kits of Kansas State University
- Safety tool kits from University of New Hampshire
- Safety tool kits from University of Washington
- Roadway Safety training program
- Construction solutions by CPWR
- NIOSH standards
- Other States employees' health manuals
- Others

After compiling and reviewing safety practices, similar ones were consolidated and the details condensed to abbreviate the presentation within the safety tool. In other words, the intent of the safety tool is not to

offer exhaustive training. Its goal is to present practices quickly and succinctly such that its use proves effective but not time-consuming.

Design of the Safety Tool

The safety tool should be used before the workday's planned operations to highlight potential hazards and describe mitigation measures. The foreman and supervisors can then use this information to prepare a customized pre-task safety talk tailored to the workday's operation that covers the specific hazards that will be present, how those hazards have historically injured KYTC maintenance workers, and preventive and mitigation techniques. The tool's purpose is to increase worker awareness of the potential hazards and recommend safety practices to avoid or minimize the potential risk of these hazards.

The tool was designed with the following characteristics in mind:

- 1- Simple and intuitive to use and understand
- 2- Quick to complete
- 3- Addresses the top frequent potential hazards
- 4- Expandable to all maintenance operations
- 5- Updatable to accommodate improvements based on safety performance

Researchers designed and developed the tool in Microsoft Excel since it is easy to use and accessible to KYTC employees. Incompatibility and platform accessibility concerns also steered the research team away from a mobile device platform and web-based applications. Number of buttons in the tool was minimized to maintain its simplicity.

The tool contains three main sections. The first section is an introductory sheet that provides user instructions (Figure 1). The second section statistically summarizes previous injuries incurred by KYTC maintenance workers for each operation, and the most frequent incident causes (Figure 2). The third section of the tool presents examples of previous incidents triggered by each of the most frequent causes and outlines suggested safety practices to minimize or eliminate potential hazards (Figure 3). These sections are formatted to fit on a single computer screen without having to scroll. The tool includes graphic illustrations of practices that require additional explanation (Figure 4), with the goal of increasing workers' understanding and reducing the amount of time required to use the tool.

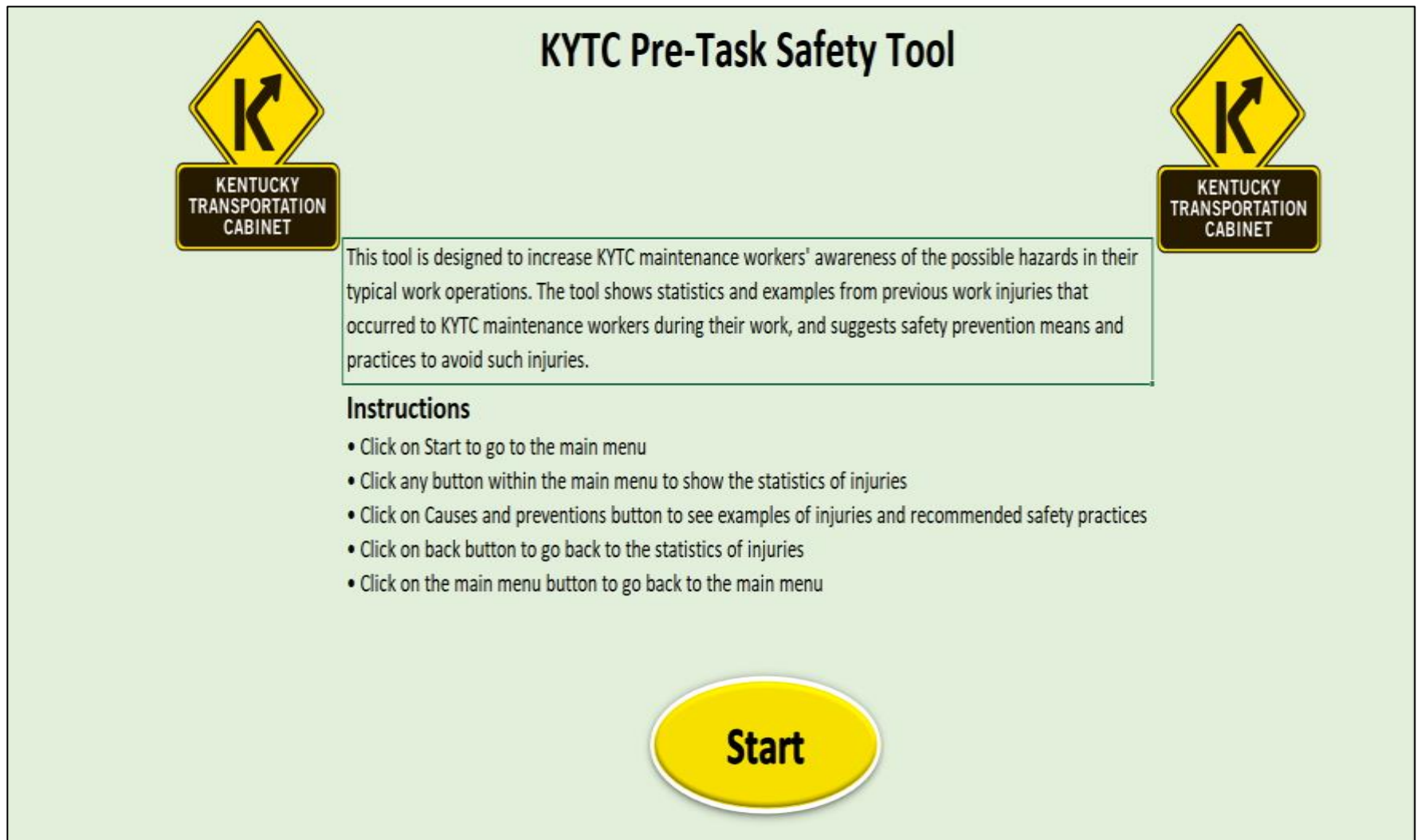


Figure 1 Introductory User Form of Tool

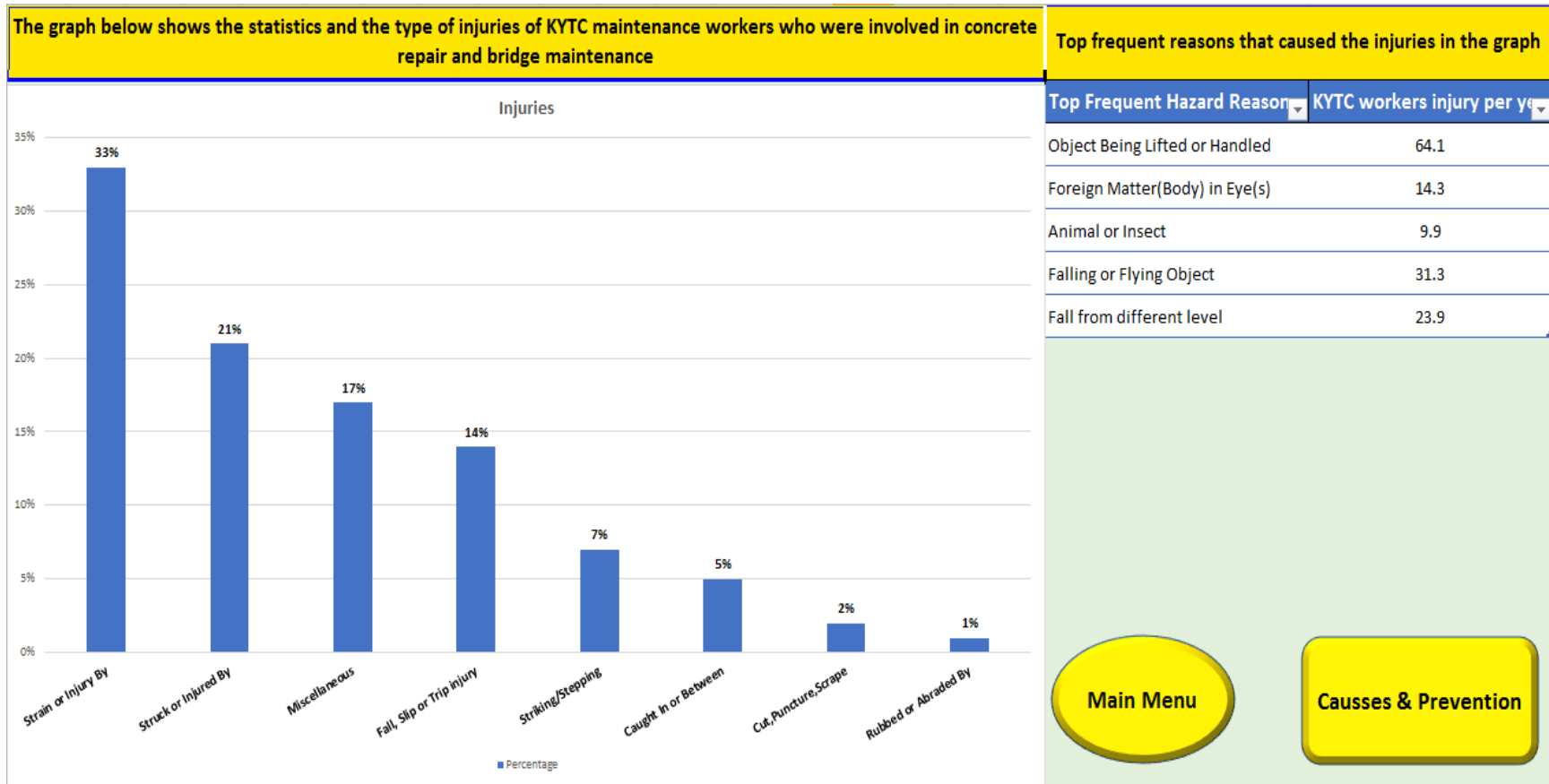


Figure 2 Statistics of Injuries and Associated Reasons of KYTC Maintenance Employees

Top Frequent Hazard Reasons	KYTC workers injury per year	Examples	Safety Best Practices
Object Being Lifted or Handled	64.1	<ul style="list-style-type: none"> Worker hurt his back and stomach while lifting concrete saw Worker twisted his knee and hurt his back while lifting and carrying concrete forms Worker injured his back and shoulder while lifting concrete bags Worker injured his back and neck while lifting and carrying concrete cylinders Worker strain his back while lifting bridge beam and metal decking 	<ol style="list-style-type: none"> Use proper lifting means or have someone to help you when you lift heavy tools, such as concrete saw. When you unload heavy items, such as concrete saw or steel beams, try to lift them while they are placed within the power zone (Click Demo for details) When you perform concrete form work, use proper mechanical lifting means or have someone to help you If meachanical lifting means are not available or possible to use, lift heavy items, such as concrete bags, with your legs not with your back and try to maintain straight spine while lifting them (Click Demo for details) When you lift or carry heavy items, try to keep them close to your body to reduce back injuries. Do not twist or bent your waist while lifting, carrying, or holding heavy items, such as concrete bags, forms, and saws.
Foreign Matter(Body) in Eye(s)	14.3	<ul style="list-style-type: none"> Wind blew concrete dust into workers eyes Worker got debris in his eye while cutting concrete using saw Worker was installing concrete forms and wind blew debris in his eyes Worker got something in his eyes while pouring concrete Worker was stripping forms on bridge and got an object in his eye 	<ol style="list-style-type: none"> Always wear eye protection, such as safety glasses or goggles. Before start working on concrete saw, inspect the saw to make sure it has the proper safety guarding. Whenever possible, use saws equiped with vacume or wet dust suppression system. Familiarize yourself with the manual and instructions attached with concrete saw Some concrete saws have safety shut off button, try to locate it and try it before starting your work.
Animal or Insect	9.9	<ul style="list-style-type: none"> Worker was bitten by insect while he was inspecting the bridge Wroker was working on bridge repair and a spider bit him on his hand 	<ol style="list-style-type: none"> Wear long sleeved shirts and pants Use insect repellants Check for tick bites each work day for lyme disease (red bullseye) In case of bite, remove the stinger and clean the area Apply cold pack for the first 24 hours, if pain persists apply hot pack For any problems, get prompt medical/first aid treatment or seek doctor help
Falling or Flying Object	31.3	<ul style="list-style-type: none"> While cutting concrete using saw, worker was struck by a piece of concrete Worker was struck by a falling rock while he was working under bridge While pouring concrete, concrete chute flew and struck worker's head 	<ol style="list-style-type: none"> Always wear PPE including, but not limited to, hard hat and safety glasses. Use facial, ear, and eye protection if your work include concrete cut When workeing under bridges, always be aware of falling objects especially in high wind work days
Fall from different level	23.9	<ul style="list-style-type: none"> Worker fell from back of truck while unloading concrete chute 	<ol style="list-style-type: none"> Avoid lifting or carrying items while moving between different level locations. Whenever possible, unload items while you are on the ground. Do not hold, carry, or lift items that block your sight line. Doing so increases potential fall hazards. When you get on and off truck bed, always maintain three point of contact (two legs and one hand or two hands and one leg)

Figure 3 Examples of Previous Incidents and Recommended Best Practices

Power Zone Lifting

Back



The power zone for lifting is close to the body, between mid-thigh and mid-chest height. Comparable to the strike zone in baseball, this zone is where arms and back can lift the most with the least amount of effort.



Always try to lift heavy weights from a position within the power zone. This minimizes the possibility of injuries, especially back injuries.

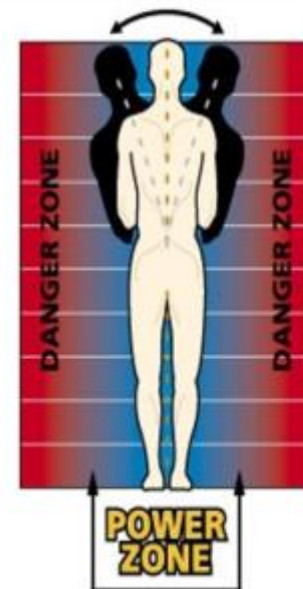


Figure 4 Demonstration of Recommended Lifting Practice (Power Zone Lifting)

Conclusion

The risks and hazards associated with jobsites in the construction industry make for a dangerous work environment. As such, many safety standards, regulations, and programs have been introduced to improve worker safety. Highway construction and maintenance is a unique part of this industry, and while many of its hazards are idiosyncratic, there are few safety standards, regulations, and programs that have been implemented with them specifically in mind. This work is often considered more dangerous than other types of construction due to the proximity of work sites to the passing traffic. Often this work is performed outside, and occasionally at night. Due to the dangers associated with traffic and vehicular accidents, the focus of safety programs and research is mostly dedicated to work zone issues. State DOT employees and contractors working in highway construction and maintenance are exposed to a variety of unique hazards specifically associated with their work but which are unrelated to adjacent traffic. Highway site safety related to personnel does not receive sufficient attention in terms of safety research and programs. Data analysis presented in this study highlighted that human factors and ergonomics play an underappreciated role in injuries suffered by highway construction and maintenance workers, yet little guidance or standards exist to address these issues.

After analyzing data associated with incidents involving KYTC maintenance employees over a 10-year period (2005-2015), researchers developed a pre-task safety tool applicable to ten operations. Adopting this tool will help supervisors communicate safety concerns to their staff and increase maintenance workers' awareness of the potential jobsite hazards. Additionally, the tool recommends safety practices for individual work tasks to prevent or minimize the risk of such hazards. Researchers designed the tool after carefully examining and analyzing incident data. After determining the leading causes of incidents associated with each maintenance operation and identifying best practices for addressing these hazards, researchers produced an electronic tool that KYTC maintenance crews can use prior to any work day. The tool intuitive and will ideally help foremen or supervisors prepare a pre-task safety talk that applies to scheduled work activities, identifying their associated hazards and specific measures for mitigating hazards. This tool can be expanded to include all KYTC maintenance operations once data are available and can be improved based on safety performance.

Recommendations and Future Work

Due to incomplete or unavailable data, the tool does not cover all 17 typical maintenance operations listed in KYTC's Maintenance Field Operations Guide. Therefore, the research team suggests developing data collection standards that may report work operations in a standardized manner in KYTC process manuals. Detailed descriptions and enhanced coding of incidents should be considered to ensure sufficient descriptions of claims are available, which can improve our understanding of incident causes and identification of ways to mitigate hazards in the future. One possible area for investigation is to examine other state DOT data collection and archiving practices. This will help KYTC expand and improve the tool and assist with evaluations of safety performance. Having accurate data will help to establish a robust benchmarking and evaluation system for future safety programs. They can also help KYTC personnel adopt a more informed data-driven approach to decision making.

Assessing the impacts of the safety tool by testing workers' knowledge before and after its use also merits consideration. The goal of such a study would be to evaluate the hazard recognition abilities of the maintenance staff and determine if the tool's use improves those abilities. As part of this study, the researchers could examine the relationship between hazard recognition ability of maintenance crews and the implementation of safe practices. Studying maintenance crews in the field would let researchers determine whether the safety programs resonate and identify areas that require further attention, in turn

helping KYTC improve its safety culture. It would also help the Cabinet understand the value of preventive safety practices and what drives the priorities and behaviors of maintenance personnel. This proposed study would result in an evaluation of KYTC's maintenance safety culture and safety citizenship, allowing for performance measurement and improvement.

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