



## KENTUCKY TRANSPORTATION CENTER

### **IMPROVE SAFETY OF WORKERS DURING HIGHWAY CONSTRUCTION AND MAINTENANCE**



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**Research Report  
KTC-07-16/SPR323-05-1F**

## **Improve Safety of Workers During Highway Construction and Maintenance**

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**In cooperation with the Kentucky Transportation Cabinet**

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16. Abstract <p>There is an inherent risk of injury or fatality in all occupations. Even secretarial occupations face jobsite hazards such as carpal tunnel and back injury. The nature of the construction industry combined with the required physical demand and rigorous work processes, make it an industry with higher risk of injury or fatality. In an effort to decrease that inbuilt jobsite risk that construction workers face, this study will analyze the current best safety practices, examine new safety technologies, and collaborate with construction workers themselves to gain a better perspective of what jobsite hazards they face.</p> <p>Specifically, this study which is entitled, "Improve Safety of Workers during Highway Construction and Maintenance," will focus on highway construction worker safety. Most all statistical data gathered will be from Kentucky construction workers, although the study is not limited by this. Studies of this nature have been completed previously, but most studies neglect to consider maintenance highway workers who encounter many of the same hazards as construction workers, and some would argue that they encounter even more hazards than construction workers.</p> <p>After analyzing all of the surveys conducted, the statistical analyses performed, and the literature reviewed, the research team has derived recommendations that we suggest that the KYTC and contractors implement in an effort to reduce workplace accidents and fatalities for construction and maintenance workers.</p>					
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## TABLE OF CONTENTS

EXECUTIVE SUMMARY .....	iv
1.0 INTRODUCTION .....	1
1.1 Problem Statement .....	1
1.2 Background and Significance of Work.....	1
1.3 Goals and Objectives of Study.....	2
2.0 LITERATURE REVIEWS .....	3
2.1 Relevant KYTC Studies.....	3
2.2 General Safety Issues in Construction .....	3
2.3 U.S. Studies Focusing on Highway Worker Safety .....	4
2.4 “Safety Climate in Construction Site Environments” .....	6
2.5 Evaluation of the Use of Rumble Strips .....	7
2.6 Balsi Beam .....	8
2.7 Robotic Safety Cones.....	8
2.8 Contractor Prequalification Based on Safety .....	9
3.0 PRELIMINARY DATA COLLECTION .....	11
3.1 First Survey .....	11
3.1.1 Purpose of Survey .....	11
3.1.2 Survey Composition .....	11
3.1.3 Survey Distribution.....	12
3.1.4 Survey Results .....	12
3.2 KYTC District Meetings.....	17
3.2.1 Format of District Discussion Sessions .....	17
3.2.2 Important Concerns Discussed During District Meetings .....	17
4.0 FINAL DATA COLLECTION.....	31
4.1 Safety Climate Survey of KYTC Workers .....	31
4.1.1 Purpose of Survey .....	31
4.1.2 Survey Composition .....	31
4.1.3 Survey Distribution.....	31
4.1.4 Survey Results .....	31
4.2 Final Safety Survey of KYTC and Contractor Workers.....	32

4.2.1	Purpose of Survey .....	32
4.2.2	Survey Composition .....	33
4.2.3	Survey Distribution.....	33
4.2.4	Survey Results .....	34
5.0	DATA ANALYSIS.....	35
5.1	Safety Climate Survey .....	36
5.1.1	Summary of Detailed Statistical Analyses of Safety Climate Survey .....	36
5.2	Final Survey.....	38
5.2.1	Summary of Detailed Statistical Analyses of Final Survey.....	38
6.0	FINAL SURVEY PROBLEM STATEMENTS & PROPOSED SOLUTIONS ..	42
6.1	Analysis of Methods to Improve Safety on KYTC Projects.....	42
6.2	Analysis of Methods to Improve Safety on Highway Construction Projects .....	49
7.0	SUMMARY AND RECOMMENDATIONS.....	54
7.1	Report Conclusions.....	54
7.2	Future Research .....	55
7.3	Recommendations.....	55
7.3.1	KYTC Recommendations .....	56
7.3.2	Contractor’s Recommendations.....	59
8.0	BIBLIOGRAPHY .....	61
9.0	APPENDICES .....	63
APPENDIX A:	RESEARCH WORK PLAN .....	64
APPENDIX B:	WORKER SAFETY COMMITTEE.....	69
APPENDIX C:	COMMITTEE MEETING MINUTES .....	71
APPENDIX D:	FIRST SAFETY SURVEY.....	80
APPENDIX E:	FINAL SAFETY SURVEY .....	88
APPENDIX F:	SAFETY CLIMATE SURVEY.....	92
APPENDIX G:	KYTC DISTRICT MAP .....	96
APPENDIX H:	SURVEY LETTER.....	98
APPENDIX I:	STATISTICAL ANALYSIS FOR CLIMATE SURVEY .....	100
APPENDIX J:	STATISTICAL ANALYSIS FOR FINAL SURVEY .....	114

## LIST OF TABLES

Table 1: Fatalities in the Highway and Street Construction Industry.....	5
Table 2: KYTC Climate Survey Responses.....	32
Table 3: KYTC Final Survey Responses.....	34
Table 4: Contractor’s Final Survey Responses.....	34
Table 5: Geographic Classification of KYTC Districts.....	35
Table 6: Climate Survey Statements.....	37
Table 7: Climate Survey – Western Kentucky.....	37
Table 8: Climate Survey – Central Kentucky.....	38
Table 9: Climate Survey – Eastern Kentucky.....	38
Table 10: Safety Survey Statements.....	39
Table 11: Safety Survey – Western Kentucky.....	40
Table 12: Safety Survey – Central Kentucky.....	40
Table 13: Safety Survey – Eastern Kentucky.....	41

## **EXECUTIVE SUMMARY**

This two year study funded by the Kentucky Transportation Cabinet (KYTC) entitled “Improve Safety of Workers During Highway Construction and Maintenance” which will be referred to as “Worker Safety Study,” has two primary objectives:

1. Identify best safety practices for workers on highway construction projects.
2. Identify best safety practices for workers on highway maintenance projects.

Highway workers from both construction and maintenance divisions are injured or killed everyday in the United States. Since the Occupational Safety & Health Act (OSHA) of 1970, the number of workplace accidents has decreased dramatically, yet there are still around 1,200 deaths on average per year in the United States due to construction related activities. Although there have been many previous studies conducted on worker safety in general, few of these studies pertain to highway construction, and even less to highway maintenance. This study has focused on improving the safety of highway maintenance operations in Kentucky. However, the results of this study could be used by any other transportation agency to improve the safety of their highway workers.

The study began by analyzing statistical information produced by the Kentucky Division of Safety & Health, trying to determine the cause for the most frequent construction related accidents across the state. Analyzing historical data such as back injuries, fall from heights, heavy equipment operations, etc., it became obvious that the information produced by this data collection would be of limited value due to the vague nature of the statistical breakdown of the presented data. It was for this reason that the research team decided to seek input from the workers to find out what problem areas they face at the jobsite, and what hazards they feel could be prevented. However, the research team did not limit their information collection to only field workers, we also wanted to gain input from managers as well as engineers. This led to the creation of the first survey for the project.

The first survey distributed was an open ended survey designed to allow the surveyed employee free writing space to discuss their thoughts, opinions, or suggestions on the stated subjects. Some of the stated subjects were mowing operations, heavy equipment operations, debris removal, jobsite communication, etc. This survey was not designed to be analytical in nature; the intent was to give the project backbone information on what workers feel about certain areas so that we could later derive an analytical rating type survey that could be distributed statewide to all available maintenance and construction workers. The research team reviewed and recorded all of the information from the first survey and was able to match similar responses into groups which led to the identification of statewide trends.

Although the information gained from the first survey was useful in the creation of an analytical survey, the research team wanted to reach more workers and find out how they actually felt about issues that were on the survey, or other issues that were not mentioned. Also, the research team knew that some workers were hesitant to fill out the first survey do to its open ended style of answering which takes time and thought to respond to. It was for this reason that the research team traveled across the state holding focus group meetings with each of the 12 districts in Kentucky. These meetings were

began with a short introduction to our study then followed by a brief survey derived from the responses gained from the first survey with the intent of presenting workers with topics to converse about. At the conclusion of the survey session the research team began a dialogue with the workers in which we were able to gain valuable information about the realities of the construction and maintenance professions across the state. We kept notes for each meeting and later compiled them. At this point in the study we had gained responses from workers twice, yet neither of the responses were analytical in nature. However, with the information gained from both the first survey and the district meetings, we were able to create the final survey which was an analytical survey.

The final survey was derived from all previous project information. It contained 15 statements and allowed the surveyed employee to rate the importance of the statement based on a rating scale of 1 to 3. The final survey was distributed to every maintenance barn and resident engineer's office in the state and enough surveys were returned to complete a reliable statistical analysis. At this point, we were able to gain adequate information from contractor's workers in Kentucky.

By using an analysis of variance (ANOVA) with a required level of significance of 0.30, the final survey statements were broken down into four levels of importance. These four rankings were developed for each of three job classifications in each of three geographic regions of the state. The statistical analysis performed on the final survey data revealed the four most significant safety improvements needed for the KYTC and Kentucky highway contractor employees. For the entire state, these four ways for improving highway worker safety as identified by KYTC and highway contractor employees are as follows:

- Use of Alternating Back-up Alarms
- Use of Automatic Shutoff for Tractors
- Improved Two-way Radio Devices
- Improved Traffic Citation Enforcement

Along with the final survey, the research team also sent out the climate survey which was designed to measure worker's perceptions of their organizations commitment to safety. This survey was also analytical in nature and consisted of several questions and statements in which the workers rated on a scale of 1 to 5.

By using an analysis of variance (ANOVA) with a required level of significance of 0.30, the safety climate survey statements were broken down into four levels of importance. These rankings were developed for the KYTC construction and maintenance employees located in each of three geographic regions of the state. The statistical analysis produced results that showed the top six concerns across the entire state. These major concerns among the KYTC employees with respect to the perception of the importance of safety are as follows:

- Co-workers Involved in Accidents
- Not Practical Safety Rules and Policies
- Avoided Safety Procedures
- Complex Rules and Procedures
- Shortcuts at the Expense of Safety
- Use of Defective Equipment

Aside from surveys and focus groups, the research team also reached out to other transportation agencies to see how they are protecting their workers. There are several states that are using innovative measures to slow down traffic in work zones such as:

- Disguising police officers with radars as construction workers in work zones and radioing ahead to police officers in cruisers to pick up speeding vehicles
- Training their police officers in OSHA compliance and give them authority to enforce OSHA rules to workers.

There are emerging safety technologies such as the balsi beam which is a mobile work zone protection device that is highly portable and highly successful at protecting workers from vehicles entering a work zone. Also robotic safety cones are an emerging technology that will reduce the need for workers to move safety cones in mobile work zones because the safety cone has a motor and GPS guidance system built into its base.

In addition, some state transportation departments have used various safety measurements like Experience Modification Ratio and data from the OSHA 200/300 log in their contractor prequalification requirements. Both Virginia and North Carolina Department of Transportations set minimum criteria used to determine if either a contractor can bid on a transportation project and/or the number and size of projects a contractor can be awarded.

After analyzing all of the surveys conducted, the statistical analyses performed, and the literature reviewed, the research team has derived the following guidelines that we suggest that the KYTC and contractors implement in an effort to reduce workplace accidents and fatalities:

#### KYTC Implementation Strategies

1. Improve Two Way Radio Quality and Consistency
2. Improve Personal Protective Equipment Selection and Availability
3. Increase First Aid Training and First Aid Kit Availability
4. Require all Mowing Tractors to have Debris Protection Device around Cab
5. Revise Current Law Enforcement Policy for Work Zones
6. Train Managers on Importance of Safety Devotion
7. Issue LED Stop Signs to all Maintenance Crews
8. Revise Lane Closure Policy
9. Require OSHA Training for all KYTC Workers
10. Introduce Safety Prequalification
11. Increase use of Speed Display Trailers
12. Continue Evaluation of Worker Safety

#### Contractor Implementation Strategies

1. Improve Two Way Radio Quality and Consistency
2. Train Managers on Importance of Safety Devotion
3. Issue LED Stop Signs to all Construction Crews
4. Require OSHA Training for all Employed Workers
5. Increase use of Speed Display Trailers
6. Improve Availability of Lighting for Night Time Construction
7. Increase Use and Quality of Project Safety Orientation
8. Continue Evaluation of Worker Safety

## **1.0 INTRODUCTION**

### **1.1 Problem Statement**

The construction industry has historically encountered far more injuries and fatalities than it statistically should. According to the 2005 Bureau of Labor Statistics Report for Kentucky, the construction industry represented 4.58% of the statewide employment, while it accounted for 11.48% of the statewide fatalities. (Bureau of Labor Statistics, 2005) In theory, a represented industry should produce equal proportions of fatalities with respect to its relative market size; however, this is not true because some industries contain more risk than others.

There is an inherent risk of injury or fatality in all occupations. Even secretarial occupations face jobsite hazards such as carpal tunnel and back injury. The nature of the construction industry combined with the required physical demand and rigorous work processes, make it an industry with higher risk of injury or fatality. In an effort to decrease that inbuilt jobsite risk that construction workers face, this study will analyze the current best safety practices, examine new safety technologies, and collaborate with construction workers themselves to gain a better perspective of what jobsite hazards they face. After all, the best way to improve jobsite safety is to eliminate risk by designing the risk out of the system. If there is no way to design risk out of the system, we must use artifacts to minimize the risk. Collaboration with Kentucky construction workers will help us realize which risks can be designed out, and how to minimize the risks that can not be avoided.

Specifically, this study which is entitled, “Improve Safety of Workers during Highway Construction and Maintenance,” and will be referred to as, “Worker Safety Study” in this report, will focus on highway construction worker safety. Most all statistical data gathered will be from Kentucky construction workers, although the study is not limited by this. Studies of this nature have been completed previously, but most studies neglect to consider maintenance highway workers who encounter many of the same hazards as construction workers, and some would argue that they encounter even more hazards than construction workers.

### **1.2 Background and Significance of Work**

Since the Occupational Safety & Health Administration (OSHA) Act of 1970, construction workplace injuries and fatalities have decreased significantly; however, it still accounts for around 1,200 deaths per year on average in the United States. There have been numerous research studies focusing on improving the safety of construction workers, but relatively few of these studies are focused on highway construction. Even less of these studies discuss maintenance workers. Also, many hazards are specific to certain geographical regions, such as hazards relating to altitude, or extreme temperatures. This being said, not every previous study completed is entirely relevant to Kentucky construction workers.

This study is completely focused on improving the safety of highway workers in Kentucky. Kentucky is a diverse state, with both mountainous and semi-plains regions. Differences in terrain directly affect the roadways in that area, and also the conditions and hazards that highway workers face while constructing and maintaining those roadways.

This study is particularly significant to Kentucky highway workers because its outcomes are intended to become implemented by the Kentucky Transportation Cabinet (KYTC). Specific hazards and risks will not be disregarded due to the financial impact of their implementation. This study will present solutions to known problem areas and link the solutions to a reduction in injuries and fatalities.

### **1.3 Goals and Objectives of Study**

At the outset of this research study, two main objectives were identified as the primary outcomes of the final report, those being:

1. Identify best safety practices for workers on highway construction projects.
2. Identify best safety practices for workers on highway maintenance projects.

The outcome of this study is intended for use by both the KYTC and contractors. It is for this reason that we are not limiting our information collection system to only KYTC workers. Contractors were also surveyed to identify their specific problem areas. Although most of the data collected in this study will come from KYTC workers, the data collected from contractor's workers was analyzed separately so that a precise action plan can be recommended, based on the alternate organizational structures that the KYTC and contractors utilize.

The recommended action will be based on traditional means of research, such as literature reviews, surveys, and focus groups. This study has been ongoing since August 2005, and much of the literature review for the project has already been completed. However, the project research team has continued literature review in an effort to keep up to date on recent relevant research.

This study also used focus groups to gain conversational feedback concerning current safety practices and alternative viewpoints concerning preliminary suggestions to safety issues. Each district had its own focus group which our research team met with. Members of the focus groups included laborers, operators, foreman, superintendents, project engineers, project managers, and district engineers.

The backbone of this study is based on the results of surveys conducted throughout the two year project duration. These surveys will be described later in this report. Each survey is progressive from the previous survey issued before it. The second survey is derived from the first survey, and the third survey is derived from the second survey. This being said, the statistical analysis completed on the final survey is where the research team will look to determine its recommendations.

## **2.0 LITERATURE REVIEWS**

### **2.1 Relevant KYTC Studies**

The Kentucky Transportation Center has conducted studies on highway construction safety in past years, but they focused on the traveling public's impact and involvement on worker safety. These studies discuss different work zone configurations and their ability to reduce traffic accidents. Other studies look into new technologies used to monitor speeds, provide drivers with up-to-date information concerning delays and stopped traffic, and provide added protection to workers if a vehicle enters the work zone. These studies are extremely important to the safety of both workers and drivers; however, they are not the focus of this study.

One of the studies completed by KYTC in recent years was of great relevance to the Worker Safety Study. "*Safety and Health Concerns for KYTC and Contractor Personnel*" ("S&H Concerns") was completed in the Fall of 2004 by Theodore Hopwood, II and Sudhir Palle. The Worker Safety Study will serve as a compliment to their study.

The objectives of Hopwood's study were to identify all safety and health (S&H) requirements that are applicable to KYTC construction projects and current KYTC's S&H training and policies. The study also discussed the liability and authority of KYTC employees' when confronted with unsafe practices carried out by contractors. Simply put, the study identifies current KYTC practices and regulations, and identifies any areas that may need improving. The data was found by way of a literature review, interviews with KYTC resident engineers, and a survey completed by district construction safety coordinators.

The study differs from the objectives set forth in this Worker Safety Study because it focuses on policies to increase safety as a whole. It does not identify specific hazardous activities or common injuries and their prevention. Hopwood's study looks at safety from a managerial level, while the Worker Safety Study looks at the construction site and actions that can, on the majority, be implemented by workers and foremen.

Hopwood's study highlighted the importance of training for all KYTC personnel who work in construction, information that should be included in the training program, and how such training should be funded. The Worker Safety Study goes beyond the training, and also focuses on its enforcement, or lack thereof.

The *S&H Concerns* study is very informative and can be used in conjunction with the Worker Safety Study when improving safety on highway construction and maintenance projects. However, it is important to note that they have different objectives and go about increasing safety by different measures. One focuses on how workers' practices can increase safety, while the other focuses on policy and its affect.

### **2.2 General Safety Issues in Construction**

A study conducted in the United Kingdom on the factors that cause the most accidents provided a list of very useful suggestions that can be applied to safety in the US (Loughborough). The study used focus groups comprised of industry leaders to guide their research, and evaluated one hundred accidents to find common causes.

The study states that safety involves everyone from management to construction workers. Everyone needs to take responsibility for enforcing and carrying out safe

practices. Management sets the tone for safety and lays out the expectations for workers. A commitment to safety is one of the strongest ways a company can show their commitment to their employees. Employees must be aware of their company's safety policies and know the ramifications of not abiding by them. Additionally, if employees are allowed to provide their input on the safety policy, they are more likely to follow it. Worker participation may result in an increase in practical ideas, as they are the ones who are performing the work, as well as provide them with a sense of ownership and responsibility (Loughborough University, 2003).

Although it is known that Personal Protective Equipment (PPE) reduces accidents and their severity, it is still not worn 100% of the time. Hardhats, safety glasses, gloves, climbing harnesses, hearing protection, etc. are considered PPE. Poor fit or poor material selections are partially to blame for this. Employers need to spend more time choosing the PPE that their company will use. More attention should be given to the design and selection of tools, equipment and materials (Loughborough University, 2003). Too often, cost is the primary determinate in selecting PPE, when it should be safety. When PPE is selected based on cost, it is often ill-fitting, bulky, hot, and more prone to breaking and impeding performance. The study brought up a very important point that "forcing workers to wear PPE when risks are not present is counterproductive" (Loughborough University, 2003). This is especially important to KYTC concerning the use of hardhats, which will be discussed in the Survey portion of this report. Forcing employees to wear PPE when there isn't a risk of appropriate injury may make a 'joke' of the safety program. For instance, climbing gear and lanyards may get in the way of carrying out the task at hand, which may then cause an injury or fall. Furthermore, too much reliance on PPE may also provide a false sense of security, making employees less aware of their actions and surroundings.

### **2.3 U.S. Studies Focusing on Highway Worker Safety**

The highway construction industry is especially treacherous, as workers must interact with public traffic as well as vehicles and equipment operating within the construction area. A study conducted for the National Institute of Occupational Safety and Health, NIOSH, entitled "Building Safer Work Zones: Measures to Prevent Worker Injuries from Vehicles and Equipment" discussed many methods to improve the safety of the workers, as well as startling facts concerning the fatalities within the industry between 1992 and 1998. 841 highway workers were killed during this time period, 492 within an active work zone, according to the Census of Fatal Occupational Injuries (CFOI). The following table, taken from the study, lists the number and percentage of work zone fatalities as well as whether the accident was equipment or vehicle-related.

Table 1: Fatalities in the highway and street construction industry (SIC 1611), CFOI, 1992-1998

	Number	Percent
Occurred in a highway or street construction work zone:	492	58.5
Vehicle or equipment-related	465	55.3
Other event	27	3.2
Occurred outside a work zone:	349	41.5
Vehicle or equipment-related	198	23.5
Other event	151	18
Total	841	100

The research study further breaks down the fatalities by occupation, type of vehicle the worker was struck-by, and primary injury source. The study showed that workers on foot were as likely to be struck by construction vehicles as regular traffic. In addition, many case studies were listed throughout the paper describing the incident as well as potential avoidance methods.

This paper is similar in scope to the Worker Safety Study in that it aims to improve the safety of highway construction workers. The NIOSH study's main objective is to prevent highway construction worker injuries from equipment and vehicles and uses past case studies as well as possible methods of prevention to accomplish that objective. The Worker Safety Study differs in that while it focuses on worker injury prevention, it is not limited to construction operations but also included maintenance operations. In addition, vehicle and equipment injuries are a major part of the study, but the research team is investigating other areas for improvement such as personal protective equipment, jobsite communication and several other topics.

The paper discussed various work zone concerns and then listed measures to be taken by contracting agencies, legislative agencies and road builders and maintenance workers to prevent work zone injuries and fatalities. Two very interesting programs were discussed in relation to public speed control and controlling safe work practices (Pratt, Fosbroke and Marsh, 2001). These particular case studies were presented to all levels of KYTC employees to gauge whether similar programs would be effective in achieving the goals set forth by the Worker Safety Study.

The first case involved using law enforcement personnel to improve worker safety in a New Jersey cooperative program. According to the study, the program has been highly effective in reducing jobsite accidents as well as public traffic accidents and fatalities. The city of Parsippany, New Jersey, is cooperating with the New Jersey State Police, Rutgers University, local and county police, international and local Laborers' Union, the New Jersey Department of Labor and the Utilities and Transportation Contractors' Association and OSHA to accomplish the goal of reducing work zone fatalities. After three to four days of OSHA training concerning risks associated with roadway construction, city police officers are authorized to visit jobsites to warn employers of unsafe work practices. Should the officers revisit the sites and find that the hazards still exist, they have authority to report the situation to OSHA.

The second case study involved undercover law enforcement personnel stationed within work zones in Racine County, Wisconsin. Deputy Sheriffs, dressed as

construction workers, were placed within active jobsites. These “workers” acted like typical laborers, except they were equipped with handheld speed detectors and portable radios. When passing motorists either sped by or were driving erratically, the undercover deputy would radio a fellow officer stationed further along the route to stop the vehicle and either issue a citation or perhaps make an arrest. This program began in the spring of 1999 and while the possible presence of enforcement vehicles can be a deterrent, the possible presence of undercover officers among the construction workers further encourages safe driving by public motorists within the work zones, according to the Racine County Sheriff, Bill McReynolds. (Pratt, Fosbroke and Marsh, p.11)

A second study, entitled “Characteristics of Worker Accidents on NYSDOT Construction Projects,” was reviewed for information pertaining to the Worker Safety Study. This study did have some correlation to the KTC study, but overall focused on vague methods to protect highway construction workers.

Satish Mohan and Wesley C. Zech created a study that identified nine basic accident types common to most construction jobs. The categories they identified were:

- |                                       |                                  |
|---------------------------------------|----------------------------------|
| -Struck/Pinned by Large Equipment     | -Demolition Accident             |
| -Trip or Fall (Elevated)              | -Injured/Struck by Tool/Material |
| -Contact w/ Electrical or Gas Utility | -Trip or Fall (Not Elevated)     |
| -Struck-by Moving/Falling Load        | -Other                           |
| -Crane/Lift Device Failure            |                                  |

From this list, the authors identified the top five types of accidents reported on NYSDOT projects. In order, they were:

- Workers Struck/Pinned by Large Equipment
- Trip or Fall (Elevated)
- Contact w/ Electrical or Gas Utility
- Struck-by Moving/Falling Load
- Crane/Lift Device Failure.

In addition to listing the percentage of fatalities, serious (hospital-level) accidents and lost time accidents, costs aspects were listed, in terms of total cost per accident type per category. Not surprising, workers who were stuck or pinned by large equipment accounted for not only the greatest number of fatalities but the greatest cost as well.

## **2.4 “Safety Climate in Construction Site Environments”**

The idea of “safety climate” has risen out of “the underlying belief that the majority of accidents are not caused by careless workers but by failure in control, which ultimately is the responsibility of management” (Mohamed 2002). The term, safety climate, was a phrase developed to explain the employees’ perceptions of the importance of safety within a company or organization. The journal article, *Safety Climate in Construction Site Environments*, discusses an attempt to measure the safety climate on various construction sites by means of a survey.

The statements on the survey were developed to measure ten different areas that were believed to impact an organization’s safety climate. Those ten different factors are as follows: management commitment, communication, rules and procedures, supportive environment, supervisory environment, workers’ involvement, personal appreciation of risk, appraisal of physical work environment and work hazards, work pressure, and worker competence. First, management commitment has been found to be the most

important for a satisfactory safety level. It has also been determined that “when employees believe that the management cares about their personal safety, they are more willing to cooperate to improve safety performance” (Mohamed 2002). Communication from management to the workers as well as feedback from the employees is very important towards safety. Suggested improvements and reporting unsafe conditions are two forms of this essential communication. It is expected that how a company applies its own safety rules and procedures can greatly influence a worker’s perception of the importance of safety. Safety problems have often been found to be a direct result of inconsistent enforcement of safety-related policies.

For the next two factors, supportive and supervisory environments, work environments that create a supportive workplace with a high degree of supervision have been shown to have a positive influence safety. Directly tied to the whole communication idea, the amount of worker involvement can also effect the perception of safety. “Management must be willing to devolve some decision-making power to the workforce by allowing them to become actively involved in developing safety interventions and safety policies, rather than simply playing the more passive role of the recipient” (Mohamed 2002).

Work hazards and the personal perception of risks associated with those hazards can affect a company’s safety climate. The level of acceptable risk varies from worker to worker which can cause problems with employees carrying out specific safety policies. It has been shown that well laid out project sites can reduce many potential work hazards resulting in a higher level of safety performance. Finally, the amount of work pressure and training given to employees can impact their view towards safety. Pressures caused by tight construction schedules and productivity bonuses have been shown to adversely effect safety. “Training, especially in hazard detection, is a major factor influencing safety levels” (Mohamed 2002).

The survey used for this journal article was reduced from 82 statements down to a more reasonable amount for the safety climate survey used for the Worker Safety Study.

## **2.5 Evaluation of the Use of Rumble Strips**

One of the suggested methods to improve work zone safety on the final safety survey, which will be discussed in greater detail later in this report, deals with the use of portable rumble strips. “Rumble strips produce an audible and vibratory warning, which draws the attention of the drivers to the existence of the speed control signs” (Dmochowski 2005). As good as they appear, studies have produced mixed results about how effective rumble strips actually are.

In the presentation entitled “Evaluation of Orange Removable Rumble Strips For Highway Work Zones” given at an annual Transportation Research Board meeting, data was given supporting the effectiveness of orange removable rumble strips on a rural two-way 65 mph highway with a work zone speed limit of 45 mph. It was concluded that the orange rumble strips reduced the speeds of cars and trucks by 1 to 2.3 mph. The visibility of the rumble strips was viewed a positive as well (Meyer 2000).

When rumble strips were studied for the journal article, “Evaluation of Rumble Strips and Police Presence as Speed Control Measures in Highway Work Zones,” the data showed somewhat different results. Rumble strips were placed on a four-lane divided rural freeway with a speed limit of 65 mph and a work zone speed limit of 45 mph.

“Alternating right lane and left lane closures were necessary to construct both sides of the roadway. Therefore, this test site had two different configurations: 1.) right lane closed (RLC) and 2.) left lane closed (LLC)” (Dmochowski 2005). When the RLC setup was used, the rumble strips reduced the vehicle speeds by 2.7 mph in the driving lane only. They were not effective for speed reduction in the passing lane. However, when the LLC setup was used, there was no significant speed reduction in the driving lane. In the passing lane, the rumble strips produced a 2.2 mph speed reduction. So in conclusion, the rumble strips effectiveness was contingent on the lane closure setup (Dmochowski 2005). It would appear that research should be done on the speed reduction caused by forcing vehicles to merge.

## **2.6 Balsi Beam**

The California Transportation Department designed and built a portable work zone barrier called the Balsi Beam. This piece of equipment was developed after an employee in the maintenance division was seriously injured while working on foot.

The Balsi Beam has its own dedicated tractor trailer to transport it, and can be easily set up in a matter of minutes. The main purpose of the balsi beam is to protect employees working on the highway from errant vehicles traveling at highway speeds (Araya, 2006). The Balsi Beam is very portable and can be set up in minutes. The Balsi Beam creates approximately 30 feet of protected work zone. The balsi beam is particularly useful at repairing potholes, sawing joints, short-term patching, bridge repair, median work, sign repair, ect...

The Balsi Beam has been shown to multiple highway districts across the western United States on a road show in 2004. The device received overwhelming support in its ease of installation and its capability to improve safety for highway maintenance workers.

Currently the Balsi Beam is patent pending and the only working device is owned by Caltrans. However, the device is being developed for potential manufacturing, and Caltrans is developing licensing agreements so that other highway agencies can manufacture their own similar device.

## **2.7 Robotic Safety Cones**

The University of Nebraska is currently developing a Robotic Safety Cone which can travel along with a mobile construction/maintenance operation. The safety cone is powered by a small motor in the base of the cone, which is attached to an axle and wheels. A GPS receiver is attached to the base unit and is guided along a predefined path (Farritor, 2002).

The use of the Robotic Safety Cones reduces the risk of workers being struck by traffic when moving the cones in mobile operations. Reducing workers to close proximity with moving traffic also reduced the likelihood of accident severity. The only worker interface with the safety cones will be when they are setup initially and taken down at the end of the operation.

Current research and development on the Robotic Safety Cones includes reducing the overall cost of the safety cones, as well as improving the path planning aspect of the cones. Although prototypes have been developed and tested, the Robotic Safety Cones are not yet available for purchase.

## 2.8 Contractor Prequalification Based on Safety

Since the idea of prequalifying contractors for government construction projects began to be practiced, safety has always been a considered factor in the process. Some government agencies have taken a more defined approach to the safety consideration. These agencies are requiring specific levels of safety performance from their contractors by factoring in common measures of safety like Experience Modification Ratios (EMR) and data from the Occupational Safety and Health Administration (OSHA)'s 200/300 log. EMR is "a standard factor used in the pricing of worker's compensation insurance, which is based on the employer's claim history" ("Rules Governing Prequalification Privileges" 2003). Two state departments of transportation, Virginia and North Carolina, have taken this approach to their contractor prequalification process.

The Virginia Department of Transportation (VADOT) uses a prequalification score when evaluating potential project bidders. The prequalification score is determined from two different scores, a quality score and a safety score. The quality score, which is based on the contractor's past performance on VADOT contracts, is seventy percent of the prequalification score. The safety score which makes up the remaining thirty percent is based on the contractor's EMR ("Rules Governing Prequalification Privileges" 2003).

To reach full prequalification status, a contractor's prequalification score must be at least 80. In addition, a minimum safety score of 70 must also be achieved. An EMR of 1.10 or less is equal to a safety score of 70 or less. If a contractor receives full prequalification status, then they are allowed to bid on all projects up to their bonding capabilities. Probationary prequalification status can be awarded to contractors. A minimum prequalification score of 75 with the same safety score requirement as full status is necessary for this level. However, "with this level of prequalification a firm can be awarded/have under contract no more than three projects at any given time. Each of these contracts will be limited to a maximum contract value of \$2,000,000" ("Rules Governing Prequalification Privileges" 2003). The final level of prequalification that a contractor may achieve is to be considered as conditional prequalified. A minimum prequalification score of 70 with a minimum quality score of 75 and a minimum safety score of 60, an EMR of 1.30, is necessary for this level. "With this level of prequalification a firm can be awarded/have under contract no more than one project at any given time. This contract will be limited to a maximum contract value of \$1,000,000" ("Rules Governing Prequalification Privileges" 2003).

The North Carolina Department of Transportation (NCDOT) uses a contractor's EMR as well as OSHA related information to determine prequalification status. According to NCDOT, a prequalified contractor must have a safety index score of, at least, 60 out of 110 possible points. First, a firm's EMR from each of the past three years is used in the safety index calculation. The scoring based on the EMR occurs in the following way: an EMR of 1.0 awards ten points, an EMR of 1.0 – 1.5 awards zero points, and an EMR of 1.5 awards negative ten points ("Requirements and Procedures for Prequalification of Bidders by North Carolina Department of Transportation" 2003).

The next set of information used to score a contractor comes from their data submitted to OSHA. A contractor's incidence rate for total lost workday cases is calculated with the following formula:

(Number of injuries and illnesses that result in a loss day or day of restrict work activity ÷ total hours worked by all employees during the calendar year) x 200,000 = Incidence Rate for Total Lost Workday Cases

The scoring based on the incidence rate occurs in the following matter: an incidence rate equal to the industry average awards ten points, an incidence rate greater than the industry average but still less than 125% of that average awards zero points, and an incidence rate greater than 125% of the industry average awards negative ten points (“Requirements and Procedures for Prequalification of Bidders by North Carolina Department of Transportation” 2003). The remaining OSHA related information used in the safety index calculation deals with contractor citations issued by OSHA over the past two years. A contractor is awarded ten points for the defined serious injury section, but five points is deducted from those ten points for each repeated OSHA defined serious injury citation received. A contractor is awarded thirty points for the being willful section, but thirty points is deducted from those thirty points for each received citations classified by OSHA as being willful. A contractor is awarded twenty-five points for the work-related fatalities section, but twenty-five points is deducted from those twenty-five points for each OSHA citation resulting from a work-related fatality (“Requirements and Procedures for Prequalification of Bidders by North Carolina Department of Transportation” 2003).

The final set of points awarded by NCDOT is determined from their own set of information on a contractor. Initially, twenty points is awarded to a contractor for the formal written suspensions by NCDOT section. For each suspension received by the contractor over the past three years, ten points is deducted. However, the formal written suspensions must be for a violation in one of the following safety areas: excavating, trenching, or shoring; fall protection; crane safety; and equipment safety devices (“Requirements and Procedures for Prequalification of Bidders by North Carolina Department of Transportation” 2003).

## **3.0 PRELIMINARY DATA COLLECTION**

### **3.1 First Survey**

#### **3.1.1 Purpose of Survey**

The major action carried out on the Worker Safety Study was the creation and distribution of the Survey to Improve Highway Worker Safety during Construction and Maintenance. This survey was created after our first Safety Advisory Committee Meeting, where the suggestion was made to focus first on work in Kentucky rather than other states. This study was being conducted for the KYTC, so it only made sense to start with Kentucky. The purpose of the survey was to gain the worker's perspective on what he/she believes are top concerns on the jobsite. The men and women who perform the construction on a daily basis are very aware of what actions are more likely to lead to accidents and can identify any shortcomings in how safety is handled at a managerial level. The information collected was used to steer the research team in the right direction, allowing them to focus further research on top issues of concern in Kentucky.

#### **3.1.2 Survey Composition**

The survey was designed to be simple and straight forward to reduce the possibility of questions concerning how to complete the survey on the jobsite. It was also important to limit the amount of questions and pages that were included in the survey to increase the likelihood that workers would take the time to comply. The research team asked that the surveys be completed anonymously by workers of various skill levels and job types to ensure a wide variety of results, and an accurate representation of highway construction and maintenance concerns in Kentucky. Although the workers who filled out the survey were not asked to list their names, they were asked to provide their title or job, the name of their supervisor, and their current job location.

The survey was divided into two parts. The research team selected areas of concern that are perceived to be common in highway construction and maintenance for the first part of the survey. The concerns were chosen based on topics discussed in the safety committee meeting, the ARTBA 4-hour safety course, and the findings of initial literature reviews.

The selected concerns were:

- Heavy Equipment Operation (Runovers and Backovers)
- Fall From Heights/Fall Protection
- Heavy Equipment Rollovers
- Mowing
- Hand/Head/Eye Injuries
- Crane Operation
- Short Term Patching/Quick Patching
- Electrical Work Activities
- Personal Protective Equipment (PPE)
- Visibility and Hearing
- Trenching/Shoring/Excavating
- Debris Removal on Highways (tires, dead animals, etc.)

- Jobsite Communication
- Public Traffic Accidents in Work Zones

Workers were asked to list any safety concerns they had in the above areas. If they had any suggestions on ways to improve upon safety in those areas, they were asked to include them, as well.

The second half of the survey, Part B, asked workers to describe any injuries that they had received while working on jobsites. If they had injuries, they were asked to provide the type of job they were completing at the time of the accident and any ways they believe the accident could have been avoided. The last item on the survey provided space for any additional comments or issues that may not have been included. The full survey is included in Appendix D.

### **3.1.3 Survey Distribution**

The research team sent the surveys to both KYTC personnel and contractors who work in Kentucky. This ensured that both public and private work was represented and comparisons could be made concerning safety attitudes between the two sectors. The surveys were sent and returned by mail with an average allowable completion time of three weeks.

Surveys were sent to each of the twelve districts and the Central Office, within KYTC. A phone call was made to each Chief District Engineer to explain the survey and its purpose. The surveys were then sent to each Construction Branch Manager and each Operations Branch Manager in the districts. The Construction Branch Manager would distribute among employees to obtain information concerning KYTC construction safety practices, while the Operation Manager would distribute among maintenance employees. Twenty surveys were sent to the construction side and thirty were sent to the maintenance side.

The Kentucky Association of Highway Contractors provided the research team with a list to 200 Kentucky Contractors. The researchers selected approximately 40 companies that worked in the highway industry. This list included mowers, stripers, asphalt pavers, signage companies, and general contractors. Twenty surveys were sent to each company with the same directions as the surveys sent to KYTC.

### **3.1.4 Survey Results**

The KYTC returned approximately 150 completed surveys. The large number of surveys provided the research team with a variety of concerns and suggestions on how to improve safety on KYTC projects. However, contractors did not respond with the same caliber. Approximately 10 surveys were received from Kentucky contractors. The poor response can be attributed to a lack of personal contact with contractors and the absence of a relationship between the companies and the University of Kentucky. Contractors may not have seen the benefit of filling out the survey, whereas KYTC employees knew the survey was co-conducted by the Kentucky Transportation Center. The high response from KYTC employees made the survey worthwhile, regardless of the poor turnout from private industry. A summary of top concerns and suggestions provided from the surveys are listed below. All comments were made by KYTC employees, unless stated otherwise.

### **Heavy Equipment Operation (Runovers and Backovers)**

The number one concern that was mentioned by employees was the need of working back-up alarms. Back-up alarms are either not installed on all equipment, or they are not functioning 100% of the time. Faulty backup alarms should not be ignored: “if equipment does not have an alarm fixed at the end of the day it must be removed from the project until it is fixed.” In addition to alarms, the use of flashing lights and horns was also mentioned. Operators have poor visibility inside heavy equipment cabs and often depend on employees on foot to move away from equipment, not the other way around.

In general, respondents said employees need to be aware of their surroundings and alert. All non-essential employees and equipment should be removed from work zone to improve visibility and decrease the possibility of people getting in the way of equipment. Equipment needs more mirrors in well placed areas and they need to be cleaned daily. Other concerns were a lack of communication between employees on site and operators. Walkie talkies were suggested as a way to improve communication and help the operator keep track of where employees are working. Again, the number one concern that was mentioned on the majority of the surveys was the absence of, or inoperable, back-up alarms.

### **Fall Protection**

The largest concern with fall protection is that employees aren't always wearing any. Respondents said that they had fewer accidents when fall protection was used and used properly. Additional training, specifically confined spaces and hands-on/field training, is something respondents said was necessary. Rescue training and proper use of life lines were also mentioned as being beneficial. Fall protection equipment needs to be provided to each individual who will be climbing, inspectors included. Equipment shouldn't be shared because the borrower doesn't know how the owner takes care of the equipment, how old it is, or when it should be replaced. It would also eliminate the need to readjust, which decreases the chance of user error.

Quite a few surveys mentioned that most falls occur when employees are climbing in and out of trucks. Three points of contact training was suggested, in addition to properly maintained steps, hand rails, and skid pads on side of dump bed. Ladders need to be braced or held at the bottom by another employee consistently. A lack of jobsite cleanliness and housekeeping was a concern and thought of as a contributing factor in falls.

Providing proper fall protection, and adequate and frequent training, was the top suggestions given by survey respondents to decrease the probability of injuries from falls, slips and trips.

### **Heavy Equipment Rollovers**

A lack of training for specific equipment that will be used was a large concern. Operators need to be trained on equipment that they will be using on the job, not general equipment that is used on other jobs. Seat belts should be worn at all times and should, therefore, be installed in all equipment. Operators need to drive equipment at slower speeds and use equipment that is appropriate for the job. Rollover Protection Devices

need to be in working order and strong safety cages are requested. One respondent did not believe operators should work on slopes they did not feel comfortable with. Another suggested that tire pressure be checked 2-3 times per day. Putting angle indicators on equipment and determining each piece of equipment's center of gravity are other actions that can be taken. Overall, good visibility, knowledge of equipment, and attention to surroundings were the top ways respondents believed accidents could be avoided.

### **Mowing**

A large concern among mowers is objects 'thrown' from the mower. These objects can hurt the operator, passing traffic, or pedestrians. Employees would like equipment to have debris shields to protect them from launched debris. Bush hogs were said to contribute the most to this problem and flail mowers were recommended, instead. Mowers should be kept 100' from each other to prevent accidents caused by debris when multiple mowers are used in one area. If equipment has a shield or enclosed cab, air-conditioning is considered a necessity although they greatly decrease the operators ability to hear which causes another hazard. Employees would also like to have improved signage, auto shutoff when operator leaves seat, more mirrors, and better lighting.

The second most common concern besides debris was traffic. Traffic control is necessary and anything that can be done to decrease the speed of drivers and increase awareness would be beneficial.

### **Hand/Head/Eye Injuries**

Employees were concerned with hand/head/eye injuries, but many said the accidents could be avoided by wearing appropriate PPE. Concern exists, however, with the availability of PPE. Proper PPE needs to be provided for all necessary jobs. Gloves should be included as provided PPE. Common sense, in addition to PPE, would eliminate many of this type of injury.

### **Crane Operation**

Crane operation is not common among KYTC employees, however, a few suggestions were provided. For example, operators need to know limits of equipment and ongoing training is a must. The use of spotters and radios is important to counteract operator's lack of visibility. One respondent was concerned that the crane's cable would break under large loads. Proper maintenance and operator training are integral in reducing the possibility of this occurring. Inspecting cranes every 6 months and testing operators on skills would help. Another respondent has had operators under the influence of drugs or alcohol. The skill of operators is the largest concern when using cranes, most likely, because it is so specialized and very few onsite personnel other than the operators, if any, are trained in crane use.

### **Short Term Patching/Quick Patching**

Short term patching requires good flaggers and traffic control. One employee stated that "traffic control should be number one priority". Often, drivers are not paying attention and/or driving too fast. Using the media, such as local news and newspapers, was suggested as a way to keep drivers informed of ongoing construction in their area. Signs and message boards were also important to survey respondents.

Warning lights are not always used or in working order, but are very important in protecting employees during patching operations. Additionally, one employee should be dedicated to watching traffic at all times, while other employees patch.

### **Electrical Work Activities**

Electrical work is not often done by KYTC employees. Many respondents put 'N/A' or said it should be done by a qualified person only. A few mentioned the importance of lockout/tagout and electrical training.

### **Personal Protective Equipment (PPE)**

Many responses listed the types of PPE that are most common, which were hard hats and safety glasses. Other employees said that additional PPE was necessary, but not always available. This included hearing protection, gloves, and chaps for use when operating a chainsaw. Many believe safety glasses should be more comfortable and resemble sunglasses to make people more likely to wear them all day.

PPE is important on a daily basis so it is necessary to buy what works and what will be used, not just what is the cheapest. Some PPE is more comfortable and durable than others. PPE that isn't worn is more financially uneconomical in the long run, than pricier PPE that will actually be used. Some people believe it is important for KYTC to provide steel toe boots and different varieties of gloves for different applications.

Some respondents had problems with hard hats and safety vests. They believe it is counter productive to require the use of hardhats for all operations, including ones that don't have a threat of falling overhead objects (Loughborough University, 2003). Many people believe safety vests are hazardous because they get caught in equipment. A common suggestion was to purchase reflective shirts, instead. This would provide a better fit and less material that could get caught in equipment, as well as increase the possibility of employees wearing the shirt all day or night.

The importance of supervisors enforcing PPE use was said to be best shown when they wear it themselves. "If you don't have the right PPE you shouldn't do the job" was a common idea.

Additionally, training was believed to be just as important as having the right PPE. PPE will not be beneficial if employees do not know how to use it properly.

### **Visibility and Hearing**

As previously mentioned, hearing protection is not as commonly provided or encouraged, as the use of hard hats, for example. This lack of enforcement is evident in the survey by the high number of 'N/A's in this area. Apparently, many are not concerned with hearing protection. The few who are concerned believe the Cabinet should provide yearly hearing tests, and some even mentioned yearly eye tests.

### **Trenching/Shoring/Excavating**

This area did not result in many comments. A few people said they enforce OSHA guidelines, but majority said 'N/A'. Some employees were concerned with the specific training provided, and thought they could benefit from confined spaces training. The importance of knowing the location of gas/electric lines and water mains was listed, in addition to knowing the soil that the crew is working with. A crew should watch for

cracks and water seepage in embankment. The majority of comments stated that shoring rules and regulations need to be known and followed.

### **Debris Removal on Highways**

The two common beliefs concerning debris removal are that KYTC should not be handling dead animal pickup, and traffic control needs to be improved. Employees are concerned with dead animal pickup because of the diseases that are involved and the heavy lifting necessary to carryout task. They believe it should be handled by another agency, such as Fish and Wildlife, or a waste facility in each county. If it is continued to be the responsibility of KYTC, backhoes or loaders should be available to pick up heavy animals, and possibly, one person from each maintenance barn should be in charge. Lifts in pickups would also help to reduce the number of back injuries caused by dead animal pickup. Often times workers are sent out alone to clear debris from a roadway, leaving virtually no way to control traffic while working. There should always be an adequate amount of workers present in order to complete the job safely.

The second largest concern was traffic control. “Blue lights slow traffic better than yellow”. Law enforcement is believed to be necessary to adequately control traffic to improve the safety of maintenance workers. This is especially true in areas such as debris removal, where it is inefficient or unfeasible to close a lane of traffic due to the short amount of time involved in task.

### **Jobsite Communication**

The number one suggestion to improve jobsite communication was to provide walkie talkies. Many employees said the quality of current walkie talkies is poor and they do not work properly. They believe more money should be invested in radios, due to their importance in increasing jobsite safety.

One respondent did not believe increasing communication would decrease accidents: “communication is a good thing in the workforce, but it can’t prevent an accident. Highway work is hazardous”. The majority, however, did not feel this way. Providing higher quality radios was the most prevalent concern among respondents, especially for communication between flaggers, operators, and foreman.

### **Public Traffic Accidents in Work Zones**

Traffic appears to be the largest concern among highway construction and maintenance employees, and this is supported by the responses in the surveys. Slower speed limits should be enforced. Police officers make a big difference and more should be placed at jobsites to fine speeding traffic. Message boards are also helpful, more so than signs, because they allow for updated and specific information. Closed roads created a concern for some employees. Barricades were said to be safer than just using signs to close roads. Police enforcement of slower speeds was the number one way KYTC employees believe traffic accidents can be avoided.

### **Injuries**

There were very few injuries listed among the approximate 150 surveys received. The few that were listed resulted in minor injuries, such as cuts on legs and smashed fingers. Other accidents resulted in sprained shoulders and back injuries. It is important

to note that although most employees did not list accidents in the survey, they are occurring, as shown in the KYTC Division of Safety and Health data. This data is shown in section 5.0.

### **Other/Conclusions**

The ‘other’ category of the survey proved to be a space for employees to reiterate their top concerns or suggestions. Training, either additional training or more specific to highway construction was the most common. Providing reflective shirts, instead of large and bulky vests, was also reiterated by many employees. Having police enforcement or an unmanned police car onsite is thought to be very beneficial. Portable rumble strips were suggested as a way to slow traffic before reaching flaggers. Listing construction in the local paper and using message boards that allow input of updated information would make drivers more aware of work zones.

## **3.2 KYTC District Meetings**

### **3.2.1 Format of District Discussion Sessions**

All eight of the district meetings were held in the same manner. An agenda was issued to each attendee upon arrival, as was a survey. After a brief presentation to familiarize the employees with the Worker Safety Study, instructions were given on how to complete the survey. After the workers had time to complete the survey, approximately 20-25 minutes, the research team led a discussion session, in which the workers expressed their thoughts on the survey as a whole, as well as each category and items within the categories.

### **3.2.2 Important Concerns Discussed During District Meetings**

The written responses often did not coincide with the verbal responses gathered during the discussion session. The following sections will list the top discussed concerns during each district meeting.

#### **Discussion from Districts 1 and 2 Meeting**

The research team gathered a fair amount of information from Districts 1 and 2. The first category, Heavy Equipment Operation, had nine main points. When asked about changing the tone of the backup alarm on heavy equipment, the workers were generally in favor. They stated that workers tend to “tune out” the current tone, as it does not change in either pitch or volume, and therefore blends in to the jobsite. A change in pitch, volume, and increasing the pace of the tone as the equipment senses an object/person would alert all within the work zone to a potential hazard. According to workers, there is also a problem with visibility in that smaller vehicles tend to pull up just behind big pickup trucks or larger equipment, leading to backovers. They suggested a dedicated area for small vehicles to park at the work site. The third largest concern/suggestion was in regard to alarms only engaging when in reverse. Objects can be in the way of machinery while it is moving forward and a sensor may help alleviate this problem.

The second category, mowing, had twelve major comments. The largest area of concern involved the sheer volume of mowing. In Districts 1 and 2, there is more

mowing to be done than there are available workers. Obviously, more workers are needed to keep the areas mowed and swept. In addition to a lack of employees to mow, there also are not enough people to sweep the roadways. If debris/grass is left on the roadway, there is an increased potential for a traffic accident. The third major concern involved the current condition of equipment. In District 1, the average age of tractors is 20 years, and the age translated into KYTC spending between \$5000 and \$6000 *annually* in repairs. By replacing the old tractors with new models, the cost of repairs would drop, and new equipment with better technology and safety options could be used.

The third category, Trenching/Shoring/Excavating had only five responses. The main concern involved the OSHA requirements being ignored by many utility contractors, even when they perform work that does not fall within state projects. The consensus of the group was to follow OSHA lay-back requirements and leave the responsibility of following the OSHA guidelines to the contractors.

The fourth category had eight comments. Fall from Heights/Fall Protection was an important area to the attendees. The main concern involved the amount of fall protection equipment available within the district. The suggestion was to keep extra fall protection equipment at the District Office and distribute it as needed. The second and third most important comments involved accessing this equipment, especially when out on a jobsite. The workers use the equipment until it starts to wear, but replacement parts are hard to find. A supply of spare parts or just more pieces of equipment in reserve may alleviate this problem. In addition, one gentleman suggested that the foreman be issued a procard from the District Office in case of emergency. That would reduce the amount of time lost on the job as well as reassure the crew that fall protection is important to KYTC.

The fifth category, Debris Removal, proved to have some very interesting comments throughout the state. In Districts 1 and 2, eleven comments were made. Every worker present agreed that the trucks need lifts to assist with lifting heavy objects. There is talk of installing lifts, but this has yet to occur. The wildlife and objects in the road tend to be heavy and, especially during the fall months, great in number. In District 2, over 300 deer are killed along roadways! The workers agree that there is just too much work for their resources and would like the job of animal removal assigned to the Department of Fish and Wildlife.

Short Term Patching was the sixth category, and it had the largest number of responses with fifteen responses. All comments came from District 2, as District 1 contracts out all patching operations. The quality of material seemed to be of great concern, as it varies between districts and even counties. According to workers, there are materials available that will stay in the holes if it is properly installed but the workers have been told that "it's too expensive." Due to material constantly moving out of the holes, the workers can't stay ahead of the patching duties. There are not enough workers to fix all of the holes. This holds true until a rehabilitation project occurs. An interesting solution was mentioned from a District 1 crewman; melting an old tire to the bottom of the hole prior to adding the asphalt sealed the hole. As of July 20, the hole was still sealed.

The seventh category was Personal Protective Equipment, with thirteen responses. Recently, KYTC switched the uniform to a bright green, polyester shirt with reflective stripes for workers. This change was met with mixed response from those at the meeting. While they liked the fact that the shirt was always on, as opposed to a removable vest,

they do not like the material, the lack of “give” with the striping material, or the fact that the color seems to attract flying insects. The workers were also quite excited about the new hardhat policy within KYTC. They liked the freedom of determining “where overhead danger exists” but at the same time are quite wary as to what will happen to the policy after the first accident. The third largest area of concern related to first aid kits. According to the workers, when they go to the stock room to replenish/replace their kits for the trucks, some to most of the items contained in the replacement kit are already outdated. In District 2, there is now a person, Nina Hill, who systematically checks all kits and ensures that they have not expired.

Jobsite Communication, the eighth category, was also a very important category to the workers. Seven items were discussed, and cell phones vs. walkie-talkies was the biggest point of contention. District 1 stated that they had good quality walkie-talkies but they were replaced with ones having a poor range, antennae that easily broke and the workers had difficulty finding a usable channel. Many suggested that in lieu of replacing two-way radios constantly, that KYTC would better spend the money on cell phones. The only problem with this suggestion involved workers within a “dead zone,” where the phones have no signal. The third point involved radio frequencies. KYTC needs a dedicated frequency for their people, as currently they share the airwaves with tugboats, ambulances and other services.

Eight topics were discussed in the area of Visibility/Hearing, the ninth category. Many of the maintenance workers discussed the need for contractors to ensure their flaggers have a valid flag license. Most problems occur when those flagging traffic are either not trained at all or very hurriedly trained to flag. The workers also stated that they would like to see the flaggers wear either a special uniform or vest to delineate themselves from the rest of the crew, as well as alert the public to the flagging operation. While flagging operations were of great concern, some workers felt that signage was also an issue. Some of the workers suggested changing the background color of the signs from orange to the bright green used for their shirts. In this manner, the different color would draw the public’s attention to the sign, and possibly make the entire work zone safer.

The last category was Miscellaneous, and it contained fourteen areas of concern. The research team questioned the workers about using portable rumble strips to warn the public of an upcoming flagging operation. This suggestion was met with a tremendous amount of enthusiasm. The workers felt that grabbing a driver’s attention and encouraging slower speeds would be very beneficial to improving the safety of all workers within the zone. Also, the workers felt that while speeding is a huge problem, the biggest deterrent is active “blue lights,” or law enforcement intervention. The workers would like to see a much larger presence on their sites, but according to some attendees, the Justice Cabinet just will not send anyone out to monitor these zones. It was also suggested that Kentucky look at Illinois law, which includes a double fine within a work zone and if a driver strikes a state worker they are subject to a \$10-20k fine and a prison sentence.

### **Discussion from Districts 3 and 4 Meeting**

The meeting held for Districts 3 and 4 in Bowling Green also yielded valuable information regarding safety concerns. Many of the issues presented by District 1 and 2 employees carried over into other districts. There were some differing opinions and responses, as reported in the following paragraphs.

Concerning Heavy Equipment Operations, these two districts had some similar responses. The employees in this area also liked the idea of an alternating alarm tone to draw attention to equipment when operating in reverse. In addition, the workers were in favor of installing a headset or radio in the cab of the equipment so the operator could maintain verbal communication with the lead man on the ground. The workers did express some concern over using a sensor on construction projects, as there are often a large number of objects in the range of the sensor that needlessly trigger an alarm.

Mowing operations were also discussed at length, but in the case of District 3, only four out of ten counties conduct mowing operations. The workers all agreed that the best way to prevent injury to the workers during mowing would be to install closed cabs on the tractors. They also stated that providing radios on the tractors would enable them to easily and quickly contact support trucks about any emergencies or sudden changes in the work area. Also, those in attendance stated that the mowers need to travel with traffic, not against it, as this tends to create a very dangerous situation for both the worker and the traveling public.

Trenching, shoring, and excavating activities are not a particular concern for those in Districts 3 and 4 as these activities are usually handled by private contractors. When KYTC does perform these operations, slopes are typically laid back, as trench boxes are very expensive to use. In addition, there should be more training, but it needs to be operation-specific in order to be effective.

The fourth area, fall from Heights/Fall Protection also had relatively little concerns related to safety. The one bucket truck in District 3 is inspected frequently using safety lanyards and all of the maintenance people who use that truck are trained by the bridge inspector. Protective equipment is readily available and in good repair. The workers would like to use a procard if they need any replacement equipment due to the quick turnaround time and the fact that the distributors are in the local area.

Debris Removal was an area in need of improvement, according to the meeting attendees. District 3 employees stated that they usually use a rolling road block while conducting this operation with a great deal of success. Warren County, located in District 3, uses local inmates for debris removal. One supervisor is responsible for two inmates, and the maintenance employees are pleased with this setup, as they are freed to concentrate on other activities. In regards to blood-borne pathogens, District 4 has made informative classes available as well as hepatitis-C shots to those working in dangerous areas such as pump stations and rest areas. Monies in the District Budget are used to fund these classes and shots.

In regards to Short Term Patching, traffic control is a major issue. Often, the maintenance crew tries to choose a time for this operation when it will least impact the public, but this is not always practical or possible. A weekly schedule is issued to the media and advisories are also issued, but there are few outlets in the rural areas to broadcast this information. The other area of concern, the quality of material, was also

discussed, and the general consensus of the group was to use a bag mix, as it is easier to control the quality of a bulk mix. The only issue with using a bag mix is cost, and the workers suggested that the state attempt to set a price with area suppliers to entice district offices to switch to a better quality product, reducing the number of repairs in the long run.

The Personal Protective Equipment statements were quite similar to the ones made in the District 1 and 2 meeting in that the new shirts were the most discussed issue. The workers agreed that the polyester material was extremely uncomfortable in the summer, the reflective striping was very hot to the touch and did not “give” and that the quality was questionable. For the most part, they all agreed that the shirts are a good idea but need to hold up better and perhaps be made from a different material. Also, the employees stated that there are first aid kits in every vehicle, but sometimes they are missing supplies and suggested that someone routinely check and restock these kits.

Quality radios and communication between KYTC and private contractors were two major areas of concern for the Jobsite Communication category. The radios have a decent range, but due to short battery life, they have to be replaced quite often. Many times, workers are on a jobsite and need to change radios 1-2 times per day due to poor batteries, costing valuable work time. In District 4, there is much confusion between the prime contractors, subcontractors and the KYTC supervisors. The crews would like to see preconstruction meetings and status meetings to eliminate confusing operations or jobsite conditions. The last big item involved flagmen. The workers want the state to hire dedicated flagmen. In that way, they are all certified, properly trained, and do not need to worry about finishing their particular work and can concentrate entirely on traffic control.

The workers stated that Visibility/Hearing remains to be an area in need of improvement. They stated that Motor Vehicle Enforcement can help monitor jobsites, but only when given enough notice, and this holds true for local law enforcement and sheriff departments as well. When asked about using LED lights in regulation signs, the workers stated that these would be extremely effective, and that if the signs are as durable as traditional signs, the Cabinet should investigate using the newer technology.

The final category, Miscellaneous, had few remarks. Mainly, the workers stated that “you can reduce the speed all you like, but unless there’s enforcement, it won’t work.” This sentiment was echoed in all eight district meetings. They also were in favor of investigating portable rumble strips being used in work zones, but were curious as to how they could be used for short term operations.

### **Discussion from District 5 Meeting**

Again, District 5 had many of the same concerns as expressed in the previous sections, but due to the dense population of the Louisville Metropolitan area, some new concerns were brought to the forefront.

Twenty percent of the state’s traffic is in Jefferson County. According to Kevin Bailey, this fact alone has contributed to working at night becoming a very popular alternative for operations. To make Heavy Equipment Operation safer, District 5 has ordered ANSI approved lighted vests for their crews to improve nighttime visibility. They did state that the public is the biggest obstacle to nighttime construction, as they

complain about the noise, lights, etc. but this is a small tradeoff for safety and convenience.

Mowing is not a concern, as only a small portion of Trimble, Oldham and Bullitt counties will continue mowing operations after the next contract expires. Signage is the biggest problem, as mowing is a mobile and fast operation. It was stated that contractors' mowers tend to operate very dangerously on interstates and need to be more aware of where and when they operate. Operating at a slow speed in the passing lane is dangerous, and this behavior should never be allowed to occur.

Trenching/Shoring/Excavating was also not overly important, except for concerns involving reconstruction. Due to the dense population in District 5, there is no room to properly shore a trench due to gas lines, water mains and fiber optics. The workers would like more right-of-way to safely conduct their operations.

Falls from Heights/Fall Protection was discussed, as there are thirty bridges on I-64 between Lexington and Louisville scheduled for repainting. The crews would like more training both on how to properly use equipment and for bridge inspection operations. One gentleman informed the research team that on the Kennedy Bridge, two workers fell, one was tied off. Those falls illustrated to the workers onsite exactly how important proper fall protection is to the safety of a worker.

In regards to Debris Removal, District 5 has ordered tommy lifts for newer trucks. As the older trucks are replaced, they will all eventually have these lifts, eliminating the need to remove objects by hand, risking back injuries. In Jefferson County, there is one man dedicated to debris removal but in outlying counties, at least two, sometimes more people are sent for this operation.

A police escort is the best way to make short term patching a safer operation, according to the attendees. Lane closures are used on the interstates, but this is a moving operation in rural areas. In addition, the quality of material is a problem in District 5 as well. In cold weather, it is very difficult to acquire a good, cold mix, but there were no suggestions as to how to alleviate this problem.

Personal Protective Equipment discussions from District 5 yielded some new concerns for the research team. Workers agreed that everyone on a crew should be CPR certified, not just one person. They argued that the one person trained may be absent on a day where that training becomes critical. The beginning of the construction season is an optimal time for training, and should be utilized. The workers also questioned exposure to asphalt fumes on paving jobs and wanted to know if that practice was dangerous or if they should be issued respiratory masks.

Jobsite Communication was another big area of concern due to the sheer volume of work done within District 5. Those present stated that it is a challenge to keep operators and flagmen in constant contact due to the noise level as well as hand-eye coordination regarding operating the equipment and using a two-way radio. They stated that if a hands-free headset were given to the operator, that would be a smart solution to the communication breakdown. District 5 does have their two-way radios on the state radio system, using an extra channel. In addition, the workers would like to see some more planning and coordination meetings between the contractors and the Cabinet.

Two new ideas surfaced in this discussion in the area of Visibility/Hearing. Regarding Stop/Slow paddles, the research team learned that new technology exists that uses flashing LED lights in the lettering. These lights attract the driver's attention and

have a positive impact on slowing motorists. The workers would like to see a base used with the “Stop/Slow” paddles, as they are very heavy and difficult to hold still for long periods of time.

Under the Miscellaneous section, another problem was brought to the attention of the research team. According to the attendees, checking the reflectivity of roadway striping is quite dangerous because, currently, they must actually walk into an active roadway to conduct this operation. There is no real optimal way to do this operation, but other states, such as Texas, use a special testing vehicle to do this, especially on interstates. The workers want KYTC to consider purchasing their own vehicle for this purpose, or investigate the possibility of renting such a vehicle from another state.

### **Discussion from District 6 Meeting**

No field workers attended the District 6 meetings, only Resident Engineers. As a result, many issues discussed in other district meetings were not viewed as a problem for District 6. As the Principal Investigator, Dr. Donn Hancher, did not attend this meeting, the research team was looked upon with a good deal of suspicion. Some insightful information was gathered, but in general, the research team was led to believe that safety is generally very good in the district, with little room for improvement.

The major concern regarding Heavy Equipment Operation dealt with when the alarms actually engage. For the most part, alarms are only active when the transmission is in reverse, but the alarms should be active whenever the axels turn, whether in reverse or neutral. This could help reduce the number and severity of accidental runovers and backovers.

Mowing is not a major concern as only two out of eleven counties, or eighteen percent, within the district have mowing operations. There is a great speed differential between the tractors and the motoring public, but the only suggestion to improve safety was to use better signage within mowing zones.

The participants indicated that Trenching operations are not a large problem within District 6. They stated that it is OSHA, not KYTC’s job to regulate contractor practices on sate projects. The only course of action for KYTC is to shut down the job if the contractors are not operating in compliance with OSHA regulations.

In regards to Fall from Heights/Fall Protection, there has been an improvement in safety recently. From a design standpoint, there are more tie-off points on bridges, beneficial to both the construction and maintenance workers. In the past, there were problems with fall protection procurement, but that situation had been remedied. The largest area for improvement is the check-out system for the equipment. Different people need the equipment; no one person has a dedicated harness. The research team believes that if enough equipment is purchased by the district, this problem will be solved.

Debris Removal was an issue in that there are no heavy lifting devices on trucks. Also, there is not a safe area to conduct this operation, especially on a narrow shoulder or a bridge approach. The district does use a law enforcement officer with a rolling roadblock to help protect the workers, a system that seems to work.

With respect to Short Term Patching Operations, District 6 uses Variable Message Boards (VMBs) to assist with communication to the public. The Resident Engineers stated that they generally get the same quality patching for each hole but sometimes workers do not fill the patch correctly. If the workers do their jobs properly, the patches

have to be done less frequently. Also, if the crew size were increased, this could help resolve the quality issue.

The responses from the Personal Protective Equipment category once again centered around the new uniforms. Again, the workers agreed that the highly visible shirts are a step in the right direction, but the quality and material should be improved. Also, the new hardhat policy was discussed. Many of the Residents feel that the new policy leaves too much freedom to the individual worker. They would prefer mandatory hardhat usage to remain the policy, especially on construction projects.

Jobsite Communication was an area of concern, especially when flagging operations occur. Those present would like to see all flagmen, both state employees and contractor employees hold a valid flag license before being allowed to direct traffic.

Visibility/Hearing was not an issue in District 6, with the exception of lighting. All new trucks have good lighting packages, but this is not the case with older trucks. As the trucks are replaced, all will have the new lighting packages.

The Miscellaneous section once again centered on how to slow the public in work zones. On long term projects, the speed reduction is often ignored, and the only way to change this is to change the attitude of the general public. When asked about using portable rumble strips, those present stated that they would not be inclined to use them, as they feel the strips are more of a hazard than a benefit. Snow and ice removal was a concern, as private landowners and businesses push the excess into state roadways, creating dangers for both the salt truck operators as well as other motorists. They would like to see more lighting on salt trucks to alleviate this problem.

### **Discussion from District 7 Meeting**

The meeting at District 7 was held first, and as such, set the tone for all of the other district meetings. The following paragraphs summarize the discussion of this meeting.

Heavy Equipment Operation was an area of concern for District 7. Those present at the meeting felt that while changing the tone for the backup alarms would initially draw workers' attention, complacency would quickly settle. They felt that changing a tone every few weeks would prevent complacency among the workers. In addition, most present felt that crew cabs should also be equipped with backup alarms to prevent accidents and questioned why the fleet management department denied this suggestion.

Mowing is not a major concern in District 7, with the exception of some slope mowing and improving sight distance. Those present were concerned about roadways not being swept after mowing, and wanted a bid item included for sweeping. Also, they would like to use red LED lights on both the tractors and the support trucks.

The biggest problem regarding Trenching/Shoring/Excavating involves continuity between the districts. Every district should follow the same procedures when performing these operations. District 7 would like to see man boxes included as a bid item for contractors, thus encouraging much safer trench practices.

The discussion regarding Fall from Heights/Fall Protection centered around contractors. The state employees are constantly telling contractors' employees to use their equipment. While the state does have the right to inform the contractor after several warnings that a worker must be off site, they would like those in management to back up their decision. In regards to District 7, they have good equipment, and it is readily available to the workers.

Debris Removal was also an area of concern, as District 7 does not have lifting devices on its trucks. The maintenance crews would also like better lighting on vehicles when conducting these operations, especially at night. In addition, debris removal should not be a one person job, so an increase in crew size is necessary.

Short Term Patching is a dangerous operation everywhere, and this was the case with District 7. Those attending the meeting said that in order to safely patch roads, there must be a lane closure. To this end, the district uses VMBs to alert the public that there is a rolling lane closure for the distance necessary. Also, there are only two crash cushions in the entire district, far fewer than what is needed.

The new shirt policy was discussed in detail with regards to Personal Protective Equipment. When asked about the current shirt contract, the Resident Engineers informed the research team that the contract has been terminated and that a new shirt is being investigated. This particular type of shirt is much more breathable and the reflective tape will have some stretch to it, an improvement over the current shirt. Also, the research team was asked why the Cabinet made the decision to require construction crews use white hardhats, as they blend in with the state trucks used on jobsites, making it difficult for operators to spot workers.

The main concern regarding jobsite communication involved money. They questioned why the State would not purchase walkie-talkies for the districts, as well as discussed the lack of communication between KYTC employees on jobsites. Also, the Residents stated that if safety and PPE were such a priority to KTC then those items should have a separate budget and not be grouped into the Overhead category.

Visibility/Hearing was important to District 7. The Resident Engineers suggested using CB radios to dialogue with truckers, thus using a sort of civilian traffic control in active work zones. Also, they would like to use a flashing stop/slow paddle, but the weight and visibility at night were a concern. One person suggested installing temporary signals in areas where flagging operations are needed for an extended period of time and questioned the research team about cost effectiveness.

For the Miscellaneous category, speed reduction was discussed at length. On US62, there is a VMB broadcasting a speed reduction to 45mph. A sheriff in that area writes about 25 tickets per day, a great revenue source. It was suggested that the DriveSmart cameras used in workzones take a photo of a speeding car as it passes the radar sign, then send the offending driver a ticket. This could help, but implementation would be costly and met with great resistance. Portable rumble strips could aid in traffic control, but would work best if traffic slows initially.

### **Discussion from Districts 8 and 11 Meeting**

A total of twelve employees attended this meeting; 6 from District 8 and 6 from District 11. Those attending represented both the engineering aspect and the field worker's viewpoints regarding safety. Both groups agreed that better communication between operators and the ground crew was the biggest area of concern regarding Heavy Equipment Operation. In order to accomplish an improvement of communication, the workers recommended that a two-way radio with a good operating range be installed in every piece of equipment. In addition, they believe that installing a camera system in certain machines, such as dump trucks, could greatly reduce backover incidents.

Mowing was an area of concern, as approximately one-half of all mowing within the two districts is a KYTC operation. Due to the difference in geography between Western and Central Kentucky versus Eastern Kentucky, the workers believe that the state should consider these factors when choosing equipment. That is to say, equipment that works well on the flat areas of Central and Western Kentucky is often dangerous to operate on the mountainous terrain of Eastern Kentucky.

Again, the Trenching/Shoring/Excavating category was not of particular concern, as these districts do not conduct trenching operations over four feet deep, and when necessary, they lay back the slope according to OSHA standards.

The District employees reported that Fall Protection is not an issue due to recent upgrades of equipment and better training. The one suggestion made during the discussion was to ensure that all crews have a rescue plan in place at all times, should an emergency arise. This idea should be implemented statewide due to its potential life-saving purpose.

Debris Removal sparked an interesting discussion. District 11 reported that they received blood-borne pathogen safety classes and were promised hepatitis-C shots initially, but upon learning the cost, 128 vaccinations costing \$18000, the district decided that it was cost-prohibitive and relegated the vaccinations to bridge inspectors and custodians. This was controversial, as the maintenance crews pointed out that they need to be protected as well, especially when working in old sewer pipes that drain into ditches. Concerning the removal of dead animals, this operation is difficult to conduct promptly, as “no sane person wants to do it.” Perhaps using prisoners for litter removal would alleviate some of the burden from the maintenance crews.

The meeting attendees stated that using escort vehicles during Short Term Patching operations would be key to improving safety, as the flashing lights alert the public to the workers’ presence. Also, when patching in heavily traveled areas, there needs to be more traffic control, and it was suggested that proper signage would improve the attitude of public motorists and lead to safer driving habits on the part of the public.

Concerning Personal Protective Equipment, the top concern at this meeting was consistency. The workers believe that when the state mandates a policy, every district should be required to implement the changes at the same time. This was especially important regarding the new shirts. The heavily populated districts as well as the busier districts implemented the change quickly, while other districts either lagged behind or had yet to embrace the change. Another suggestion was to encourage district supply facilities to stock both safety sunglasses as well as regular safety glasses, as the sunglasses encourage PPE usage on sunny days, rather than workers using their own sunglasses, which may not be ANSI certified.

Jobsite Communication yielded some interesting topics, including battery life, LED signs and constant maintenance issues. The nickel-cadmium batteries are useful, due to their long life, but the workers stated that the battery must completely run down before recharging. If this does not happen, then it develops a memory and loses its useful lifespan, not ideal for expensive batteries. There is an issue of constant maintenance regarding the upkeep of these radios. Much time is spent either fixing the radios or just finding ones that are charged and working. Statewide, this is a problem. The workers also decided that flashing LED STOP/SLOW signs would be beneficial, especially on curvy roads where visibility is limited.

Flagging was the largest area in need of improvement in the Visibility/Hearing portion of the discussion. Flagmen should exercise common sense, apparently a trait lacking among many contractor employees as well as state employees. Also, should a flagman hit a car with his paddle for ignoring his/her signals, that action should be backed up by the state, as the public needs to be aware of the dangers to the workers that he/she is trying to protect.

The miscellaneous section of the discussion once again centered around a lack of KYTC employees, and the fact that without an adequate crew size, safety shortcuts are more likely to be utilized. The workers also stated that safety classes concerning multiple topics, including pathogens, CPR and basic First Aid, should be taught to everyone in all 12 districts. Also, those present believe that if workers understand why the safety practice/policy is more important, that it is an investment in their own wellbeing, then they will be more inclined to follow that practice or policy.

### **Discussion from District 9 Meeting**

Some new ideas arose during the District 9 discussion, held at the district office in Flemingsburg, Kentucky. Several field workers were present, as were resident engineers and the Chief District Engineer, Katrina Bradley. There was a great turnout due to a celebration held for a fifty-year employee the day of the meeting.

Heavy Equipment Operation was an important area, and the research team discovered that the practice of using cameras has been integrated into District 9. Those present agreed that an alarm that increases in volume as an object is approached would be helpful in preventing backover incidents, both on equipment and on crew cab trucks. The camera systems have been installed on bucket trucks, and the operators have noticed a drastic improvement in safety and ease of operation. The maintenance crews would like the operator and the lead ground man to have a hands-free headset operating on a dedicated channel to improve communication.

Mowing on narrow roadways is an issue within the district, as an extra person following the last operator would assist in protection. The crews would like to install new LED lighting packages on tractors, similar to a contractor near Louisville. These lighting packages would greatly increase visibility, especially when mowing along hillcrests and curves. Also, they believe that mowing signs should be placed closer together to keep the public informed and alert.

The employees in District 9 have some concerns regarding Trenching, Shoring, and Excavating operations. They would like to see a trench box listed as a bid item, or that the Cabinet should own a trench box for these operations. The employees realize that they cannot police contractors as far as OSHA guidelines, but they would like more training and the authority to enforce OSHA policies. Also, the workers realize that right-of-way is a problem, and feel that the state should try to acquire more right-of-way whenever possible, in order to conduct the work safely.

Falls from Heights were more an issue than Fall Protection in District 9. It was stated that workers do not recognize height issues that occur everyday, especially in the six to eight foot range. In the field, however, they like the system of instant reporting of hazardous behavior and in-house reprimands. The attendees did state that they felt their training and equipment were more than adequate in District 9.

Concerning Debris Removal, the maintenance crews would like to use a lift device requiring a two-person crew. Other states use this method, and with a good deal of success, according to the workers. They would also like some short training sessions concerning preventive measures regarding blood-borne diseases, possibly using a link through the district website.

Short Term Patching is always an issue, and the size of crews is the biggest safety impediment. The workers would like to see four to six people per patching crew. Also, they feel that a rolling road block would work very well in protecting the workers from regular traffic during this quick operation.

PPE in District 9 is always improving, and this was obvious during the discussion. Recognizing the shortcomings of the new polyester shirts, the District has begun to test new shirts. One surveyor named Phil commented that the cotton/mesh blend shirt he was testing was very comfortable and much easier to wear. The employees also like the personal accountability that came with the new hardhat policy. One person stated, "It's nice to see that the Cabinet is making a very respectable effort to improve PPE for its workers."

Jobsite Communication remains a concern, especially involving radios and open stations. The maintenance workers want to try the Family Radio Service channels and equipment, as the radios operate on a ½-Watt system instead of the traditional 5-W system. These would be very useful in short work zones and are economical, as they are less than \$100/pair at most discount stores. The district does have dedicated channels for the two-way radios but battery life is still questionable. The workers stated that the I-com radios by Vercom have a much better battery life and would like to see the Cabinet purchase those models for the crews.

Authority is very important regarding Visibility/Hearing within District 9. The inspectors within the district feel that they need the authority to reprimand the contractor's flagmen in order to keep the jobsite safe and accident-free. There is a problem regarding lane closures, as often there is a confusing lane shift or intersection configuration.

There was a concern regarding the safety of portable rumble strips during wet pavement conditions, discussed under the Miscellaneous topic. The workers feel that worker awareness is the biggest safety problem in most jobsites. Regarding the traveling public, those present were very much in favor of stationing an undercover officer with a radar gun and a walkie-talkie in the work zone to reduce speeding drivers.

### **Discussion from Districts 10 and 12 Meeting**

The final district meeting took place on September 8, 2006 at the District 12 office in Pikeville, Kentucky. Employees from both districts were quite vocal during the discussion session and yielded very interesting viewpoints on all ten topics.

The research team questioned the groups about how useful a hands-free headset would be during Heavy Equipment Operations. The general response was that the idea was good, but most operators were concerned about the distractions that come with radio communication. They stated that a radio/microphone combination using a trigger button on the steering wheel would be easier to use, and less of a distraction. The group was interested in learning more about using cameras to prevent backup accidents.

Mowing was not a major area of concern, as District 12 contracts all mowing operations to private contractors. District 10 does conduct some mowing operations, and the biggest problem involved sweeping the roadway after mowing, especially during the first cycle. Concerning closed cabs on tractors, District 10 does possess some of these tractors, and they are quite popular among the operators.

Trenching/Shoring/Excavating continued to be a minor area of concern. The State uses the standard practice for laying slopes back or sending the job out to private contractors. Right-of-way is a problem in both districts, and the crews feel that the state should buy more right-of-way, especially when work is necessary on small rural roadways.

Both of the Districts informed the research team that Fall from Heights/Fall Protection issues have improved, but concerns still exist. In these districts, the fall protection needs to be upgraded. From a construction inspection view, the inspectors need more training and access to the equipment. To decrease accidents during routine salt truck cleaning and maintenance, one person suggested building a ramp to reduce ladder falls when cleaning the tops of these trucks.

Debris Removal was also a major concern for the districts. Lift gates would greatly reduce the number of back injuries, and should be installed immediately, according to the workers. The workers also were upset that only bridge crews received hepatitis shots, and feel that all maintenance personnel should be protected, as dangers exist when working near drainage ditches. The other major area of concern involved a need for more portable lighting when removing debris at night.

Consistency was the big issue regarding Short Term Patching. The employees all agreed that there should be standardized procedures statewide regarding material and installation methods. In addition, the crews would like more traffic control during these operations but stated that the short duration of the operation hindered improving traffic control.

The discussion regarding Personal Protective Equipment had many common concerns discussed, as well as some new ideas. The change to bright green shirts was again viewed as a good idea in need of refining. The workers would like to see a 5-year color change cycle with the shirts to discourage complacency. The representatives also stated that when choosing any type of PPE, safety should be the first concern, followed by comfort. The safety coordinator in District 12 has improved CPR and First Aid Training, but this is not the case in District 10, as few crews have someone with this training, and the district does not currently have a Safety Coordinator on staff.

Jobsite Communication discussions continued to center around the radios that are currently in use. According to the crews, UHF radios are better to use because they have a licensed frequency and the workers do not have to deal with interference from other users. The resident engineers present were opposed to using long range radios and wanted to shorten work zones to combat range problems. They would also like to see KYTC use the active/inactive work zone flashing light system for speed control, similar to West Virginia, Virginia and Maryland.

In regards to improving Visibility/Hearing, the idea of using a flashing LED paddle was met with enthusiasm. Many workers also felt that Variable Message Boards are overused and have become static signs, defeating their intended purpose. They said that

these signs should be used for 1-2 days. If a project lasts longer, permanent signage should be installed, but kept current and removed promptly at the end of the project.

The Miscellaneous portion of the discussion yielded many good points and ideas for safety improvement. The idea of using portable rumble strips for small operations was popular with all workers except one motorcycle enthusiast who was concerned about the safety of the cyclist, not the flagmen. Those present also thought that using tractor-trailer drivers as a method of traffic control could work quite well within their work zones. Raising public awareness and enforcing work zone speed limits remained an issue, though through the DriveSmart campaign, this has improved. Judges were contacted by the districts and stated that they meted out the proper fines for issued tickets, thus discouraging the public to break the law in hopes that the ticket would later be dismissed.

## **4.0 FINAL DATA COLLECTION**

### **4.1 Safety Climate Survey of KYTC Workers**

#### **4.1.1 Purpose of Survey**

The purpose of the climate survey was to measure worker's perception of organizational commitment to safety by asking a series of questions, followed by a series of statements in which workers rated the accuracy of that statement.

Safety climate is a psychological phenomenon, which is usually defined as, "the perceptions of the state of safety at a particular time" (Hui Zhang, 2002). The perception of safety affects both the job and the organization, and vice versa. Since worker perception can affect the organization, and naturally the organization can affect the worker's perception, then the worker's perception of safety should be a fairly accurate assessment of the organization's commitment to safety (Cooper, 2000).

#### **4.1.2 Survey Composition**

The climate survey contains two sections, questions, and ratings. The first section of the survey which contains 21 questions and five possible choices: Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree. The research team opted to give the worker five choices as opposed to three choices, for the reason that there could be a significant difference between a worker "Agreeing," and "Strongly Agreeing" to the content of the questions given. In the final survey, the content of the questions was more suited for three answer choices. The questions in the Climate Survey were aimed to specifically address how the worker feels about how important safety is to their organization. Most of the questions in this section are of the positive nature, with only a few negative natured questions.

The second section of the climate survey contained a series of five statements or scenarios in which the worker rated their support for the statement or scenario from 1 – 10. The climate survey can be viewed in Appendix F.

#### **4.1.3 Survey Distribution**

The project team distributed surveys to both KYTC workers and contractors, each in separate ways. Concerning KYTC, we distributed surveys both to their construction division (resident engineer's offices), and their maintenance divisions (maintenance barns). The research team sent out a package with 10 surveys to the resident engineer's offices, and 20 surveys to the maintenance barns. These packages also included instructions and details concerning the survey, addressed to the managers of each facility, along with prepaid return envelopes.

#### **4.1.4 Survey Results**

We did not receive back any results from contractors, and only received partial results from the KYTC, although it was an adequate amount to conduct a statistical analysis with a high confidence interval. It should be noted that maintenance workers returned over four times more surveys than construction workers. The chart below denotes the breakdown of responses from the KYTC.

Table 2: KYTC Climate Survey Responses

District	Maintenance	District	Construction
	Returned Surveys		Returned Surveys
1	44	1	0
2	73	2	9
3	8	3	0
4	91	4	9
5	24	5	16
6	58	6	7
7	0	7	17
8	27	8	6
9	48	9	0
10	61	10	7
11	2	11	10
12	0	12	10
Total:	436	Total:	91
Total Response:	527		

## 4.2 Final Safety Survey of KYTC and Contractor Workers

### 4.2.1 Purpose of Survey

The final survey was completely created from the results of the second survey, and the focus group meetings that the research team conducted. The primary purpose of this survey was to consolidate the information received in the second survey into a one-page front-and-back, easily understood survey which could be mass distributed with high return rates. This was important because the statistical analysis of this survey would serve as the basis for the recommendations.

An alternate purpose of this final survey was to confirm problem areas that were unclear from the second survey. For instance, some areas on the second survey were considered statistically neutral, even though the focus group meetings indicated that there were areas of high concern. Since the final survey was distributed to many more people than the second survey, the research team hoped that a definite answer would appear.

A key issue in this survey was simplicity. The first survey issued was open-ended, meaning that workers could write any response they wished. The second survey was based on a ranking system, from 1 – 5, which we found to be somewhat confusing to workers when dealing with statements of negative nature. This being said, it was important to word all questions so that they were all positive in nature and could be easily interpreted. To accomplish this, the research team prepared the final survey and distributed it to the committee members at the September 2006 Full Advisory Committee Meeting where each member could read the survey and suggest changes based on their

concerns. Significant changes were made to the final survey after discussion with the committee. Initially, the questions, which asked for agreement or disagreement, were given five choices: Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree. In an effort to reduce confusion to workers, the two extreme choices were deleted.

Also, each question was broken down into two sections. The first section was to answer the question as described above, either: Disagree, Neutral, Agree. The second part of the question asked for the workers opinion on the probable impact on jobsite safety, if the idea was implemented. To answer this, workers rated the idea from 1 – 5. 1 meaning no impact, and 5 meaning complete improvement. This allowed the research team to evaluate not only if the worker agreed with the statement, but also how important the statement was.

#### **4.2.2 Survey Composition**

The final survey can be viewed in full in Appendix E. The content of the survey consisted of 15 statements for the worker to evaluate. Two of the questions from the survey were equipment related, two of the questions related to mowing operations, two questions related to flagging operations, and several other questions as well.

As previously mentioned, workers were asked to evaluate the statements in two ways: agreement, and impact. Reason being, a worker might agree that they need better selection of Personal Protective Equipment (PPE), but the impact it would have on the jobsite safety is minimal, if any. So with this second piece of information, the statistical analysis capabilities were increased.

#### **4.2.3 Survey Distribution**

Proper distribution of the final survey was a key to achieving an accurate statistical analysis, which was the primary purpose of the survey. Before this point in the study, contractor involvement was minimal, so involving them in this final survey was crucial to the final outcome.

We distributed surveys to both KYTC workers and contractors, each in separate ways. Concerning KYTC, we distributed surveys both to their construction division (resident engineer's offices), and their maintenance divisions (maintenance barns). The research team sent out a package with 10 surveys to the resident engineer's offices, and 20 surveys to the maintenance barns. These packages also included instructions and details concerning the survey, addressed to the managers of each facility, along with prepaid return envelopes.

The research team attempted to distribute surveys to contractors in the same manner, by mailing out packages with prepaid return envelopes, but our response was unsatisfactory. This was probably due to the fact that at the time of year that we sent our surveys to the contractors, many of their employees were off on winter break. In a final attempt to gain statistical data from contractors, the research team was invited to the Plant Mix Asphalt Industry of Kentucky annual meeting, where most of Kentucky's paving companies were in attendance. We were able to distribute and receive back an adequate amount of surveys to complete the statistical analysis.

#### 4.2.4 Survey Results

The final survey was successful in the fact that we received enough surveys to conduct a statistical analysis with a high level of confidence pertaining to each statement. This is true for both the KYTC and contractors. The chart below denotes the breakdown of responses from KYTC workers.

Table 3: KYTC Final Survey Responses

District	Maintenance	District	Construction
	Returned Surveys		Returned Surveys
1	45	1	5
2	83	2	14
3	8	3	7
4	98	4	10
5	22	5	17
6	60	6	6
7	0	7	16
8	38	8	12
9	69	9	6
10	93	10	8
11	0	11	24
12	0	12	9
Total:	516	Total:	134
Total Response:	650		

The chart below denotes the breakdown of responses from contractors. The research team decided to breakdown the contractor's surveys by geographical region to provide specific results for each region, as they vary greatly in roadway types.

Table 4: Contractor's Final Survey Responses

Geographical Region	Returned Surveys
Western	51
Central	122
Eastern	27
Total Response:	200

## 5.0 DATA ANALYSIS

For both surveys, participants were directed to evaluate each statement based on their level of agreement toward the issue. On the safety climate survey, a five-point Likert scale was used. Numerical values were assigned to each of the potential evaluation levels. For example on the safety climate survey, ‘Strongly Agree’ was weighted as the number 5 and ‘Strongly Disagree’ was weighted as the number 1. On the final safety survey, a three-point Likert scale was used. The scale on the final safety survey was similarly weighted like the safety climate survey. However, on the final safety survey, ‘Agree’ was treated as a ‘3’ and ‘Disagree’ was treated as a ‘1’ for evaluation mean calculations.

The data from the surveys was broken down by two methods. The first method was to simply rank the survey statements by the mean value of their evaluation. For the safety climate survey, the ranking was done from the lowest to the greatest value. For the final safety survey, the ranking was done by the highest to the lowest mean value.

After the initial ranking was completed, an analysis of variance (ANOVA) was done. However, unlike most applications of the ANOVA, it was not used to determine statistical differences among various parameters. For this analysis, the ANOVA was used to determine similarities in order to group the survey statement responses into various ranking levels. For both sets of data, one from the safety climate survey and one from the final safety survey, a significance level of 0.30 was determined to be the threshold for enough similarities for survey statements to be grouped under the same ranking level. If an ANOVA revealed that the responses from the survey had a significance level of 0.30 or greater, then those responses were determined to be similar enough to be considered as the same level of ranking. If an ANOVA revealed that the responses from the survey had a significance level of less than 0.30, then those responses were determined not to be similar enough to be considered as the same level of ranking and were moved to the following lower level of ranking.

For both sets of survey data, the ANOVA’s were performed on the data in its entirety as well as different subsets within the information. Subsets were based on geographic location and job classification. The geographic location categories were determined based on the KYTC District Map. A copy of this map can be seen in the Appendix G. In Table 5, the different geographic classifications used in the analyses are listed along with a description of the KYTC districts that compose each classification.

Table 5: Geographic Classifications  
of KYTC Districts

Classification	KYTC District
Western	1, 2, 3, 4
Central	5, 6, 7, 8
Eastern	9, 10, 11, 12

The job classification subset allowed the data to be divided by one of the following three job types: Construction, Maintenance, and Contractor. The construction category was made up of KYTC employees who worked in their division of construction. Similarly, the maintenance category was made up of KYTC employees who worked in their division of maintenance. The third category, contractor, was composed of responses from employees of Kentucky highway contractors who were surveyed.

## **5.1 Safety Climate Survey**

As stated above, the data collected from the surveys has been analyzed based on geographic location and job classification. The statements on the survey were grouped into one of four different rankings. Rankings were compiled so that a statement in the group ranked first is considered to be one of the most critical and important issues and a statement in the group ranked fourth is considered to one of the least important issues among the workers in that specific area, job classification, or a combination of the two. Some statements on the safety climate survey were worded as negative statement. In other words, a positive response towards one of these negative statements reveals a problem area. In order to account for this issue, the evaluation scale was reversed for such statements when compiling the data. For the safety climate survey, a low evaluation average translated into a higher ranking, an important issue.

The statistical data calculated from SPSS, a statistical analysis program, has been placed in a variety of tables for each ranking. Most of the tables, which are located in Appendix J, show the statements before the significance level drops below 0.30 which indicates the start of the next lower rank.

### **5.1.1 Summary of Detailed Statistical Analyses of Safety Climate Survey**

In this section, the top concerns of KYTC construction and maintenance employees from the three geographic regions of the state will be discussed. The various similarities and differences between the regions and job classifications will also be discussed. For simplicity, only the statement numbers are giving in each of the tables displaying information about a particular region. The statement numbers correspond to the list of statements in Table 6. This table only briefly describes each statement, yet the full version of the safety climate survey statements can be found in Appendix F.

Table 6: Climate Survey Statements

1. Equal to Getting the Job Done
2. Problems Addressed Quickly
3. Employees Praised
4. Employees Disciplined
5. Clearly Communicated Lessons
6. Feedback Encouraged
7. Sources of Information
8. Complex Rules and Procedures
9. Employees Remind Each Other
10. Safe Workplace
11. Safety Talks
12. Avoided Safety Procedures
13. Hazardous Situations Reported
14. Accident Investigations
15. Co-worker in Accident
16. Necessary Rules
17. Not Practical Rules and Policies
18. Laying Out Safe Work Areas
19. Defective Equipment
20. Enough Time for Safety
21. Shortcuts at expense of safety

For the western portion of the state, employees in the construction and maintenance division agree that there are certain safety rules and policies that are not practical as displayed in Table 7 which shows statement 17 being a concern for each group. Apparently, the maintenance employees believe that one of their co-workers will be involved in an accident. This belief is considering especially since it could evolve into an attitude of accepting such an issue as an unavoidable fact. The construction workers in the western portion of the state view the avoidance of safety procedures and shortcuts taken at the expense of safety as additional concerns.

Table 7: Climate Survey - Western Kentucky

<u>Job Classification</u>	<u>Statement Numbers</u>
Construction	12, 17, 21
Maintenance	15, 17

The two concerns expressed by the western maintenance employees are shared by both the central and eastern maintenance employees. For the central region of the state shown in Table 8, the construction employees also believe that one of their co-workers will be involved in an accident as well as some of the safety rules are not practical. The central construction employees also share the remaining two concerns of the western construction employees. Apparently, the central construction workers have an issue with

working with defluctive equipment. Finally, hazardous situations experienced by the workers are not reported as often as they should.

Table 8: Climate Survey - Central Kentucky

Job Classification	Statement Numbers
Construction	12, 13, 15, 17, 19, 21
Maintenance	15, 17

In Table 9, it appears as though there are a number of concerns from the eastern construction employees. However, it is more likely that the number of respondents is too small. This can be seen in more detail in Appendix I. The eastern construction workers share the all of same concerns as the central construction employees with the addition of four issues. Apparently among the construction employees, neither praise nor disciplinary action is given in the appropriate amount for working safe or unsafe. Also, there is a belief that employees do not remind each other about safety enough among the eastern construction employees. Finally, the eastern construction workers view themselves as being under time constraints that do not allow enough time of performing work in a safe manner. As stated, the eastern maintenance employees shared two concerns with their western and central counterparts. However, they also view enough of their safety procedures are avoided to be considered an issue. This point can be seen with addition of statement 12 in Table 9 under the maintenance job classification.

Table 9: Climate Survey - Eastern Kentucky

Job Classification	Statement Numbers
Construction	3, 4, 9, 12, 13, 15, 17, 19, 20, 21
Maintenance	12, 15, 17

## 5.2 Final Survey

As stated above, the data collected from the surveys has been analyzed based on geographic location and job classification. The statements on the survey were grouped into one of four different rankings. Rankings were compiled so that a statement in the group ranked first is considered to be one that is believed to improve work zone safety the most and a statement in the group ranked fourth is considered to one that is believed to improve work zone safety the least among the workers in that specific area, job classification, or a combination of the two. For the final safety survey, a high evaluation average translated into a higher ranking, an important issue. Another difference from the safety climate is, on the final safety survey, a three-point Likert scale is used, instead of the five-point scale.

The statistical data compiled from the collection of final safety survey responses has been placed in a variety of tables for each ranking. Most of the tables which are located in Appendix J show the statements before the significance level drops below 0.30 which indicates the start of the next lower rank.

### 5.2.1 Summary of Detailed Statistical Analyses of Final Survey

In this section, the top concerns of KYTC construction and maintenance employees as well as ones from Kentucky highway contractors from the three geographic regions of the state will be discussed. The various similarities and differences between

the regions and job classifications will also be discussed. For simplicity, only the statement numbers are given in each of the tables displaying information about a particular region. The statement numbers correspond to the list of statements in Table 10. This table only briefly describes each statement, yet the full version of the final safety survey statements can be found in Appendix E.

Table 10: Safety Survey Statements

1. Sensors/Cameras for Blind Areas
2. Alternating Back-up Alarms
3. Closed Cabs for Tractors
4. Auto-shutoff for Tractors
5. Increased Crew Sizes
6. Two-way Radio Devices
7. Procedure for Trench Box
8. Availability and Selection of PPE
9. First Aid Kits and CPR
10. Yearly Physical Exams
11. Flagmen Training
12. Lightweight Flashing Paddles
13. Portable Rumble Strips
14. Lighting for Nighttime Activities
15. Traffic Citation Enforcement

According to the results from the final safety survey, there are three safety improvements that all western highway workers regardless of job classification view as having a great potential to enhance safety in work zones. Two of the three improvements are concerned with equipment. Alternating back-up alarms and automatic shutoffs for equipment are believed to have the potential of improving highway work zone safety. The third improvement shared by each group within the western part of the state is the use of two-way radio devices with improved battery life, range, and dedicated frequencies.

At first glance, Table 11 displays that the western KYTC construction employees believe that almost every improvement listed on the final safety survey should be considered as having the greatest potential towards enhancing safety. However, the large number of statements is more likely due to the small number of respondents from the state construction area. Besides the three shared improvements, two additional improvements also were determined to be in the top ranking by the western contractors. Improved availability of first aid kits and CPR trained personnel was found to need improvement. Given the fact that more construction activities are being performed at night, the second additional improvement of better lighting for nighttime activities was expected.

Finally, like the western contractors, the western KYTC maintenance employees also viewed two more improvements as important enough to be in the top ranking. Since mowing is considered a maintenance function, the use of closed cabs for tractors was an expected top improvement. A closed cab is meant to protect the driver from the debris

which is propelled back during mowing operations. A better traffic citation enforcement plan was also an expected top improvement for all three groups, not just maintenance.

Table 11: Safety Survey - Western Kentucky

Job Classification	Statement Numbers
Contractor	2, 4, 6, 9, 14
Construction	1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 14, 15
Maintenance	2, 3, 4, 6, 15

Moving across the state, three safety improvements were shared among all highway workers in the central part of Kentucky. Of these shared three, only one improvement, automatic shutoffs for tractors, was shared among all highway workers in the western part of the state. As seen in Table 12, one of the two remaining improvements shared among the central workers was improved lighting for nighttime activities. Given that the major metropolitan areas, Louisville and Lexington, are located in the central part of the state, many construction and maintenance activities are performed at night to avoid the larger traffic volumes experienced during the day. Lastly, the use of improved traffic citation enforcement plan is also shared among the three groups.

Table 12: Safety Survey – Central Kentucky

Job Classification	Statement Numbers
Contractor	2, 4, 11, 14, 15
Construction	2, 4, 7, 11, 14, 15
Maintenance	3, 4, 6, 8, 14, 15

Between the contractor and KYTC construction workers, there is only one statement that is not shared by both. This is probably the case because statement 7 deals with an improved procedure for obtaining a trench box which is an issue mainly for the KYTC given their limited supply. The use of alternating back-up alarms and improved flagmen training are improvements viewed as having a great deal of potential towards enhancing safety by contractors and state construction workers. The similarities between these two groups are understandable considering that they perform many of the same work activities.

Finally, the central maintenance employees believed that there are three additional improvements that could improve safety the most besides the three shared improvements. As stated before with the western part of the state, closed cabs for tractors is an important improvement towards safety among the maintenance employees given that mowing operations are performed by this group. The second improvement is use of two-way radio devices with improved battery life, range, and dedicated frequencies. Such an improvement is expected from maintenance employees given the distances that can be experienced between members of a mowing or clean-up crew. Improving the availability and selection of personal protection equipment (PPE) is the final addition for the central maintenance employees.

For the eastern region of Kentucky, only one statement is shared by each job classification within this region. The use of automatic shutoff for tractors is not only the statement shared by every highway worker in this region; it is also the only one shared by every highway worker in the state. As seen in Table 13, this is the case because the eastern KYTC construction only believed that this improvement is one with the greatest potential to enhance safety.

Table 13: Safety Survey – Eastern Kentucky

Job Classification	Statement Numbers
Contractor	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
Construction	4
Maintenance	3, 4, 6, 8, 9, 14

When looking at Table 13, it is easy to think that eastern highway contractors believe that all but one of the improvements listed on the final safety have the greatest potential to impact safety in a positive way. However, due to the low number of eastern contractor respondents, it is more likely that the statistical analysis could not cause separation among the statements. As one would expect given the number of statements, the top safety improvements viewed by the KYTC eastern maintenance employees are also ones listed by the eastern highway contractors.

All but one of the eastern maintenance employees’ statements were viewed by both the central and eastern maintenance employees as the top safety improvements. As expected, the use of closed cabs for tractors was viewed as a top safety improvement. For the same reasons stated for the central maintenance employees, improved two-way radio devices was also determined to be important. Given the rural nature of most of the eastern region of Kentucky, improved lighting for nighttime activities was unexpected listed improvement. Improved availability and selection of PPE is the last improvement shared by the central and eastern maintenance workers. The only difference between the central and eastern maintenance top safety improvements was the improved use of first aid kits and availability of CPR trained personnel. This improvement appeared as a top method to enhance safety in the western part of Kentucky among KYTC construction and highway contractor workers in that region.

## 6.0 FINAL SURVEY PROBLEM STATEMENTS & PROPOSED SOLUTIONS

### Statement Specific Analyses

The statement specific analyses presented in this section are from the final survey sent. There were 15 statements in the final survey, and each statement's presented solution(s) are specific for the KYTC and contractors. Reason being, several questions either are irrelevant or impractical for contractors.

### Solutions

The solutions presented in this section are general and simple solutions. Also, some statements have multiple solutions to abate the specific problem and it is not the purpose of this section to list variations of previously presented solutions. Solutions are general in nature and will remain open to creative variations that will solve intricate problems.

Offering solutions for every statement in the final survey allows the end user of this study to understand how to mitigate issues that were not considered significant through the statistical analysis.

Several of the solutions presented in section 6.2 (Contractor's Analysis) are the same or very similar to the solutions presented in section 6.1 (KYTC Analysis). This is because these solutions are generic in nature and would solve the same problems for both the KYTC and contractors. Also, some of the statements given in the final survey do not directly apply to contractors; therefore solutions will not be given to these statements.

### 6.1 Analysis of Methods to Improve Safety on KYTC Projects

**Statement 1:** We should use sensors and/or cameras mounted on the rear of equipment and/or vehicles to detect objects in blind areas (mounted as not to distract the operator).

**Solution:** The issue with this statement is lack of vision, whether the object is in front of a large truck or behind a small truck, the issue remains the same. The KYTC subscribes to the work rule that the operator of a large truck (dump truck) must physically check the perimeter of his truck before moving it; although there is a problem with this rule if an object moves into the blind area of that vehicle in between the time that the operator checks the perimeter and when he moves the vehicle. This work rule should be slightly altered to include a worker on the ground with a full view of the area to direct the vehicle to its desired path. If another worker can not be devoted to this task every time the vehicle needs to move, other considerations should be made. One of those being the addition of cameras mounted on the rear of vehicles with a screen in the cab so that the operator can view it. The camera should only be activated when the vehicle is in the reverse gear. These cameras should be mounted on vehicles that have an increased likelihood of causing a struck-by accident while in reverse, such as dump trucks, utility trucks, or other tall trucks with poor rear vision.

**Statement 2:** We should use back-up alarms with alternating tones and/or sounds to keep workers attentive.

**Solution:** Most all large construction equipment and trucks have back-up alarms factory installed. The issue is that the tone produced by these vehicles does not change. It is the same tone throughout the lifetime of the vehicle. Also most all vehicles share the same tone, making it difficult to delineate exactly which vehicle's alarm is engaged. The idea behind this statement is that hearing the same tone throughout the lifetime of a vehicle leads a worker to become unaware that the alarm is signifying a possible hazard. If the alarm does not alert the worker that a vehicle is backing up, then the alarm is not effective. To mitigate this issue, alarm sounds should change so that it is impossible for the worker to become indifferent to a certain tone. Although this study has not researched the time span that is required for a worker to become indifferent to a tone, a study like that could be conducted. Knowing that time span, the backup alarm on a vehicle could be set to change, keeping workers aware of the hazard created by backing vehicles/equipment. Vehicles could be equipped with several different and unique tones so all vehicles do not change to the same tone at the same time.

**Statement 3:** Concerning mowing operations, we should use tractors with closed cabs to prevent flying debris from striking the operator.

**Solution:** The issue with this statement is that tractor operators can be struck by flying debris while mowing. A possible solution to this problem is the use of tractors with closed cabs that would prevent flying debris from striking the mower. Another possible alternative is to require tractors to use a type of screening or netting to intercept flying debris; although this study has not researched the size of typical flying debris that is causing accidents of this nature. If the debris is large enough that it will not fly through a screen and small enough that it can be stopped by a screen, this would be a much more feasible solution.

**Statement 4:** Concerning mowing operations, we should use tractors with auto-shutoff so that if the operator is thrown from the seat, the engine will be shutoff.

**Solution:** This statement pertains to the hazard created when the operator of a tractor is thrown from his seat, leaving the tractor unmanned and free to follow the path of least resistance. Although many tractors come equipped with an auto shutoff function, not all tractors have this function. Some are deactivated to allow the operator to stand up while operating the tractor. A possible solution is to only purchase tractors with this the auto shutoff function. Also, instruct operators and mechanics of the importance of this function and implement a fine for any tampering with this function.

Also, compliance with the current policy regarding the use of seatbelts at all times could help eliminate this problem.

**Statement 5:** We need increased crew sizes to accommodate lookout personnel and to improve quality of work.

**Solution:** From the focus group meetings that the research team held at each district, it became apparent that most maintenance crews have the perception that they are undermanned, which leads to their crew members working unsafely. A realistic situation is one or two men are sent to clear debris from a roadway. The debris is too heavy for one man to handle, so the two men must move the debris, leaving no one to control traffic or to warn of oncoming traffic. This is a common scenario. It can also be asserted that having too many men on a crew can be unsafe, due to congestion and confusion. A solution to this problem is to increase the crew sizes of critical maintenance crews so that there is always a dedicated flagman. Another possible solution is to use new technology to reduce labor demands. Such as using a hoisting system to lift heavy loads, so that one man can focus on that task, and the other man perform necessary traffic control.

**Statement 6:** We need two-way radio devices with longer range, longer battery life, and dedicated frequencies.

**Solution:** This statement concerns communication on jobsites, specifically, flagging operations. Flagmen must stay in contact with each other to coordinate traffic movements. Flagmen must also stay in contact with equipment operators to inform them of traffic movements. A common problem in flagging operations is two-way radio devices moving out of range from one another and also their batteries depleting before the workday is complete. Another issue is two-way radio devices intercepting frequencies from other radios such as ambulances or tractor trailer drivers. A solution to this problem is for the KYTC to contract with a two-way radio manufacturer for purchase of a high performance type radio that has excellent range and battery life, and only use that type of radio. Instead of each district, maintenance barn, or crew using their own type of two-way radio, develop a policy which mandates use of the provided radio. This radio would have preset frequencies which can not intercept errant frequencies. The most important characteristics of the radio would be long range, even in mountainous or forest regions, and also high battery life with battery life monitoring capabilities so that workers know when their battery is depleting and can take appropriate measures.

**Statement 7:** We need a well known and understood Standard Procedure for how to obtain a trench box when needed.

**Solution:** Although it is a rare occasion, KYTC workers can become involved with excavation operations that require the use of excavation control methods. Not all situations have the required real estate to slope the sides of an excavation appropriately. In these situations, some form of mechanical excavation protection is needed. The most commonly used protection method is the trench box; however, maintenance barns do not have direct access to obtain these trench boxes, often times leaving the workers with no alternative but to complete the work without the trench box. A solution to this issue is for the KYTC to define a standard procedure for how to rent a trench box when needed; also, workers need advanced training on how to use trench boxes properly. Another alternative would be for the KYTC to purchase their own trench boxes.

**Statement 8:** We need improved availability and selection of Personal Protective Equipment (PPE) such as gloves, safety glasses, reflective clothing, hardhats, ear protection, heights protection, foot protection, respiratory protection and weather protection.

**Solution:** The main issue with this statement is that workers often are reluctant to wear certain PPE because the PPE is not comfortable. Workers are more likely to wear their PPE if the PPE is aesthetically pleasing, easy to use, as well as comfortable. Many pieces of PPE in current use by the KYTC are obtained through traditional low-bid contracts, supplying workers with PPE that does not fit correctly, and is not as durable as other types. Also, workers have difficulty obtaining new PPE when out in the field. It is not uncommon for PPE to be lost or damaged beyond useable standards while working. When this happens, extra PPE is often not immediately available to the worker. Extra PPE should be issued to crews so that workers are never without proper PPE.

**Statement 9:** We need improved availability of first aid kits, as well as more personnel trained in first aid/CPR.

**Solution:** The current policy employed by the KYTC on CPR/First Aid training is that at least one person per crew must have their certification. This policy does not take into account the size of the crew, the level of risk involved with each crew, or the job position of the crew member who obtained the certification. For instance, there might be one crew member certified in CPR for a three person crew, or a 15 person crew. The number of certified crew members should be a function of the size of the crew. Also, with increased occupational risk, there should be increased required number of certifications per crew. A crew performing maintenance on I-64 should have more certified crew members than a crew of construction

inspectors. Lastly, the crew members certified should be the actual crew members working in the field. Workers indicated that their crew's secretary would receive the CPR/First Aid training in order to meet the KYTC requirements, yet their secretaries will never work in the field where injury is most likely to occur. Also, crew members of different status should receive the training, such as a general laborer, an equipment operator, and a foreman, so that it is more likely that if an accident does occur, a certified crew member will be present to aid the injured worker.

**Statement 10:** We need yearly physicals to monitor vision, hearing, and other construction/maintenance sensitive abilities.

**Solution:** The main issue with this statement is that workers often lose their construction sensitive abilities due to the conditions created by their job. Often times these abilities are deteriorating due to natural ageing or other natural phenomenon. Whether it is job related, or naturally caused, workers need their health monitored in order to insure that they are able to work safely. Also, recurring physicals are important because they can spot problems in their early stages of development, such as back problems, or loss of hearing. Once these problems have been identified, workers can take the necessary precautions to eliminate the source of the problem, or begin treatment of the problem. There could be some opposition to implementing the yearly physicals policy because some workers already know that they should not be allowed to do their job in their current state of health, and that if a doctor found their exact condition and reported it to their employer, they would no longer be able to work that particular job.

**Statement 11:** We need increased flagmen training and certification programs. All flagmen should be certified by the state, especially contractor's flagmen. Also, all maintenance and construction workers should understand basic hand signals.

**Solution:** This statement addresses the need for flagmen training for anyone performing flagging duties on a KYTC funded project or operation. Through the district meetings that the project team conducted, we learned that it is not uncommon for flagging duties to be given to a crew member who is being punished or on probation, not taking into consideration whether the crew member has been trained in proper flagging procedures. This is especially a problem for contractors. It was brought to the attention of the project team that the KYTC will begin requiring all flagmen, whether they are employed by the KYTC or contractors, to be trained and certified, and have their certification on hand beginning the Fall 2007. It is for this reason that no further consideration will be given to the implementation strategy.

**Statement 12:** We need our flagmen to use lightweight flashing paddles with LED lights around the stop sign and in the STOP word to help capture the attention of oncoming traffic.

**Solution:** There are many maintenance crews across Kentucky that have already begun use of Light Emitting Diode (LED) Stop signs with great success. These stop signs are used by flagmen and increase the visibility of the stop sign to oncoming traffic. The stop signs have LED lights around the perimeter of the sign as well as in the work STOP. This stop sign is more likely to gain the attention of drivers with impaired vision, as the flashing LED lights are very bright. The stop signs are lightweight and easy to use. Through meeting with each district at the focus group sessions, crews were able to tell us how effective the flashing paddles are. These paddles are especially effective in nighttime construction.

**Statement 13:** We need to place portable rumble strips in front of flagmen to help capture the attention of oncoming traffic as well as slow them down.

**Solution:** This statement also concerns gaining the attention of oncoming traffic so that they know that there is construction or maintenance ahead. Portable Rumble Strips are used to produce audio and vibratory sensations when driving over them. They are typically placed about 200 feet to 1,000 feet ahead of flagmen, then also place within construction zones to help slow traffic down. They are about .25 - .75 inch tall, 6 inches wide, and 12 feet long. They typically come in rolls with adhesive primer to place on the strip just before installing. They require around 10 minutes to be properly installed. These Portable Rumble Strips have found success in urban areas, as well as in construction zones just before a lane shift; however there has been limited success and mixed reviews on their use in rural areas.

**Statement 14:** We need improved lighting for nighttime construction and maintenance activities.

**Solution:** This statement concerns lighting during nighttime construction and maintenance operations. There is an increasing demand for nighttime construction, with increases in traffic volumes and roadway congestion. However, we have found that many workers do not have proper lighting to properly perform their worker duties. This is often because the lack of portable light stations, or their insufficient quality and capabilities. Often times small flashlights that can mount on a hard hat can provide adequate lighting in a small area, but when a larger area needs to be lighted the larger portable light stations are needed, and workers indicate that these light stations are not readily available. Crews in highly urban areas especially need access to these portable light stations, as well as personal lighting equipment.

**Statement 15:** We need to develop a traffic citation enforcement plan to follow up on citations written in work zones and apply pressure to the judicial system to enforce all of these. Also the plan needs to include severe penalties for repeat offenders.

**Solution:** This statement deals with the lack of enforcement of written citations given in construction work zones. Most all construction and maintenance workers indicate the law enforcement presence on a jobsite is the key way to slow down traffic, which in turn will decrease the likelihood of struck-by accidents and also decrease their severity. Workers indicate that it is not easy to get a police officer to patrol a work zone, but when they are present the workers feel much safer. Workers also indicate that when officers are on the jobsite, they typically do stay busy issuing double-fine citations to speeding vehicles, however these citations are rarely enforced in courts. It is most likely because of the fact that officers have to take extra time to appear in court before a citation is actually enforced. Whatever the reason behind the lack of enforcement, it is clear that these citations are not being enforced, and in turn local drivers are realizing that although they might get a double-fine when speeding through a work zone, it will not cost them anything monetarily. The project team recommends new legislation to be passed which does not require the presence of the ticketing officer at the court appearance for the traffic offender. These fines should always be enforced, and the fines could also be raised to triple-fines, which should help slow down traffic even more. This subject could be the topic of an entire research project and is far too complex for the scope of the Worker Safety Study, since this solution is only an indirect way to improve the safety of workers.

## 6.2 Analysis of Methods to Improve Safety on Highway Construction Projects

**Statement 1:** We should use sensors and/or cameras mounted on the rear of equipment and/or vehicles to detect objects in blind areas (mounted as not to distract the operator).

**Solution:** Aside from increased training to truck drivers employed by contractors, the use of rear mounted cameras will decrease the likelihood of backing up accidents. Using rear mounted cameras on all larger trucks such as dump trucks, as well as all pickup trucks possible would improve worker safety. Backup cameras can also be highly effective on certain pieces of heavy equipment. See the KYTC analysis for this statement for additional information.

**Statement 2:** We should use back-up alarms with alternating tones and/or sounds to keep workers attentive.

**Solution:** Most all large construction equipment and trucks have back-up alarms factory installed. The issue is that the tone produced by these vehicles does not change. It is the same tone throughout the lifetime of the vehicle. Also most all vehicles share the same tone, making it difficult to delineate exactly what vehicle's alarm is engaged. The idea behind this statement is that hearing the same tone throughout the lifetime of a vehicle leads a worker to become unaware that the alarm is signifying a possible hazard. If the alarm does not alert the worker that a vehicle is backing up, then the alarm is not effective. To mitigate this issue, alarm sounds should change so that it is impossible for the worker to become indifferent to a certain tone. Although this study has not researched the time span that is required for a worker to become indifferent to a tone, this study could be conducted. Knowing that time span, the backup alarm on a vehicle could be set to change, keeping workers aware of the hazard created with backing vehicles/equipment. Vehicles could be equipped with several different and unique tones, so all vehicles do not change to the same tone at the same time.

**Statement 3:** Concerning mowing operations, we should use tractors with closed cabs to prevent flying debris from striking the operator.

**Solution:** This does not directly affect contractors; therefore, no further consideration will be given.

**Statement 4:** Concerning mowing operations, we should use tractors with auto-shutoff so that if the operator is thrown from the seat, the engine will be shutoff.

**Solution:** This does not directly affect contractors; therefore, no further consideration will be given.

**Statement 5:** We need increased crew sizes to accommodate lookout personnel and to improve quality of work.

**Solution:** Contractor's workers who completed the Final Survey indicated that crew sizes were adequate; therefore, no further consideration will be given.

**Statement 6:** We need two-way radio devices with longer range, longer battery life, and dedicated frequencies.

**Solution:** Much like the KYTC, there seems to be a lack of consistency in the procurement of two-way radio devices. Although the project team had no way of gaining information on the quality of contractor's two-way devices, it should be noted that the KYTC has problems with battery life and range of their devices. The project team recommends that contractor's contract with two-way radio suppliers/distributors, or consistently purchases the same brand of devices.

**Statement 7:** We need a well known and understood Standard Procedure for how to obtain a trench box when needed.

**Solution:** Generally on highway projects there is a limited need for trench boxes; however there are some cases when they are required. In those situations when a trench box is needed, it is not uncommon for workers to not realize that there is a need for the trench box, as well as not know where or how to obtain one. Contractors should heavily train their workers on how to spot the need for trench boxes, and where to obtain them.

**Statement 8:** We need improved availability and selection of Personal Protective Equipment (PPE) such as gloves, safety glasses, reflective clothing, hardhats, ear protection, heights protection, foot protection, respiratory protection and weather protection.

**Solution:** Much like the KYTC, contractor's workers often times damage or lose their PPE while working in the field, with no means of replenishing their supply until they drive back to their shop, which is not always an option. This being said, the project team suggests that contractors keep extra PPE on the jobsite at all times. We have found that contractors generally supply their workers with high quality and comfortable PPE. The main issue is having enough PPE and keeping it accessible to workers in the field.

**Statement 9:** We need improved availability of first aid kits, as well as more personnel trained in first aid/CPR.

**Solution:** This issue with this statement is the amount of first aid kits as well as the amount of personnel trained to perform first aid and CPR. The nature of highway construction is such that crew members are often transferred from crew to crew, and it is possible that one crew could end up without a CPR trained employee. It is for this reason that we suggest that contractors train all of their employees, both operators and labors in CPR and first aid, so that all crews will be guaranteed to have trained workers.

**Statement 10:** We need yearly physicals to monitor vision, hearing, and other construction sensitive abilities.

**Solution:** The main issue with this statement is that workers often times lose their construction sensitive abilities due to the conditions created by their job. Often times these abilities are deteriorating due to natural ageing or other natural phenomenon. Whether it is job related, or naturally caused, workers need their health monitored in order to insure that they are able to work safely. Also, recurring physicals are important because they can spot problems in their early stages of development, such as back problems, or loss of hearing. Once these problems have been identified, workers can take the necessary precautions to eliminate the source of the problem, or begin treatment of the problem. There could be some opposition to implementing the yearly physicals policy because some workers already know that they should not be allowed to do their job in their current state of health, and that if a doctor found their exact condition and reported it to their employer, they would no longer be able to work that particular job.

**Statement 11:** We need increased flagmen training and certification programs. All flagmen should be certified by the state, especially contractor's flagmen. Also, all maintenance and construction workers should understand basic hand signals.

**Solution:** It was brought to the attention of the project team that the KYTC will begin requiring all flagmen, whether they are employed by the KYTC or contractors, to be trained and certified, and have their certification on hand beginning in the Fall 2007. It is for this reason that no further consideration will be given to the implementation strategy or cost feasibility.

**Statement 12:** We need our flagmen to use lightweight flashing paddles with LED lights around the stop sign and in the STOP word to help capture the attention of oncoming traffic.

**Solution:** Light Emitting Diode (LED) Stop Signs are used by flagmen, and increase the visibility of the stop sign to oncoming traffic. The stop

signs have LED lights around the perimeter of the sign as well as in the work STOP. This stop sign is more likely to gain the attention of drivers with impaired vision, as the flashing LED lights are very bright. The stop signs are lightweight and easy to use. Through meeting with each district at the focus group sessions, crews were able to tell us how effective the flashing paddles are. These paddles are especially effective in nighttime construction.

**Statement 13:** We need to place portable rumble strips in front of flagmen to help capture the attention of oncoming traffic as well as slow them down.

**Solution:** This statement also concerns gaining the attention of oncoming traffic so that they know that there is construction or maintenance ahead. Portable Rumble Strips are used to produce audio and vibratory sensations when driving over them. They are typically placed about 200 feet to 1,000 feet ahead of flagmen, then also place within construction zones to help slow traffic down. They are about .25 - .75 inch tall, 6 inches wide, and 12 feet long. They typically come in rolls with adhesive primer to place on the strip just be installing. They require around 10 minutes to properly setup. These Portable Rumble Strips have found success in urban areas, as well as in construction zones just before a lane shift; however there has been limited success and mixed reviews on their use in rural areas.

**Statement 14:** We need improved lighting for nighttime construction and maintenance activities.

**Solution:** This is an especially important issue for contractors, as nighttime construction is becoming more and more the only acceptable way to perform construction in urban areas. This issue concerns more of the actual lighting provided to perform construction related activities than that of oncoming traffic seeing the construction operation or workers. Workers often do not have adequate lighting to safely perform their work duties, whether they are labors or equipment operators. Possible solutions include equipping each worker with a small flash light that mounts to the worker's hardhat, as well as equipping workers with small handheld flashlights, as well as provide portable light stations, and adequate lighting on heavy equipment including backup lights.

**Statement 15:** We need to develop a traffic citation enforcement plan to follow up on citations written in work zones and apply pressure to the judicial system to enforce all of these. Also the plan needs to include severe penalties for repeat offenders.

**Solution:** This does not directly affect contractors; therefore, no further consideration will be given.

## **7.0 SUMMARY AND RECOMMENDATIONS**

### **7.1 Report Conclusions**

Since OSHA's inauguration in 1970, workplace accidents and fatalities have certainly decreased; however, workers are still being injured or killed everyday in the construction and maintenance fields. The OSHA approach to worker safety involves a micromanaged worker who has been trained, who uses proper Personal Protective Equipment, and who is in constant compliance with safety regulations. There are other approaches to protecting workers from hazards that can work in conjunction with the OSHA approach, such as improving the safety culture within an organization, or using incentives to reward safe practices. How an organization chooses to protect their workers will be unique to each organization, although any construction organization working in the United States certainly is required to follow safety guidelines as set by OSHA. An effective safety program should encompass OSHA compliance as well as a broad and unique safety policy defined by an organization's leaders, and it is for this reason that this study has focused on both improving safety standards as well as improving safety culture.

The focus of this Worker Safety Study has been based on surveys, literature reviews and focus groups. The project team has relied on workers themselves to provide us with the information that we have used to outline recommendations that will hopefully be implemented to make their workplace safer.

The first survey was sent out completely open-ended to workers. Workers completed these surveys and the project team compiled them to find some similarities among the responses. It was through these similarities that the project team derived the second survey. Workers completed these surveys, although the project team later found out that there was some confusion among workers on how to properly complete the survey. Due to this confusion, as well as the small sample size from the second survey, we created the final survey which was a short and simple survey that could be easily distributed to all KYTC workers and several contractors' workers. The project team also created the climate survey which gave us a way to analyze the perceptions that workers held about how safety committed their organizations are. The project team was able to complete an in depth statistical analysis on the final and climate surveys from which we are able to determine statements that were statistically significant. In total, the project team created four surveys.

The project team has also reached out to other states, learning their new and innovative practices and policies that are improving the safety of their workers. We have researched new technologies that are making the work place safer and reducing risk. It is the compilation of four surveys and continuing literature review that we were able to recommend actions that we advise the KYTC to implement as well as contractors in Kentucky.

The project team believes that the implementation of these action plans will reduce worksite accidents and fatalities for highway workers. Although some of the recommended actions seem to have no direct association with improving safety among highway workers, any action suggested has been researched and shown to have either a direct or indirect positive influence on worker safety.

There are barriers to overcome with implementing these action plans, and each specific recommendation will have its own barrier. Some of the notable barriers that the

research team has learned of or forecasts include: natural resistance to change, additional funding, action plan leadership, contractor resistance to KYTC policy changes, and contractor resistance to provide additional funding for fear of losing work. In general, contractors are often times hesitant to improve safety because it costs additional money that their competition might not be spending, which can cause them to lose work to their competition or ultimately never win any bids. This is the underlying reason why we are suggesting that the KYTC require prequalification of their contractors, effectively leveling the requirements for all contractors bidding on their work. This means that safety should cost the same for any contractor. It should be noted that previous research indicates that improving safety can actually be more profitable to contractors. This same research has also shown a correlation between increased safety and increased productivity, which is generally thought to be difficult.

## **7.2 Future Research Topics**

The project team also recommends future research to be completed on worker safety in Kentucky that would measure the effectiveness of the recommendations that the project team has suggested. This study would compare existing accident/fatality data to future data at 1, 2, 4 years from their implementation dates. Also, we recommend continuing research on worker safety through literature reviews as well as annual statewide or regional meetings among district safety coordinators to discuss safety issues and ideas. In the near future, the project team suggests that the KYTC begin work on implementing the changes needed, as well as apply pressure to contractors to implement the action plans set for them. The KYTC could also choose one district to begin trial implementations of all of the recommended actions and gather results by interviewing workers and managers about the new action plans. This would give the KYTC a better idea of what should be implemented statewide and what should be implemented only to a certain region, or simply not at all.

Improving the safety of workers should continue indefinitely and should not be considered complete even after all recommendations are implemented. As construction and maintenance activities evolve, new hazards will be created as old ones are eliminated. That is the reason why the project team is recommending continuing research on improving worker safety as the most important item on our list of recommendations.

## **7.3 Recommendations**

This section lists the final product of the research conducted from August 2005 to June 2007. The actions are based on surveys completed by highway workers in Kentucky, as well as literature reviews completed to investigate what other states are doing to keep their workers safe. We have also investigated new safety technologies that are in use, or will be in use in the future.

The action plans are broken down into two sections: KYTC and contractors. This was necessary because of the great differences between the two organizations. Although there will be cost involved with the implementation of these action plans, we believe that they will help reduce jobsite accidents and fatalities. It should also be noted that since contractors typically work for the KYTC, we recommend that the KYTC governs the implementation of the action plans for contractors.

### 7.3.1 KYTC Recommendations

- 1. Two-Way Radios** – This is one of the top complaints among KYTC workers interviewed and surveyed. Workers want two way radios with longer ranges, increased battery life, as well as a battery monitoring system (similar to checking the battery status on a cellular phone). It should also be noted that although there seems to be a contract already in place with a certain two-way radio provider, workers indicate that they use multiple brands and types of two-way radios. There should be consistency with the two-way radio supplier so there are not multiple learning curves to overcome. We also suggest that the existing contract be modified to include a return/repair clause, or the new contract should include this clause if there is no existing contract.
- 2. Personal Protective Equipment** – The project team recommends the use of comfortable and aesthetically pleasing PPE. Research has shown that workers are more likely to use their PPE if it is comfortable to wear and not large, heavy, and bulky. It should be noted that comfortable and aesthetically pleasing PPE is widely available and the additional cost compared to currently used PPE is marginal. This slightly more expensive PPE seems to also be more durable than PPE in current use by the KYTC. Workers also indicated that PPE is not always readily available, especially at the jobsite. We recommend that extra PPE is always accessible at the location of work, since this is the most likely place for damage to PPE to occur.
- 3. First Aid Training** – Currently, only one crew member is required to be trained in first aid/CPR. We recommend that the amount of trained personnel be a function of the crew size, and also that the trained personnel be of different job positions, so that not all of the trained workers are laborers, or not all are operators, but a mixture of various positions. We suggest that at least half of the crew be trained and that managers always make sure that there are First Aid/CPR trained personnel present on the jobsite.
- 4. Closed Cab Tractors** – Workers from the KYTC have indicated that they need closed cab the tractors for mowing operations to protect the operator from being thrown from tractor in an accident, and to prevent flying debris from striking the operator. We suggest that the KYTC require the use of seatbelts at all times, and also implement the use of an ejection prevention system such as a screen or chain mesh. We do not recommend the use of glass closed cabs because of the additional weight added to the upper portion of the tractor, increasing the chance of a roll over. Another function, which may be more of an issue than being ejected from a seat, is protection from flying debris. Closing or partially closing a tractor will prevent some debris from entering the cab and striking the operator, which is not an uncommon accident among maintenance mowers.

- 5. Law Enforcement Policy** – Throughout the duration of this research project, the use of law enforcement on jobsites has been discussed many times with workers, project team members, and committee members. Most all agree that the use of law enforcement on jobsites is one of the most effective ways to slow down traffic. However, we have learned that it is a rare occasion to get a law enforcement vehicle to patrol a jobsite, but when they are present there are very notable differences in traffic speeds.

We have learned that when tickets are issued in work zones, most of them are not enforced. We suggest that the KYTC devise a system that follows up on tickets written to make sure that they are enforced by a judge. As it is now, the ticketing officer has to appear in court in order for the ticket to be enforced, and this must be done on the officer's own time which is a huge disincentive for the officer to show up at the case.

We also suggest that there be additional funding given to provide incentive for officers to patrol jobsites, such as adding a bid item in contracts and letting the contractors make arrangements. Another suggestion is to use Automated Speed Enforcement so that officers are not required on jobsites to issue tickets. Much like cameras at stop lights, automated speed enforcement does not require vehicles to be pulled over; tickets are simply mailed to the address associated with the vehicles license plate.
- 6. Manager Devotion to Safety Training** – This suggestion is derived from recent research completed on safety culture and safety climate. This research indicates that if workers perceive that their managers are devoted to safety, they will also be devoted to safety. We suggest implementing a safety climate course for managers of workers as well as supervisors. Managers need to stress to their workers that safety is more important than unsafe productivity.
- 7. Light Emitting Diode Stop Signs** – The project team has researched the use of LED Stop Signs, which have LED lights around the perimeter of the sign, as well as in the word STOP. We have found that these stop signs are effective at gaining the attention of traffic, especially in low visibility areas. We recommend that all maintenance crews completing work use a LED Stop Sign.
- 8. New Policy on Length of Lane Closure** – We have heard numerous complaints about long lane closures with no workers present or workers only working during 100 yards of a 10 mile lane closure. This causes traffic to not respect the jobsite as they should and increases the chance of an accident occurring. Although there is already a limit on the length of lane closure, this policy is rarely enforced. We recommend first that the current policies be enforced, and we also recommend the use of disincentives for excessive lane closure. Other states have used policies such as rental fees for lane closures, such as \$0/FT/Day for 0 – 1 Mile of Lane Closure, \$5/FT/Day for 1 – 3 miles of Lane Closure, \$10/FT/Day for 3+ Miles of Lane Closure. This rental system would provide incentive for contractors to limit the length of their lane closure to only what is absolutely required, in order to complete their work and maximize profits.

- 9. OSHA Training** – We have found that some states require all internal and external (contractor's) workers complete the OSHA-10 Training course, which is a 10 hour training course about various safety hazards. We suggest that the KYTC require all of its workers to complete the OSHA-10 or an equivalent training course, as well as require contractor's workers to have completed the training as well. This training should be reoccurring at certain specified time intervals such as three to five years.
- 10. Safety Prequalification** – There are several other states that use a contractor's safety record as a prequalification standard to bid on any of their projects. Some of the measures used in the prequalification include EMR, OSHA Recordable Accidents, Safety Philosophies (toolbox meetings, drug testing, alcohol testing, training, etc...). Typically several variables are assigned a weight and the maximum score possible is 100. A numerical score is given for each contractor and only those contractors whose scores are greater than a certain value (65 – 75 typically) are allowed to work on a state funded project. We suggest that the KYTC research and implement some type of Safety Prequalification, which would in turn require contractors to keep their workers safe or they could not work state projects.
- 11. Increase Use of Speed Display Trailers** – Research has shown that speed display trailers are highly effective at slowing down traffic in any situation. We suggest that the KYTC require that contractors use speed display trailers on certain projects depending on several variables such as dollar value, danger, risk, hazards, traffic volume, traffic speeds, ect...
- 12. Continue Evaluation of Worker Safety in Kentucky** – Construction and maintenance activities will continue to evolve and new risks will be created. We recommend that there is a continued effort to improve the safety of highway workers in Kentucky through annual statewide meetings among safety coordinators so that they can discuss safety issues. These meetings should include discussion of near misses, accidents, new technologies, new policies, ideas, ect... We suggest that the meetings be limited to 12 – 20 people so that everyone has a chance to discuss their thoughts. For this to be successful there would need to be a leader of this event who plans and coordinates it every year. We suggest that this responsibility be given to the head safety coordinator in the central office.

### 7.3.2 Contractor's Recommendations

1. **Two-Way Radios** – This statement on the final survey ranked very high among contractor's workers. Workers want two way radios with longer ranges, increased battery life, as well as a battery monitoring system (similar to checking the battery status on a cellular phone). There should be consistency with the two-way radio supplier so there are not multiple learning curves to overcome. We suggest the use of just one brand of Two-Way Radios. We also suggest contracting with a supplier of Two-Way Radios to make the procurement, return, and repair of radios simple for workers and supervisors.
2. **Manager Devotion to Safety Training** – This suggestion is derived from recent research done on safety culture and safety climate. This research indicates that if workers perceive that their managers are devoted to safety, they will also be devoted to safety. We suggest implementing a safety climate course for managers of workers as well as supervisors. Managers need to stress to their workers that safety is more important than unsafe productivity.
3. **Light Emitting Diode Stop Signs** – The project team has researched the use of LED Stop Signs, which have LED lights around the perimeter of the sign, as well as in the word STOP. We have found that these stop signs are effective at gaining the attention of traffic, especially in low visibility areas. We recommend that all crews completing work have access to a LED Stop Sign.
4. **OSHA Training** – We have found that some states require that all internal and external (contractor's) workers complete the OSHA-10 Training course, which is a 10 hour training course about various safety hazards. We suggest the use of the OSHA-10 to all contractors' workers as well as the OSHA-30 to foremen and supervisors. This training should be reoccurring at certain specified time intervals such as three to five years.
5. **Increase Use of Speed Display Trailers** – Research has shown that speed display trailers are highly effective at slowing down traffic in any situation. We suggest that contractors use speed display trailers on certain projects depending on several variables such as dollar value, danger, risk, hazards, traffic volume, traffic speeds, ect... to reduce the speed of traffic.
6. **Night Time Lighting** – Night time construction and maintenance is becoming more and more popular with the increase of congestion on the roadways. Workers have indicated on the final survey that they would like increased lighting for night time construction and maintenance. We suggest that all workers are equipped with flashlights, as well as small clips on flashlights that clip to a workers hat. We also suggest that contractors use more portable lighting stations that are taller and brighter as well as maintain the lighting on their heavy equipment.

7. **Project Safety Orientation** – Although this is not a new idea or technology, project safety orientations to new workers on a project or new workers in general are often times dismissed if projects are in a rush to be completed. We suggest that all new workers on a jobsite be trained for that specific job site’s hazards and risks. We also recommend worker led safety toolbox talks at least one time per week per crew.
  
8. **Continue Evaluation of Worker Safety in Kentucky** – Construction and maintenance activities will continue to evolve and new risks will be created. We recommend that there is a continued effort to improve the safety of highway workers in Kentucky through annual statewide meetings among safety coordinators so that they can discuss safety issues. These meetings should include discussion of near misses, accidents, new technologies, new policies, ideas, ect... We suggest that the meetings be limited to 12 – 20 people so that everyone has a chance to discuss their thoughts. For this to be successful there would need to be a leader of this event who plans and coordinates it every year. We suggest that professional organizations such as American Society of Civil Engineers (ASCE) or Associated General Contractors (AGC) coordinate this meeting.

The KYTC and highway contractor management personnel are the ones who are ultimately responsible for implementing any safety improvements. Even if those personnel disagree with the above recommendations and the results from the collected surveys, these issues and concerns need to be addressed in some manner. Due to the amount of input from the KYTC and highway contractor’s workers, a lack of a managerial response could be just as damaging towards safety as any of the issues addressed in both of the surveys.

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## **9.0 APPENDICES**

## APPENDIX A: RESEARCH WORK PLAN

## **Research Work Plan**

### **I. IDENTIFICATION**

- A. Title of Study:** **Improve Safety of Workers during Highway Construction and Maintenance**
- B. Proposer:** University of Kentucky  
Research Foundation
- C. Research Agency:** Kentucky Transportation Center  
College of Engineering  
University of Kentucky  
Lexington, Kentucky 40506-0281
- D. Responsible Principal:** Paul E. Toussaint, P.E., Director  
Kentucky Transportation Center  
University of Kentucky  
Lexington, Kentucky 40506-0281
- E. Principal Investigator:** Donn E. Hancher, Ph.D., P.E.  
Terrell-McDowell Professor of  
Construction Engineering and Management  
Department of Civil Engineering  
University of Kentucky  
Lexington, Kentucky 40506-0281
- F. Co-Principal Investigator(s):** Paul M. Goodrum, Ph.D., P.E.  
Assistant Professor  
Department of Civil Engineering  
University of Kentucky  
Lexington, Kentucky 40506-0281

## **RESEARCH OBJECTIVES:**

Traffic accidents in construction work-zones have been studied for many years with many research reports and recommendations presented. Traffic accidents are caused by several factors, including driving error, inadequate vision, poor road surface condition, construction obstructions, inadequate traffic control, and improper management of material, equipment, and personnel during construction. Successful work-zone safety management can minimize traffic accidents, and reduce deaths and injuries to both the traveling public and highway workers in work-zones.

This research was proposed for the Kentucky Transportation Cabinet to place more emphasis on the great concern for the safety of construction and maintenance workers while they do highway work. There is certainly potential for injuries to workers by the traveling public; however, there are many other worker safety issues that have been identified by government and industry groups, such as: Safety Management (organizational commitment), Materials Handling (overexertion, repetitive motion, sprains and strains), “Struck-By” Accidents (worker run-overs and back-overs), Fleet Safety (on the road vehicle accidents), and Safe Equipment and Machinery Operations. Many enhancements can be attained through improved project safety management practices during construction and maintenance operations on highways.

The main research objectives of this study will be to:

- 1) Identify best safety practices for workers on highway construction projects
- 2) Identify best safety practices for workers on highway maintenance projects

## **DESIRED RESEARCH RESULTS:**

The study objectives will be accomplished through the following tasks:

- 1) Literature Search – review past studies on highway work-zone safety, construction worker safety and maintenance worker safety;
- 2) Survey other State Transportation Agencies regarding their practices for improving worker safety for construction and maintenance projects;
- 3) Conduct case studies of highway construction and maintenance projects to determine which methods and techniques most effectively improve worker and public safety; and
- 4) Develop KYTC construction and maintenance guidelines based on identified best practices for consistent worker safety.

## **IMPLEMENTATION BARRIERS:**

Some practices that may be shown to be extremely effective may also require large amounts of capital to implement. Therefore defining the business case will be critical.

**WORK PLAN:**

2-year duration. Project completion date: June 30, 2007.

Fiscal Year	2005-2006				2006-2007			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
<b>Task</b>								
Form Team								
Lit Review								
Survey STAs								
Case Studies								
Develop guidelines								
Draft Report								
Draft Implementation Plan								

**LEVEL OF EFFORT**

PROJECT TASKS	LEVEL OF EFFORT %
<b>Task 1: Form Team</b>	<b>5%</b>
<b>Task 2: Literature Review</b>	<b>15%</b>
<b>Task 3: Survey STAs</b>	<b>25%</b>
<b>Task 4: Case Studies</b>	<b>25%</b>
<b>Task 5: Develop Guidelines</b>	<b>10%</b>
<b>Task 6: Draft Report</b>	<b>15%</b>
<b>Task 7: Draft Implementation Plan</b>	<b>5%</b>
<b>TOTAL</b>	<b>100%</b>

**PROJECT BUDGET**

ITEM	PROJECT COSTS (\$)		
	YR1 (FY2006)	YR2 (FY2007)	TOTAL
Personnel	\$43,438	\$50,636	\$94,074
Telephone, comm.	\$ 250	\$250	\$500
Travel	\$2000	\$2000	\$4,000
Printing, Supplies	\$500	\$500	\$1,000
Admin Expenses	\$7,658	\$8,752	\$16,410
Total Direct Costs	\$53,846	\$61,538	\$115,384
Indirect Costs (30%)	\$16,154	\$18,462	\$34,616
<b>Totals</b>	<b>\$70,000</b>	<b>\$80,000</b>	<b>\$150,000</b>

**IMPROVED SAFETY OF WORKERS DURING HIGHWAY CONSTRUCTION AND  
MAINTENANCE (Study # 06-323)**

Accidents in construction work-zones are caused by a combination of factors and this problem has been studied several times under the title Work Zone Safety. There is also a great concern for the safety of construction and maintenance workers while they do highway work. There is certainly potential for injuries to workers by the traveling public; however, there are many other worker safety issues that have been identified by government and industry groups, such as: Safety Management (organizational commitment), Materials Handling (overexertion, repetitive motion, sprains and strains), “Struck-By” Accidents (worker run-overs and back-overs), Fleet Safety (on the road vehicle accidents), and Safe Equipment and Machinery Operations. Many enhancements can be attained through improved project safety management practices during construction and maintenance operations on highways. The main objectives of this study will be to 1) identify best safety practices used for workers on highway construction projects, and 2) identify best safety practices for workers on highway maintenance projects.

The study objectives will be accomplished through the following tasks: 1) Literature Search – review past studies on highway work-zone safety, construction worker safety and maintenance worker safety; 2) Survey other State Transportation Agencies regarding their practices for improving worker safety for construction and maintenance projects; 3) Conduct case studies of highway construction and maintenance projects to determine which methods and techniques most effectively improve worker and public safety; and 4) Develop KYTC construction and maintenance guidelines based on identified best practices for consistent worker safety. (Contact: Donn E. Hancher, 859-257-1864, 859-338-3472, [hancher@engr.uky.edu](mailto:hancher@engr.uky.edu)) (Study Advisory Chair: Vibert Forsythe, 502-564-4780, [Vibert.Forsythe@ky.gov](mailto:Vibert.Forsythe@ky.gov))

## APPENDIX B: WORKER SAFETY COMMITTEE

## Improving Worker Safety Committee

Title of Research: Improve Safety of Workers during Highway Construction and Maintenance

### Committee Members:

Dr. Donn Hancher	UK	(859) 257-1864	Hancher@engr.uky.edu
Vibert Forsythe * Chair of Committee	KYTC Central Office Construction	(502) 564-4780	Vibert.forsythe@ky.gov
Todd Morrison * Co-chair	KYTC District 3 Operations/Maintenance	(270) 746-7898	Todd.morrison@ky.gov
Tony Bowling	KYTC District 10 Operations/Maintenance	(606) 666-8841	Tony.bowling@ky.gov
Steve Farmer	KYTC District 7 Operations/Maintenance	(859) 246-2355	Steve.farmer@ky.gov
Jeff Wolfe	KYTC Central Office Traffic	(502) 564-3020	Jeff.wolfe@ky.gov
Allen Ravenscraft	KYTC Central Office Construction	(502) 564-4780	Allen.ravenscraft@ky.gov
Kevin Bailey	KYTC District 5 Construction	(502) 458-4163	Kevin.bailey@ky.gov
Terry Chism	FHWA	(502) 223-6720	Terry.chism@fhwa.dot.gov
Robert Farley	FHWA	(502) 223-6744	Robert.farley@fhwa.dot.gov
Tom Hinkle	Hinkle Contracting Co.	(859) 987-3670	tomhinkle@hinklecontracting.com
Thomas Haydon, III	Haydon Bridge Co.	(859) 336-7533	Thomas1@haydonbridgecompany.com
Neil Swartz	Swartz Mowing	(606) 674-2971	swartz@kih.net
Dr. Paul Goodrum	UK	(859) 257-5416	pgoodrum@engr.uky.edu
Kristin Smith	UK Research Assistant	(859) 257-1036	Kmsmit0@engr.uky.edu
Robin Meagher	UK Research Assistant	(859)-257-1036	Rnmeag0@engr.uky.edu
Kenny Bussey	UK Research Assistant	(859) 257-1036	Krbuss0@engr.uky.edu
Jon Ross	UK Research Assistant	(859) 257-1036	Jhross0@engr.uky.edu

APPENDIX C: COMMITTEE MEETING MINUTES

## **Initial Committee Meeting Minutes – August 26, 2005**

Initial committee meeting concerning worker safety during highway construction and maintenance

Held on August 26<sup>th</sup> in RGAN 387

### **Attendees:**

Vibert Forsythe (Committee Chair), Todd Morrison (Co-Chair), Tony Bowling, Steve Farmer, Jeff Wolfe, Allen Ravenscraft, Kevin Bailey, Tom Haydon III, Robert Farley, Neil Swartz, Dr. Goodrum, Dr. Hancher, Kristin Smith and Robin Meagher

### Introduction:

Welcome and Introduction – Dr. Hancher

Presentations – Robin Meagher and Kristin Smith

Group Introductions

### **Discussion:**

#### **Goals/Objectives**

The committee chair brought up the importance of creating a study that can be used and is not immediately shelved

Our goal should be to create a study that contains ideas that can be implemented at the worker/site level.

We should focus in issues that are specific to Kentucky. A literature review might be of more help later in the study. Starting with a survey of Kentucky departments and contractors would help identify our strongest areas of concerns and current practices. A survey of other states may also be helpful, but focus should be placed on Kentucky, initially.

Look into what MANAGEMENT can do and what the WORKER can do to increase safety.

Determine if there are things that the cabinet can do to make conducting work safer for contractors. What is the Cabinet's role in contractor's safety? What is the Cabinet authorized/expected to do when unsafe acts are occurring at construction sites?

Determine if contractors and the cabinet need to be handled separately in the study. It was pointed out that contractors are there to earn a living and in a competitive business. Money is not as much of an obstacle for government maintenance workers as it is for contractors. Your safety record may be considered, depending on the job, but ultimately it is the low bid that is important.

Can state pay for training? Contract employees may leave one company and go to another, but they will most likely stay in KY.

### **Mentioned Areas of Concern:**

- Visibility
- Nighttime construction
- Rushed work
- Traffic accidents involving flagmen
- Fall protection
- PPE
- Crane work
- Electrical work (overhead and underground)
- Trenching/shoring/excavating
- Routine items-debris removal, for example
- Mobile work zones
- Communication

**Maintenance Issues:**

Swartz Mowing works for 11 of the 12 districts. They are continually on the road and very concerned with worker safety. Visibility was one concern mentioned by maintenance. Concern was mentioned during aerial work and repair of suspended traffic signals, as well.

**Causes of Accidents**

A good point was mentioned that many accidents occur because employees are too focused on traffic and not on the task at hand.

**Other Items Discussed:**

- Offering safety incentive programs-would that be of help?
- Should safety be included as a bid item?
- The use of police enforcement in work zones. The money from double work zone fines is not making it back to the police forces. Often, local officials drop fines.
- Safety starts at the top. Management must be committed. Employees who are not following company safety plans should face predetermined consequences.

**Steps to Take:**

- Contact the Division of Safety and Health Services for spreadsheets that can identify what are the most common accidents (A. Ravenscraft)
- Look into JB Resources, KyOSHA, KAHC and possibly AGC for data concerning frequency and type of accidents
- Develop survey to determine major safety issues and hazards that Cabinet workers, contractors and craft workers are facing on jobsites.
- Determine who should receive the survey

## **Second Committee Meeting Minutes – December 14, 2005**

Held December 14, 2005 in RGAN 387

Attendees:

Robin Meagher-Research Assistant, Kristin Smith-Research Assistant, Vibert Forsythe Tracy Bubnik of Hinkle Contracting, Thomas Haydon, III, Jeff Wolfe, Dr. Donn Hancher, Dr. Paul Goodrum, Bob Farley, Steve Farmer, Kevin Bailey

### **Robin's Presentation**

- statistical information
- OSHA Recordables
- break down more, not just by district
- multi-parts greatest number, but back injuries are the second-most common
- Leg injuries are 23% of lost days per injury (back 20%), multiple 34%
- lifting heavy objects major cause of back injuries

### **Kristin's Presentation**

- see attached sheet for survey results to date
- follow up on contractors
- follow up with Charles Lovorn to get contractor involvement
- change format to yes/no questions
- try again when workload isn't an issue
- anonymity
- short-term patching is a tricky operation—and seems to be a major concern to all involved, there's not really enough time to set up before the job is done
- public sentiment is a problem concerning safety (lane closures)
- new patching techniques? Rapid-set technology is evolving
- not enough staff/equipment to keep up with the workload (also not enough \$\$)
- “accident holes” (semi wrecked—patch while cleaning up wreck=free lane closure)

### **3 separate, distinct categories**

- maintenance-have own issues
- construction-have some issues
- public dictating to officials and throwing wrenches in the work
  
- change prequalifications? (EMRs and Lost-time accident reporting)
- enforcing things that are already law seems silly
- lime green shirts have been ordered to replace vests, also bump caps
- also reflective lime green jackets for cold weather
- talk vs. action (safety is going to cost the Cabinet on projects)

### **Topics to Study**

- Short-Term Patching Operations
- Hard Hat Concerns (temperature/comfort level)
- Use/Wear PPE when necessary. But when is it necessary? Employee involvement when choosing?
- Robin #2 and 3 (recommendations)
- focus on contractors—restructure for timeliness, ease of choices
- sign crews? Traffic? (Send a different set of questionnaires) Did we miss anyone?

## **Minutes from Full Advisory Committee Meeting – September 28, 2006**

Attendees:

Dr. Donn Hancher, Kristin Smith, Jon Ross, Kenny Bussey, Vibert Forsythe, Todd Morrison, Kevin Bailey, Allen Ravenscraft, Tony Bowling, Tom Hinkle, Chad LaRue

On September 28, 2006 a final advisory committee was held in RGAN 387. This meeting was scheduled to update the committee on the progress of the safety project. Several important topics were discussed at the meetings, and all members present provided valuable input for the continuation of research. In addition, the meeting was held to finalize the plans for the remainder of the study, including distribution of the third survey, seeking information from manufacturers, other state agencies and using a trial implementation on select state projects to test some safety practices suggested in the surveys and to gain feedback.

The meeting started with an introduction by Dr. Hancher. The committee was reminded of the original project goals; to improve the safety of highway construction workers as well as the safety of highway maintenance workers. Next, a series of PowerPoint presentations were conducted. First, Kristin Smith gave a summary of Robin Meagher's Master's Report about the first phase of the research study. Next, Kristin Smith and Kenny Bussey summarized the District Meetings and results of the second survey, both conducted during the summer months. The main issue regarding the survey was that those who participated did not really understand the directions. As a result, the survey results did not match the concerns brought up during the discussion portion of the district meetings.

One important topic stressed by many members was the feedback, or lack thereof, from contractors pertaining to the first survey. Mr. Chad LaRue, Director of Membership Services for the Kentucky Association of Highway Contractors was present, and he suggested that we use contractors from his membership files as contacts for the third survey.

The research team also presented a prototype for the third and final survey. The team created the survey from the results of the second survey as well as the discussions held at the district meetings. Some committee members suggested that since many field workers for the Cabinet had little or no education beyond a high school level, the research team may want to change to wording and instructions on the survey to make it easier to understand and complete. All present agreed that this would be a good course of action. The main purpose of the third survey was agreed upon by the committee: the target problems could easily be identified by creating some very specific questions. In addition, the committee heard a presentation about NIOSH research on workzone safety, information about the National Work Zone Safety Information Clearinghouse and ARTBA's safety program.

The committee agreed that once the results from the third survey had been analyzed, it would be an appropriate course of action to create a series of trial implementations on state projects. In this manner, the ideas proposed by the research team could be investigated in a real world setting, and the workers could give feedback prior to the end of the research project, i.e. the results could be included in the final

report. Finally, Dr. Hancher discussed the final report creation, to be handled by Jon Ross and Kenny Bussey.

## **Minutes from Full Advisory Committee Meeting – April 12, 2007**

This meeting was the final full committee meeting for the Improve Safety of Workers during Highway Construction and Maintenance study. The intent of the meeting was to communicate the project team's recent work completed and their preliminary recommendations. The study is scheduled for completion June 28, 2007.

### **Location:**

Oliver H. Raymond Building (Civil Engineering) Room 112 (Large Conference Room)

### **Date/Time:**

Thursday – April 12, 2007

### **Attendees:**

Vibert Forsythe (Committee Chair), Todd Morrison (Co – Committee Chair), Allen Ravenscraft, Steve Farmer, Kim Ellis, Rob Hecker, Tom Hinkle, Jeff Wolfe, Dr. Donn Hancher, Kenneth Bussey, and Jonathon Ross

### **Introduction – Dr. Donn E. Hancher:**

The worker safety study is in its final stage before completion. Thus far, four graduate students have worked on the study, two of which have already graduated (Robin Meagher and Kristin Smith). This last phase of the study includes compiling statistical data gathered from construction and maintenance workers of the Kentucky Transportation Cabinet and Kentucky Highway Contractors. Data was also collected from literature reviews.

### **Recent Work – Jonathon Ross**

Since the last full committee meeting in September 2006, the research team created and distributed the final survey and the climate survey. The final survey was derived mainly from the district meetings conducted in the summer of 2006. The climate survey was created using behavioral safety research. The total response from the KYTC and Kentucky Contractors were adequate to produce reliable statistical information.

### **Statistical Analysis – Kenneth Bussey:**

The final survey comprised of two different surveys, a final safety survey and a safety climate survey. The final safety survey was distributed to construction and maintenance workers in the KYTC and various Kentucky highway contractors. With a total of 650 responses to the final safety survey, a reliable statistical analysis was able to be done. The analysis revealed areas of major concern across the entire state among contractor and state highway maintenance and construction workers. Examples of such concerns are: automatic shutoff for tractors; improved two-way radio devices; improved traffic citation enforcement; and back-up alarms with alternating tones. The analysis also revealed differences between geographic regions and worker classification. Secondary safety concerns were also determined. The differences and other safety concerns will be discussed in detail in the final report.

The safety climate survey was only distributed to KYTC construction and maintenance workers. With a total of 527 responses to the safety climate survey, a reliable statistical analysis was able to be done. The analysis revealed issues of major concern across the entire state among KYTC maintenance and construction workers. Example issues were: “It is only a matter of time before one of my co-workers is involved in an accident”; “Some rules and policies are not really practical”; and “On the jobsite, some safety procedures are avoided to meet deadlines.” The analysis also revealed differences between geographic region and worker classification. Secondary statements were also determined. The differences and other statements will be discussed in detail in the final report.

**Additional Safety Research – Kenneth Bussey:**

The use of safety as a condition for the prequalification of contractors has been used by a variety of different state agencies including transportation departments. Currently, the Kentucky Transportation Cabinet states that safety is considered in the determining of prequalification status. However, there is no mention of how safety is factored into the process and its weight in comparison to the other components that are part of the decision making process. The North Carolina and Virginia Departments of Transportation have quantified the safety portion of their prequalification process by using a variety of factors, such as the Experience Modification Ratio (EMR) and data from the OSHA 200/300 Log.

**Other Issues Reviewed – Jonathon Ross:**

Portable rumble strips seem to be very limited in effectiveness and seem to produce minimal reduction in traveling speed through construction work zones.

The “Balsi beam” is in development at California Department of Transportation and will eventually be available for purchase. It is a portable work zone protection barrier with exceptional initial reviews.

Robotic Safety Cones are in development at the University of Nebraska. They have the capabilities to move on a GPS guided path, 5 MPH and appear to be comparable in price to a regular safety cone.

**Preliminary Recommendations – Jonathon Ross:**

- Two Way Radios: Improve Master Agreement Specifications
- Personal Protection Equipment:
- First Aid Training: Number of Required Personnel with Certifications Should Increase.
- Closed Cab Tractors: Screen Mesh; Safety Glasses
- Law Enforcement Policy: Investigate Double Fine Policy.
- Manager Devotion to Training: Create “Climate Training” for Managers; Praise/Punish Workers.
- Light Emitting Diode (LED) Stop Signs:
- New Policy on Lane Closures: Policy in Place but not Enforced.
- Flagmen Training: Currently in Place.
- OSHA-10: Require Contractor’s Workers to Complete OSHA-10.

- Introduce Prequalification: Derive Prequalification System.
- Increase Use of Speed Display Trailers:
- Continue Evaluation of Worker Safety in Kentucky: Regional Annual Meetings to Communicate Safety Information.

**Additional Comments:**

Worker cell phone usage can be a safety hazard and should be addressed with workers.

Communication in general is a safety issue.

Over-use of flashing/hazard lights makes public become indifferent to their significance.

Training should be given to address the correct usage of these lights.

**Conclusions – Dr. Donn E. Hancher:**

The final report will be compiled of information gathered over the past two years from both surveys and literature reviews. It will include the research team's recommendations to the KYTC and Kentucky Contractors. Our recommendations will be sent to the committee chairs for a final review, and the project will closeout at the end of June, 2007.

There will also be a paper developed from this research which will be submitted to the Transportation Research Board in late July. Authors of this report will be Dr. Donn E. Hancher, Robin Meagher, Kristin Smith, Kenneth Bussey, and Jonathon Ross.

## APPENDIX D: FIRST SAFETY SURVEY

## Survey to Improve Highway Worker Safety During Construction and Maintenance

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### PURPOSE OF THIS SURVEY

Construction continues to be one of the most dangerous professions. Accidents occur on worksites daily and numerous days-away-from-work are lost. Maintenance employees are exposed to many of the same hazards, but there is limited information available concerning such accidents.

We are conducting a research project on worker safety during highway construction and maintenance. This survey was created to determine safety concerns on the jobsite, according to workers. The received responses will help to identify where, why, and how accidents are occurring. This information will better direct our research and allow us to focus on relevant safety issues and seek steps that can be taken to reduce the number of accidents in the future.

This survey is made up of two parts: the first offers previously identified areas of concern and asks respondents to validate such concerns. The second part asks respondents if they have incurred any job related injuries in the last few years, and if so, how the injury occurred. We are asking supervisors to distribute this survey among all workers, both in construction and maintenance areas, and return completed surveys to your Chief District Engineer by October 12, 2005. Any questions concerning the research project or survey can be directed to Dr. Donn Hancher at the University of Kentucky.

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### TO BE FILLED OUT BY PERSON WHO COMPLETES SURVEY:

Company or Government unit for which you work: \_\_\_\_\_

\_\_\_\_\_

Supervisor (or name and position of Person who gave you this survey): \_\_\_\_\_

\_\_\_\_\_

Location of Job: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Position/Title: \_\_\_\_\_ Date: \_\_\_\_\_

PLEASE RETURN QUESTIONNAIRE AND SUPPORTING INFORMATION BY: **10/12/05**

TO: Dr. Donn E. Hancher  
Civil Engineering Dept.  
151B Raymond Building  
University of Kentucky  
Lexington, KY 40506-0281

TEL: (859) 257-1864 or 257-4857  
FAX: (859) 257-4404  
email: [hancher@engr.uky.edu](mailto:hancher@engr.uky.edu)

**THANK YOU FOR YOUR VALUABLE ASSISTANCE ON THIS PROJECT!!**

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**Part A:**

Please note any safety concerns you have with the following listed items. If you have suggestions on ways to improve upon safety in these areas, please describe.

A. Heavy Equipment Operation (Runovers and Backovers):

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B. Fall from Heights/Fall Protection:

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C. Heavy Equipment Rollovers:

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D. Mowing:

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E. Hand/Head/Eye Injuries

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F. Crane Operation

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G. Short Term Patching/Quick Patching

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H. Electrical Work Activities

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I. Personal Protection Equipment (PPE)

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J. Visibility and Hearing

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K. Trenching/Shoring/Excavating

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L. Debris Removal on Highway (tires, dead animals, etc.)

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M. Jobsite Communication

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APPENDIX E: FINAL SAFETY SURVEY

University of Kentucky Transportation Research Center  
**Survey to Improve Highway Worker Safety During Construction and Maintenance**

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Construction continues to be one of the most dangerous professions. Accidents occur on worksites daily, resulting in numerous days-away-from-work. Maintenance employees are exposed to many of the same hazards, but there is limited information available concerning such accidents.

We are conducting a research project on worker safety during highway construction and maintenance. This final survey was created to evaluate and confirm the most important issues on the jobsite, according to workers.

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**KYDOT:**

District (1-12): \_\_\_\_\_

Division (Construction or Maintenance): \_\_\_\_\_

Job Title: \_\_\_\_\_

**CONTRACTOR:**

Western, Central, Northern, Eastern KY?

Company: \_\_\_\_\_

Job Title: \_\_\_\_\_

**Please answer BOTH parts of the following questions:**

1. We should use sensors and/or cameras mounted on the rear of equipment and/or vehicles to detect objects in blind areas (mounted as not to distract the operator).

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact jobsite safety?  
**1   2   3   4   5                  (1=No Impact, 5=Great Improvement)**

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2. We should use back-up alarms with alternating tones and/or sounds to keep workers attentive.

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact jobsite safety?  
**1   2   3   4   5                  (1=No Impact, 5=Great Improvement)**

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3. Concerning mowing operations, we should use tractors with closed cabs to prevent flying debris from striking the operator.

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact mowing safety?  
**1   2   3   4   5                  (1=No Impact, 5= Great Improvement)**

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4. Concerning mowing operations, we should use tractors with auto-shutoff so that if the operator is thrown from the seat, the engine will be shutoff.

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact mowing safety?  
**1   2   3   4   5                  (1=No Impact, 5= Great Improvement)**

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5. We need increased crew sizes to accommodate lookout personnel and to improve quality of work.

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact jobsite safety?  
**1   2   3   4   5                  (1=No Impact, 5= Great Improvement)**

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6. We need two-way radio devices with longer range, longer battery life, and dedicated frequencies.

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact jobsite safety?  
**1   2   3   4   5                  (1=No Impact, 5= Great Improvement)**

7. We need a well known and understood Standard Procedure for how to obtain a trench box when needed.

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact jobsite safety?  
**1   2   3   4   5                  (1=No Impact, 5= Great Improvement)**

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8. We need improved availability and selection of PPE such as gloves, safety glasses, reflective clothing, hardhats, ear protection, heights protection, foot protection, respiratory protection and weather protection.

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact jobsite safety?  
**1   2   3   4   5                  (1=No Impact, 5= Great Improvement)**

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9. We need improved availability of first aid kits, as well as more personnel trained in first aid/CPR.

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact jobsite safety?  
**1   2   3   4   5                  (1=No Impact, 5= Great Improvement)**

---

10. We need yearly physicals to monitor vision, hearing, and other construction sensitive abilities.

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact worker safety?  
**1   2   3   4   5                  (1=No Impact, 5= Great Improvement)**

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11. We need increased flagmen training and certification programs. All flagmen should be certified by the state, especially contractor's flagmen. Also, all maintenance and construction workers should understand basic hand signals.

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact jobsite safety?  
**1   2   3   4   5                  (1=No Impact, 5= Great Improvement)**

---

12. We need our flagmen to use lightweight flashing paddles with LED lights around the stop sign and in the STOP word to help capture the attention of oncoming traffic.

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact jobsite safety?  
**1   2   3   4   5                  (1=No Impact, 5= Great Improvement)**

---

13. We need to place portable rumble strips in front of flagmen to help capture the attention of oncoming traffic as well as slow them down.

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact jobsite safety?  
**1   2   3   4   5                  (1=No Impact, 5= Great Improvement)**

---

14. We need improved lighting for nighttime construction and maintenance activities.

**Disagree                  Neutral                  Agree**  
If this idea was implemented, how do you feel it would impact jobsite safety?  
**1   2   3   4   5                  (1=No Impact, 5= Great Improvement)**

15. We need to develop a traffic citation enforcement plan to follow up on citations written in workzones and apply pressure to the judicial system to enforce all of these. Also the plan needs to include severe penalties for repeat offenders.

**Disagree                      Neutral                      Agree**

If this idea was implemented, how do you feel it would impact jobsite safety?

**1   2   3   4   5                      (1=No Impact, 5= Great Improvement)**

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If there are safety issues that have not been addressed on this survey, please comment below:

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**Thank you for completing this survey. Your input is highly valued!**

## APPENDIX F: SAFETY CLIMATE SURVEY

**Survey to Improve Highway Worker Safety During Construction and Maintenance**

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Construction continues to be one of the most dangerous professions. Accidents occur on worksites daily, resulting in numerous days-away-from-work. Maintenance employees are exposed to many of the same hazards, but there is limited information available concerning such accidents.

We are conducting a research project on worker safety during highway construction and maintenance. This final survey was created to evaluate and confirm the attitudes and beliefs toward safety among the workers.

---

**KYDOT:**

District (1-12): \_\_\_\_\_

Division (Construction or Maintenance): \_\_\_\_\_

Job Title: \_\_\_\_\_

**CONTRACTOR:**

Western, Central, Northern,  
Eastern KY?

Company: \_\_\_\_\_

Job Title: \_\_\_\_\_

**Please answer the following questions:**

- |    |  |                          |                 |                |              |                       |
|----|--|--------------------------|-----------------|----------------|--------------|-----------------------|
| 1. | Safety is considered to be equally as important as getting the job done.                     | <b>Strongly Disagree</b> | <b>Disagree</b> | <b>Neutral</b> | <b>Agree</b> | <b>Strongly Agree</b> |
| 2. | Safety problems and concerns when raised are quick addressed and corrected.                  | <b>Strongly Disagree</b> | <b>Disagree</b> | <b>Neutral</b> | <b>Agree</b> | <b>Strongly Agree</b> |
| 3. | Employees are praised for working safely.  | <b>Strongly Disagree</b> | <b>Disagree</b> | <b>Neutral</b> | <b>Agree</b> | <b>Strongly Agree</b> |
| 4. | Employees are disciplined for working unsafely.  | <b>Strongly Disagree</b> | <b>Disagree</b> | <b>Neutral</b> | <b>Agree</b> | <b>Strongly Agree</b> |
| 5. | Safety information and lessons learned from accidents are clearly communicated to employees. | <b>Strongly Disagree</b> | <b>Disagree</b> | <b>Neutral</b> | <b>Agree</b> | <b>Strongly Agree</b> |
| 6. | Feedback on safety issues from employees is encouraged.                                      | <b>Strongly Disagree</b> | <b>Disagree</b> | <b>Neutral</b> | <b>Agree</b> | <b>Strongly Agree</b> |
| 7. | Current safety rules and procedures are good sources of information on safety.               | <b>Strongly Disagree</b> | <b>Disagree</b> | <b>Neutral</b> | <b>Agree</b> | <b>Strongly Agree</b> |
-

8.	Current safety rules and procedures are too complex.	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
9.	On the jobsite, employees remind each other on how to work safely.	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
10.	On the jobsite, employees believe it is their responsibility to maintain a safe workplace.	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
11.	On the jobsite, supervisors/safety officers believe safety is important and participate in regular safety talks.	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
12.	On the jobsite, some safety procedures are avoided to meet deadlines.	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
13.	On the jobsite, accidents and potentially hazardous situations are reported by everyone.	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
14.	On the jobsite, accident investigations are conducted.	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
15.	It is only a matter of time before one of my co-workers is involved in an accident.	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
16.	Some rules are really necessary to get the job done safely.	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
17.	Some rules and policies are not really practical.	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
18.	When we are out on the job, safety is an important consideration when laying out the work area.	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
19.	When we are out on the job, working with defective equipment is not allowed under any circumstances.	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>

20. On the jobsite, enough time is given to get the job done safely.  
**Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree**

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21. On the jobsite, shortcuts are taken at the expense of safety.  
**Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree**

Do you support any of the following statements? **If yes, please rate each statement on a 1-9 scale (where 9=very strong support).** Think about the current role that safety plays within your workplace.

1. Safety plays an effective role in preventing accidents.

**Rate:**\_\_\_\_\_

2. Safety reduces occupational risk.

**Rate:**\_\_\_\_\_

3. Safety makes it possible to get the job done.

**Rate:**\_\_\_\_\_

4. Safety is not restrictive.

**Rate:**\_\_\_\_\_

5. Safety has a positive influence on morale.

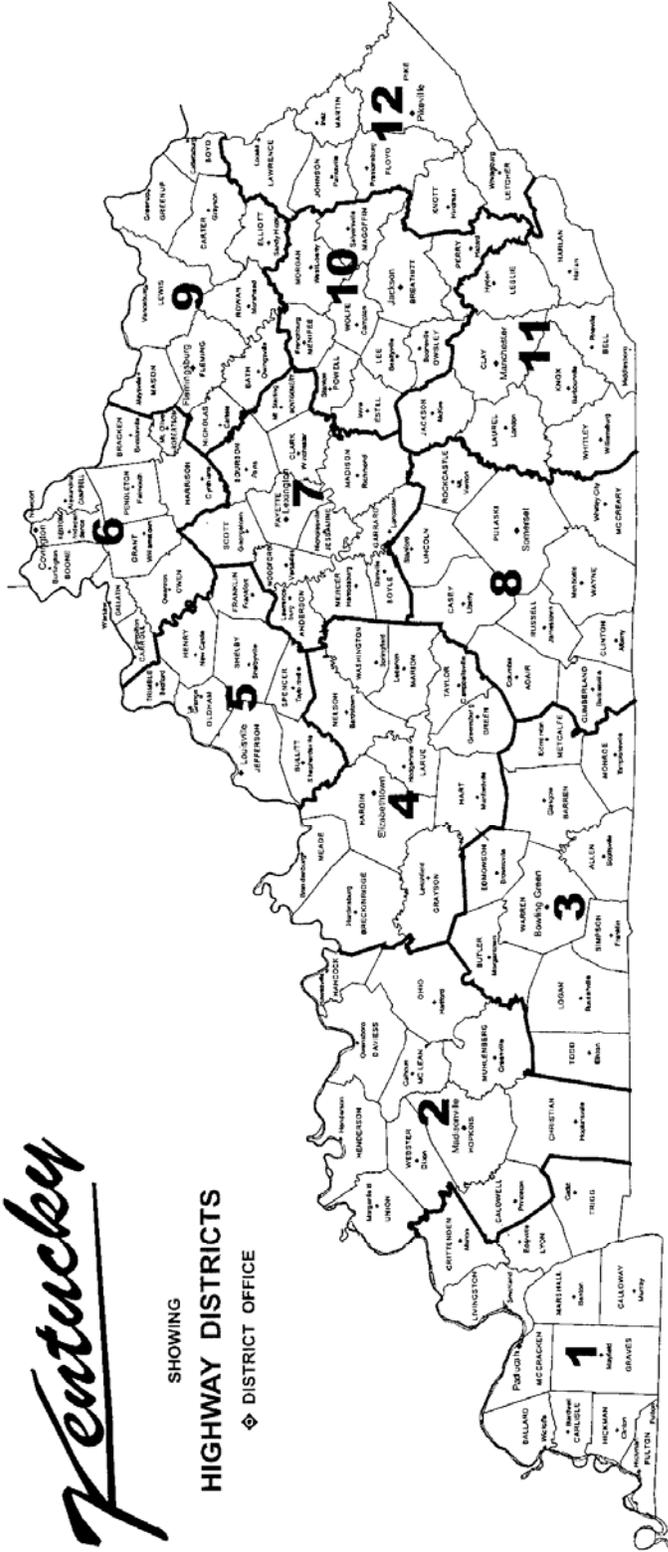
**Rate:**\_\_\_\_\_

**Thank you for completing this survey. Your input is highly valued!**

APPENDIX G: KYTC DISTRICT MAP

# Kentucky

SHOWING  
HIGHWAY DISTRICTS  
◆ DISTRICT OFFICE



APPENDIX H: SURVEY LETTER

January 17, 2007

Dear Superintendents and Managers/Resident Engineers:

Safety has long been a concern in the construction industry. Each year many workers are injured due to various causes. We are conducting a study focusing on improving worker safety during highway construction and maintenance operations for the Kentucky Transportation Cabinet. This third and final survey was created to evaluate and confirm the most important safety issues on the jobsite through the eyes of the field workers. For the first portion of the survey, participants will tell us if they agree, disagree or are neutral about new safety practices as well as what affect those ideas would have on workzone safety if implemented. For the second portion of the survey, participants will tell us if they strongly agree, agree, strongly disagree, disagree, or are neutral on safety statements describing the current views toward safety amongst the workers.

It would be greatly appreciated if you could distribute the enclosed surveys to workers. We would like input from all levels, from laborers to foremen to supervisors. Feel free to keep a copy for yourself and if you feel you have more interested workers than surveys, you may request more surveys, or make copies yourself, if easier. The survey is also available in PDF format, which we can email upon request.

We kindly request that the surveys be completed and returned to me at the University by Wednesday, January 31, 2007. A prepaid return envelope with address is enclosed. If you have any questions, or would like more information, please feel free to contact myself or one of my research assistants, Kenny Bussey at [krbuss0@engr.uky.edu](mailto:krbuss0@engr.uky.edu) or Jon Ross at [jhross0@engr.uky.edu](mailto:jhross0@engr.uky.edu). Both can be reached by phone at (859) 257-1036. Again, thank you for your time and cooperation in assisting with our research.

Sincerely,

Dr. Donn E. Hancher, P.E.  
Associate Dean for Administration and Academic Affairs  
Terrell-McDowell Chair Professor of Construction Engineering and Management  
Tel: 859-257-1864 Cell: 859-338-3472

## APPENDIX I: STATISTICAL ANALYSIS FOR CLIMATE SURVEY

### State Construction Statistical Analysis

For KYTC employees who work for the division of construction and are located in the western part of Kentucky, three statements in Table 2 were considered the issues of the greatest concern within the survey. These statements were also determined to be statistically equal to each other. Statement number 17, “Some rules and policies are not really practical,” is the statement with the lowest evaluation mean of 2.56. Because of the negative nature of this statement, the reversed evaluation scale places the mean above “Agree” but below “Neutral.”

Table 2: Climate Survey - Western - Construction – First

Question No.	Mean	N	F-Value	Significance
12. Avoided Safety Procedures	2.72	18	1.21	0.31
17. Not Practical Rules and Policies	2.56	18		
21. Shortcuts at expense of safety	3.11	18		

As seen in Table 3, the small number of respondents can cause problems. Even with a significance level of 0.30, the second ranking is congested with 12 of the 21 total statements on the survey. With a larger sample size, a more reasonable set of statements would make up the second ranking.

Table 3: Climate Survey - Western - Construction – Second

Question No.	Mean	N	F-Value	Significance
2. Problems Addressed Quickly	3.39	18	1.10	0.37
3. Employees Praised	3.22	18		
4. Employees Disciplined	3.65	17		
5. Clearly Communicated Lessons	3.72	18		
6. Feedback Encouraged	3.61	18		
7. Sources of Information	3.56	18		
8. Complex Rules and Procedures	3.17	18		
9. Employees Remind Each Other	3.65	17		
13. Hazardous Situations Reported	3.28	18		
14. Accident Investigations	3.72	18		
15. Co-worker in Accident	3.17	18		
19. Defective Equipment	3.56	18		

The following two tables, Table 4 and Table 5, show the statements of the least concern among KYTC construction workers in the western part of the state. Statement 18, “When we are out on the job, safety is an important consideration when laying out the work area,” is the area of least concern for this entire group. This fact can be seen in Table 5, where statement 18 is bold, with significance level of 0.21.

Table 4: Climate Survey - Western - Construction - Third

Question No.	Mean	N	F-Value	Significance
10. Safe Workplace	3.83	18	0.05	0.96
11. Safety Talks	3.89	18		

Table 5: Climate Survey - Western - Construction - Fourth

Question No.	Mean	N	F-Value	Significance
10. Safe Workplace	3.83	18	1.54	0.21
11. Safety Talks	3.89	18		
<b>18. Laying Out Safe Work Areas</b>	4.22	18		
20. Enough Time for Safety	3.83	18		

Beginning with Table 6, the safety climate survey statement rankings for KYTC construction employees located in the central portion of the state are displayed. Six statistically equal statements are viewed as being the greatest concern among those safety statements mentioned in the survey. Three statements, 12, 17, and 21, also appeared in the same ranking for the western Kentucky construction workers.

Table 6: Climate Survey - Central - Construction - First

Question No.	Mean	N	F-Value	Significance
12. Avoided Safety Procedures	2.80	45	1.09	0.37
13. Hazardous Situations Reported	3.02	45		
15. Co-worker in Accident	3.02	46		
17. Not Practical Rules and Policies	2.62	45		
19. Defective Equipment	2.98	46		
21. Shortcuts at expense of safety	2.85	46		

For the central Kentucky KYTC construction employees, the second ranking consisted of only one statement. “Employees are praised for working safely” was determined to statistically different when compared to those issues in Table 6 with a significance level of less than 0.30. It was also determined to be statistically different to those statements in the third ranking with, at most, a significance level of 0.18.

Table 7: Climate Survey - Central - Construction – Second

Question No.	Mean	N	F-Value	Significance
<b>3. Employees Praised</b>	3.09	46	1.85	0.18
4. Employees Disciplined	3.35	46		

The following two tables, Table 8 and Table 9, show the statements of the least concern among KYTC construction workers in the central part of the state. The same problem with a sample size seems to exist for the third ranking, shown in Table 8. Statement 14, “On the jobsite, accident investigations are conducted,” is the area of least concern for this entire group with an evaluation mean of 3.80.

Table 8: Climate Survey - Central - Construction – Third

Question No.	Mean	N	F-Value	Significance
2. Problems Addressed Quickly	3.41	46	0.95	0.48
4. Employees Disciplined	3.35	46		

5. Clearly Communicated Lessons	3.70	46
6. Feedback Encouraged	3.63	46
8. Complex Rules and Procedures	3.50	46
9. Employees Remind Each Other	3.35	46
10. Safe Workplace	3.57	46
11. Safety Talks	3.57	46
20. Enough Time for Safety	3.37	46

Table 9: Climate Survey - Central - Construction – Fourth

Question No.	Mean	N	F-Value	Significance
7. Sources of Information	3.76	46	0.07	0.79
14. Accident Investigations	3.80	46		

The results of the analysis done for the KYTC construction employees who work out of the one of the eastern highway districts are shown in Tables 10 through 12. Much like the western portion of the state, the small number of respondents to the climate survey has caused problems with creating any separation among the statements. Ten of the 21 statements appear in the first ranking before the significance level of 0.30 is met or exceeded. Considering that nine of the ten statements have an evaluation mean of less than 3, a larger amount of respondents could have potentially produced interesting results.

Table 10: Climate Survey - Eastern - Construction - First

Question No.	Mean	N	F-Value	Significance
3. Employees Praised	2.74	27	0.77	0.64
4. Employees Disciplined	2.74	27		
9. Employees Remind Each Other	3.15	27		
12. Avoided Safety Procedures	2.74	27		
13. Hazardous Situations Reported	2.81	27		
15. Co-worker in Accident	2.81	27		
17. Not Practical Rules and Policies	2.56	27		
19. Defective Equipment	2.96	27		
20. Enough Time for Safety	2.89	27		
21. Shortcuts at expense of safety	2.63	27		

The effects of a limited number of survey respondents can also be seen in the second ranking which is located in Table 11. A third of the statements are located within the second ranking.

Table 11: Climate Survey - Eastern - Construction – Second

Question No.	Mean	N	F-Value	Significance
2. Problems Addressed Quickly	3.27	26	0.59	0.74
5. Clearly Communicated Lessons	3.48	27		
6. Feedback Encouraged	3.30	27		

8. Complex Rules and Procedures	3.41	27
10. Safe Workplace	3.63	27
11. Safety Talks	3.33	27
14. Accident Investigations	3.26	27

The remaining statements on the safety climate survey are seen in Table 12. The issue of the least concern among the eastern KYTC construction workers is shown with an evaluation mean of 4.08 for “Safety is considered to be equally as important as getting the job done.”

Table 12: Climate Survey - Eastern - Construction - Third

Question No.	Mean	N	F-Value	Significance
1. Equal to Getting the Job Done	4.08	26	0.40	0.75
7. Sources of Information	3.85	27		
16. Necessary Rules	4.04	27		
18. Laying Out Safe Work Areas	3.88	26		

The remaining tables in this section show the data analysis when considering the KYTC construction workers across the entire state. Since the previous data sets were from this entire data set, it is only natural that some of the important findings are the same as those found in the geographic regional analysis. In Table 13, this can be seen with statement 17, “Some rules and policies are not really practical,” with an evaluation mean of 2.59 and a significance level of 0.21. This statement was never the greatest concern by itself for any of the regions, yet it was an issue in each of the regions’ first ranking.

Table 13: Climate Survey - Entire - Construction – First

Question No.	Mean	N	F-Value	Significance
12. Avoided Safety Procedures	2.77	90	1.58	0.21
<b>17. Not Practical Rules and Policies</b>	2.59	90		

For the second ranking in Table 14, statements 12, 15, and 21 show that KYTC construction workers are concerned with issues about avoidance and shortcutting safety procedures as well as the potential injury of a co-worker is an expected event. These statements almost were separated into the third ranking with a significance level of 0.33 which is just above the 0.30 cutoff.

Table 14: Climate Survey - Entire - Construction - Second

Question No.	Mean	N	F-Value	Significance
12. Avoided Safety Procedures	2.77	90	1.11	0.33
15. Co-worker in Accident	2.99	91		
21. Shortcuts at expense of safety	2.84	91		

For the third and fourth rankings shown in Tables 15 and 16, all of the remaining statements received an evaluation mean greater than 3 which translate into issues are currently not an issue.

Table 15: Climate Survey - Entire - Construction - Third

Question No.	Mean	N	F-Value	Significance
3. Employees Praised	3.01	91	0.86	0.46
4. Employees Disciplined	3.22	90		
13. Hazardous Situations Reported	3.09	90		
19. Defective Equipment	3.08	91		

Table 16: Climate Survey - Entire - Construction - Fourth

Question No.	Mean	N	F-Value	Significance
2. Problems Addressed Quickly	3.37	90	0.78	0.54
6. Feedback Encouraged	3.53	91		
8. Complex Rules and Procedures	3.41	91		
9. Employees Remind Each Other	3.34	90		
20. Enough Time for Safety	3.32	91		

### State Maintenance Statistical Analysis

For the KYTC maintenance employees in the western portion of the state, the issues that received the most negative response were different than those of the construction employees from the same area. As seen in Table 17, Statement 15, “It is only a matter of time before one of my co-workers is involved in an accident,” received the most negative feedback with an evaluation mean of 2.58. It should be noted that the statement distribution among the four rankings is greatly improved when analysis was done on the western maintenance employees due to the larger number of respondents.

Table 17: Climate Survey - Western - Maintenance - First

Question No.	Mean	N	F-Value	Significance
15. Co-worker in Accident	2.58	213	0.96	0.33
17. Not Practical Rules and Policies	2.67	216		

In the second ranking level shown in Table 18, neither of the two statements received an evaluation mean that was lower than three. With means of 3.16 and 3.21 making up the second ranking, all but the two issues brought up in the first ranking are not major concerns for the western KYTC maintenance employees.

Table 18: Climate Survey - Western - Maintenance - Second

Question No.	Mean	N	F-Value	Significance
8. Complex Rules and Procedures	3.16	216	0.27	0.60
12. Avoided Safety Procedures	3.21	213		

In Table 19, only one statement shown in bold from the safety climate survey was determined to be in the third ranking level. Statement 21, “On the jobsite, shortcuts are taken at the expense of safety,” made up the third ranking with an evaluation mean of 3.35 and a level of significance of 0.21.

Table 19: Climate Survey - Western - Maintenance - Third

Question No.	Mean	N	F-Value	Significance
19. Defective Equipment	3.47	216	1.58	0.21
<b>21. Shortcuts at expense of safety</b>	3.35	216		

The fourth ranking level for the western KYTC maintenance employees was the only level that did have more than two statements. Statement 19, “When we are out on the job, working with defective equipment is not allowed under any circumstances,” reached an evaluation mean of 3.47 and was the lowest within the ranking level.

Table 20: Climate Survey - Western - Maintenance - Fourth

Question No.	Mean	N	F-Value	Significance
3. Employees Praised	3.63	212	1.17	0.32
4. Employees Disciplined	3.58	215		
13. Hazardous Situations Reported	3.56	216		
19. Defective Equipment	3.47	216		

The KYTC central maintenance employees viewed the same statements as the western maintenance workers to be the ones of the greatest concerns. However, the evaluation means of 2.65 and 2.77 for statements 15 and 17 were slightly higher than those means from the western workers. As seen in Table 21, the level of significance also differed from the western maintenance’s first ranking.

Table 21: Climate Survey - Central - Maintenance - First

Question No.	Mean	N	F-Value	Significance
15. Co-worker in Accident	2.65	108	0.83	0.36
17. Not Practical Rules and Policies	2.77	108		

Outside of the first ranking, it can be seen that with even just double the amount of respondents can make a difference on the distribution of statements among the remaining three ranking levels. For the central maintenance workers, the second ranking increased to five statements instead of two. But an even greater can be seen in Table 23 when comparing the third ranking of the western to the central maintenance employees with an increase from two to seven statements. As seen in Table 22, the second ranking for the central maintenance workers is a combination of the second, third, and half of the fourth rankings for the western maintenance employees.

Table 22: Climate Survey - Central - Maintenance - Second

Question No.	Mean	N	F-Value	Significance
3. Employees Praised	3.19	109	0.67	0.61

4. Employees Disciplined	3.34	108
12. Avoided Safety Procedures	3.13	109
19. Defective Equipment	3.19	108
21. Shortcuts at expense of safety	3.28	109

Table 23: Climate Survey - Central - Maintenance - Third

Question No.	Mean	N	F-Value	Significance
2. Problems Addressed Quickly	3.44	109	0.81	0.56
5. Clearly Communicated Lessons	3.44	108		
6. Feedback Encouraged	3.56	108		
8. Complex Rules and Procedures	3.42	107		
13. Hazardous Situations Reported	3.64	108		
14. Accident Investigations	3.50	108		
20. Enough Time for Safety	3.49	107		

With the majority of the statements being contained in the second and third rankings because of the low number of maintenance respondents from the central portion of the state, the fourth ranking contains statements 9 and 11 with their respective evaluation means being 3.72 and 3.81. In Table 24, a level of significance of 0.40 is obtained before it drops below 0.30 when the two statements are compared to any of the five remaining statements from the safety climate survey.

Table 24: Climate Survey - Central - Maintenance - Fourth

Question No.	Mean	N	F-Value	Significance
9. Employees Remind Each Other	3.72	109	0.72	0.40
11. Safety Talks	3.81	109		

Two of the same statements in the western and central maintenance employees' first ranking are also in the first ranking for the eastern KYTC maintenance workers. As seen in Table 25, statement 12, "On the jobsite, some safety procedures are avoid to meet deadlines," was an issue that was determined to be one to be included in the first ranking for the eastern workers.

Table 25: Climate Survey - Eastern - Maintenance - First

Question No.	Mean	N	F-Value	Significance
12. Avoided Safety Procedures	2.96	111	1.01	0.37
15. Co-worker in Accident	2.82	111		
17. Not Practical Rules and Policies	2.77	111		

Also like the two previous geographic groupings, first ranking has contained statements with evaluation means that are lower than three. Whereas, the second ranking starts with evaluation means that are greater than three. This can be seen for the eastern maintenance workers in Table 26. Like it was stated before, all but the three issues

brought up in the first ranking are not major concerns for the eastern KYTC maintenance employees.

Table 26: Climate Survey - Eastern - Maintenance - Second

Question No.	Mean	N	F-Value	Significance
8. Complex Rules and Procedures	3.23	111	0.43	0.51
21. Shortcuts at expense of safety	3.33	109		

For the third and fourth rankings, the major problem with a low number of respondents can be seen in both Tables 27 and 28. The third ranking contains nine statements and the fourth ranking contains six statements. As stated before, with such low numbers, the fourth ranking includes statements with evaluation means greater than four with the lowest being 4.02.

Table 27: Climate Survey - Eastern - Maintenance - Third

Question No.	Mean	N	F-Value	Significance
2. Problems Addressed Quickly	3.67	110	1.05	0.40
3. Employees Praised	3.73	111		
4. Employees Disciplined	3.68	111		
5. Clearly Communicated Lessons	3.92	108		
6. Feedback Encouraged	3.86	111		
13. Hazardous Situations Reported	3.65	111		
14. Accident Investigations	3.69	111		
19. Defective Equipment	3.65	111		
20. Enough Time for Safety	3.77	111		

Table 28: Climate Survey - Eastern - Maintenance - Fourth

Question No.	Mean	N	F-Value	Significance
7. Sources of Information	4.04	110	1.19	0.31
9. Employees Remind Each Other	4.02	111		
10. Safe Workplace	4.22	109		
11. Safety Talks	4.07	111		
16. Necessary Rules	4.11	110		
18. Laying Out Safe Work Areas	4.15	111		

With a sample size of 435, the analysis of the entire KYTC maintenance grouping produced very desirable results in respect to statement distribution among the four ranking levels. In Table 29, with statements 15 and 17 appearing in each of the three geographic regions' first ranking, it is expected that those same two appear in the first ranking for all of KYTC maintenance respondents.

Table 29: Climate Survey - Entire - Maintenance - First

Question No.	Mean	N	F-Value	Significance
--------------	------	---	---------	--------------

15. Co-worker in Accident	2.66	432	0.89	0.35
17. Not Practical Rules and Policies	2.72	435		

For the second ranking in Table 30, statement 12, “On the jobsite, some safety procedures are avoided to meet deadlines,” is the only statement within this ranking. Maintenance respondents across the state gave the statement an evaluation mean of 3.13. It was also determined that differed from the statement located in the third ranking with a level of significance of 0.08 which is below the 0.30 threshold.

Table 30: Climate Survey - Entire - Maintenance - Second

Question No.	Mean	N	F-Value	Significance
8. Complex Rules and Procedures	3.24	434	3.10	0.08
<b>12. Avoided Safety Procedures</b>	3.13	433		

Once again, a single statement occupies a ranking level. Statement 8, “Current safety rules and procedures are too complex,” is the only statement to have been determined to be in the third ranking for all of the KYTC maintenance respondents. As shown in Table 31, it achieved this position with an evaluation mean of 3.24 and a level of significance of 0.23.

Table 31: Climate Survey - Entire - Maintenance - Third

Question No.	Mean	N	F-Value	Significance
<b>8. Complex Rules and Procedures</b>	3.24	434	1.47	0.23
21. Shortcuts at expense of safety	3.32	434		

Finally, statement 21, “On the jobsite, shortcuts are taken at the expense of safety,” was the only statement to be determined to be in the fourth ranking as seen in Table 32. This was achieved with an evaluation mean of 3.32 and a level of significance of 0.10.

Table 32: Climate Survey - Entire - Maintenance - Fourth

Question No.	Mean	N	F-Value	Significance
19. Defective Equipment	3.44	435	2.74	0.10
<b>21. Shortcuts at expense of safety</b>	3.32	434		

### Entire State Statistical Analysis

In this section, the responses from both the KYTC construction and maintenance workers to the safety climate survey for each of three geographic regions as well as the entire state are used for the analysis shown in the tables below. Due to the larger number of responses from the maintenance employees than the construction employees, there are a lot of similarities between the analysis results from both parties and those from just the maintenance workers. For example, in Table 33, statements 15 and 17 have been determined to be in the first ranking for the employees in the western portion of the state. These statements were also the two that composed the first ranking for the maintenance workers in the western part of the state.

Table 33: Climate Survey - Western - All - First

Question No.	Mean	N	F-Value	Significance
15. Co-worker in Accident	2.63	231	0.15	0.70
17. Not Practical Rules and Policies	2.66	234		

In Table 34, statements 8 and 12 were two to be classified as the second ranking level among the western employees. A level of significance of 0.91 was calculated before it fell below the 0.30 threshold which occurred when statement 21, “On the jobsite, shortcuts are taken at the expense of safety,” was included in the analysis. Because of this, statement 21 occupies the third ranking, as seen in Table 35. With a level of significance of 0.12 when compared with statement 19, it is the only statement in the third ranking.

Table 34: Climate Survey - Western - All - Second

Question No.	Mean	N	F-Value	Significance
8. Complex Rules and Procedures	3.16	234	0.01	0.91
12. Avoided Safety Procedures	3.17	231		

Table 35: Climate Survey - Western - All - Third

Question No.	Mean	N	F-Value	Significance
19. Defective Equipment	3.47	234	2.48	0.12
<b>21. Shortcuts at expense of safety</b>	3.33	234		

Table 36 shows the results of statistical analysis for the fourth ranking level. Statement 3, “Employees are praised for working safely”, is the statement of the least negative response within this ranking with an evaluation mean of 3.60.

Table 36: Climate Survey - Western - All - Fourth

Question No.	Mean	N	F-Value	Significance
3. Employees Praised	3.60	230	0.86	0.46
4. Employees Disciplined	3.58	232		
13. Hazardous Situations Reported	3.53	234		
19. Defective Equipment	3.47	234		

Moving across Kentucky, both the central maintenance and construction workers agree with their western colleagues about which issues are of the greatest concern at this time. The first ranking for the central portion of the state, shown in Table 37, contains statements 15 and 17 with evaluation means of 2.76 and 2.73. This is to be expected with the central maintenance workers making up the majority of this group of respondents. A significance level of 0.76 is obtained before it drops below 0.30 when any of the remaining statements are included in the analysis.

Table 37: Climate Survey - Central - All – First

Question No.	Mean	N	F-Value	Significance
15. Co-worker in Accident	2.76	154	0.09	0.76
17. Not Practical Rules and Policies	2.73	153		

Even with an increase in the sample size, a better distribution of the statements could not have been achieved. This fact can be seen in Tables 38 and 39 which describe the second and third ranking statistics for the central employee responses. The number of statements found in each ranking has not changed from the number found in the rankings of the central maintenance worker responses.

Table 38: Climate Survey - Central - All - Second

Question No.	Mean	N	F-Value	Significance
3. Employees Praised	3.16	155	0.46	0.71
12. Avoided Safety Procedures	3.03	154		
19. Defective Equipment	3.12	154		
21. Shortcuts at expense of safety	3.15	155		

Table 39: Climate Survey - Central - All - Third

Question No.	Mean	N	F-Value	Significance
2. Problems Addressed Quickly	3.43	155	0.96	0.44
4. Employees Disciplined	3.34	154		
5. Clearly Communicated Lessons	3.51	154		
8. Complex Rules and Procedures	3.44	153		
13. Hazardous Situations Reported	3.31	153		
20. Enough Time for Safety	3.46	153		

The benefits of a larger sample could be seen in the fourth ranking shown in Table 40. With a level of significance of 0.35 being so close to the 0.30 threshold, additional number of respondents could easily cause separation of the statements in this ranking.

Table 40: Climate Survey - Central - All - Fourth

Question No.	Mean	N	F-Value	Significance
6. Feedback Encouraged	3.58	154	1.10	0.35
9. Employees Remind Each Other	3.61	155		
11. Safety Talks	3.74	155		
14. Accident Investigations	3.65	154		

Even with the addition of the 37 eastern construction respondents, the rankings determined from all the eastern employees who responded to the safety climate have remained the same as those calculated from the 111 eastern maintenance respondents. The minimal effects can be seen when comparing the obtained significance level of the

first ranking from Table 41 and the one from the eastern maintenance employee first ranking. The difference is only 0.05.

Table 41: Climate Survey - Eastern - All - First

Question No.	Mean	N	F-Value	Significance
12. Avoided Safety Procedures	2.92	138	1.16	0.32
15. Co-worker in Accident	2.82	138		
17. Not Practical Rules and Policies	2.73	138		

Continuing on the theme of similarities between the eastern maintenance and the entire eastern state employee responses, the levels of significance for the second and third rankings in Tables 42 and 43 differ from those in the second and third ranking of the eastern maintenance responses by almost same amount as mention in the first ranking discussion.

Table 42: Climate Survey - Eastern - All - Second

Question No.	Mean	N	F-Value	Significance
8. Complex Rules and Procedures	3.27	138	0.37	0.55
21. Shortcuts at expense of safety	3.19	136		

Table 43: Climate Survey - Eastern - All - Third

Question No.	Mean	N	F-Value	Significance
2. Problems Addressed Quickly	3.60	136	0.97	0.45
3. Employees Praised	3.54	138		
4. Employees Disciplined	3.50	138		
6. Feedback Encouraged	3.75	138		
13. Hazardous Situations Reported	3.49	138		
14. Accident Investigations	3.61	138		
19. Defective Equipment	3.51	138		
20. Enough Time for Safety	3.60	138		

Like for the central portion of the state, the benefits of a larger sample could be seen in the fourth ranking shown in Table 44. With a level of significance of 0.31 being so close to the 0.30 threshold, additional number of respondents could easily cause separation of the statements in this ranking.

Table 44: Climate Survey - Eastern - All - Fourth

Question No.	Mean	N	F-Value	Significance
5. Clearly Communicated Lessons	3.83	135	1.20	0.31
7. Sources of Information	4.00	137		
9. Employees Remind Each Other	3.85	138		
11. Safety Talks	3.93	138		

The final set of tables show the statistical data for the entire state. Along with the tables created from the entire state maintenance employee responses, a reliable and desirable separation among the statements can be seen. This is largely due to a respondent sample size of 526. Once again, due to the amount maintenance respondents, the statements and their rankings almost mirror those determined from the maintenance responses across the entire state. This can be seen in Table 45 with statements 15 and 17 being in the first ranking for all of the respondents across the state which is the same case for the first ranking for all of the maintenance respondents across the state.

Table 45: Climate Survey - Entire - All - First

Question No.	Mean	N	F-Value	Significance
15. Co-worker in Accident	2.72	523	0.09	0.77
17. Not Practical Rules and Policies	2.70	525		

As shown in Table 46, the second ranking for the entire state respondents contains only one of the climate survey statements. Statement 12, “On the jobsite, some safety procedures are avoided to meet deadlines,” has an evaluation mean of 3.07 and a level of significance of 0.01 when compared against statements that make up the third ranking.

Table 46: Climate Survey - Entire - All - Second

Question No.	Mean	N	F-Value	Significance
<b>12. Avoided Safety Procedures</b>	3.07	523	7.20	0.01
21. Shortcuts at expense of safety	3.24	525		

The increased in the sample size caused by the analysis done on state employees as a whole resulted in statements 8 and 21 both being in the third ranking which is located below in Table 47. With their evaluation means of 3.27 and 3.24 having a difference of 0.03, it would be expected that both statements fall into the same ranking.

Table 47: Climate Survey - Entire - All - Third

Question No.	Mean	N	F-Value	Significance
8. Complex Rules and Procedures	3.27	525	0.29	0.59
21. Shortcuts at expense of safety	3.24	525		

Another major difference when doing an analysis on the state in its entity as compared to one done with only KYTC maintenance employees across the state is a new statement occupies the fourth ranking. Statement 19, “When we are out on the job, working with defective equipment is not allowed under any circumstances,” was determined to be the only statement in the fourth ranking with an evaluation mean of 3.38 and a level of significance of 0.28.

Table 48: Climate Survey - Entire - All - Fourth

Question No.	Mean	N	F-Value	Significance
3. Employees Praised	3.45	523	1.15	0.28
<b>19. Defective Equipment</b>	3.38	526		

## APPENDIX J: STATISTICAL ANALYSIS FOR FINAL SURVEY

### Contractor Statistical Analysis

Unlike the safety climate survey, the final safety survey was sent to a variety of different Kentucky highway contractors. Those contractors who are located in the western portion of the state seemed to agree the most with the statements listed in Table 49 as methods to improve work zone safety. The ANOVA done on the statements within the first ranking achieved a level of significance of 0.35 before going beyond the 0.30 threshold.

Table 49: Safety Survey - Western - Contractor - First

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.82	50	1.12	0.35
4. Auto-shutoff for Tractors	2.94	51		
6. Two-way Radio Devices	2.92	51		
9. First Aid Kits and CPR	2.90	50		
14. Lighting for Nighttime Activities	2.86	50		

The same problem that appeared in the safety climate survey when a small sample size was present is also appearing in both the first and second rankings of western contractors' responses to the survey statements. Two-third of the statements is appearing in the first two rankings. With a sample size of 51, achieving a high degree of statement distribution among the rankings can be very difficult. Statement 10, "We need yearly physicals to monitor vision, hearing, and other construction sensitive abilities," was viewed as having the greatest potential to improve safety within the second ranking with an evaluation mean of 2.61.

Table 50: Safety Survey - Western - Contractor - Second

Question No.	Mean	N	F-Value	Significance
3. Closed Cabs for Tractors	2.57	51	0.68	0.61
7. Procedure for Trench Box	2.57	51		
8. Availability and Selection of PPE	2.61	49		
10. Yearly Physical Exams	2.44	50		
12. Lightweight Flashing Paddles	2.60	50		

For the third ranking, a significance level of 0.59 was achieved before the 0.30 threshold was reached. One should be getting the idea that all of the statements contained on the final safety survey were viewed at least by some of the western contractors as a good method to improve safety. This point can be seen with statement 13, "We need to place portable rumble strips in front of flagmen to help capture the attention of oncoming traffic as well as slow them down," having the lowest evaluation mean within the third ranking of 2.22.

Table 51: Safety Survey - Western - Contractor - Third

Question No.	Mean	N	F-Value	Significance
1. Sensors/Cameras for Blind Areas	2.28	50	0.53	0.59
5. Increased Crew Sizes	2.36	50		
13. Portable Rumble Strips	2.22	50		

Continuing across the state, there was a greater response from the highway contractors located in the central portion of Kentucky. Even with 123 respondents, the same problems associated with a small sample size were still experienced. Five statements from the survey, as seen in Table 52, made up the first ranking with a level of significance of 0.35. Statement 2, “We should use back-up alarms with alternating tones and/or sounds to keep workers attentive,” achieved the highest evaluation mean within the ranking with a mean of 2.89.

Table 52: Safety Survey - Central - Contractor - First

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.89	122	1.11	0.35
4. Auto-shutoff for Tractors	2.82	118		
11. Flagmen Training	2.82	118		
14. Lighting for Nighttime Activities	2.88	121		
15. Traffic Citation Enforcement	2.80	123		

Statement 9, “We need improved availability of first aid kits, as well as more personnel trained in first aid/CPR,” dropped from the first ranking with the western contractors to the second ranking with the central contractors. It and three other statements make up the second ranking as seen in Table 53 with a level of significance of 0.46.

Table 53: Safety Survey - Central - Contractor - Second

Question No.	Mean	N	F-Value	Significance
3. Closed Cabs for Tractors	2.70	119	0.87	0.46
6. Two-way Radio Devices	2.65	121		
8. Availability and Selection of PPE	2.68	121		
9. First Aid Kits and CPR	2.76	122		

With evaluation means having the largest difference being one of 0.03, it is understandable that statements 7, 10, and 12 would occupy the same ranking level. The third ranking level shown in Table 54, comprised of these three statements, only reached a significance level of 0.89 before plummeting to below the 0.30 threshold. Such a feature was able to be achieved with an evaluation mean difference between the lowest mean with the third ranking and the mean for the only statement in the fourth ranking being 0.11.

Table 54: Safety Survey - Central - Contractor - Third

Question No.	Mean	N	F-Value	Significance
7. Procedure for Trench Box	2.59	118	0.12	0.89
10. Yearly Physical Exams	2.56	122		
12. Lightweight Flashing Paddles	2.58	122		

As stated above, the fourth ranking for the central contractors is only comprised of statement 1, “We should use sensors and/or cameras mounted on the rear of equipment

and/or vehicles to detect objects in blind areas (mounted as not to distract the operator).” Separation from the other two remaining statements from the survey was achieved with an evaluation mean of 2.45 and a level of significance of 0.17 which can be seen in Table 55.

Table 55: Safety Survey - Central - Contractor - Fourth

Question No.	Mean	N	F-Value	Significance
<b>1. Sensors/Cameras for Blind Areas</b>	2.45	119	1.90	0.17
5. Increased Crew Sizes	2.33	120		

Because a sample size of 27 was able to be collected from the eastern contractors, only two rankings were able to be created. The first ranking, shown in Table 56, contains 14 of the total 15 statements from the final safety survey. The evaluation means vary from as high as 2.92 for statement 15 to 2.58 for statements 10 and 13. Even with such a difference, a level of significance of 0.57 was obtained. In order to reach or exceed the 0.30 threshold, statement 1 with an evaluation mean of 2.42 had to be included in the analysis. As a result, shown in Table 57, the second ranking is only comprised of statement 1 which the analysis produced a level of significance of 0.24.

Table 56: Safety Survey - Eastern - Contractor - First

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.70	27	0.89	0.57
3. Closed Cabs for Tractors	2.67	27		
4. Auto-shutoff for Tractors	2.78	27		
5. Increased Crew Sizes	2.67	27		
6. Two-way Radio Devices	2.89	27		
7. Procedure for Trench Box	2.74	27		
8. Availability and Selection of PPE	2.73	26		
9. First Aid Kits and CPR	2.62	26		
10. Yearly Physical Exams	2.58	26		
11. Flagmen Training	2.73	26		
12. Lightweight Flashing Paddles	2.69	26		
13. Portable Rumble Strips	2.58	26		
14. Lighting for Nighttime Activities	2.77	26		
15. Traffic Citation Enforcement	2.92	26		

Table 57: Safety Survey - Eastern - Contractor - Second

Question No.	Mean	N	F-Value	Significance
<b>1. Sensors/Cameras for Blind Areas</b>	2.42	26	1.25	0.24
2. Alternating Back-up Alarms	2.70	27		
3. Closed Cabs for Tractors	2.67	27		
4. Auto-shutoff for Tractors	2.78	27		
5. Increased Crew Sizes	2.67	27		
6. Two-way Radio Devices	2.89	27		

7. Procedure for Trench Box	2.74	27
8. Availability and Selection of PPE	2.73	26
9. First Aid Kits and CPR	2.62	26
10. Yearly Physical Exams	2.58	26
11. Flagmen Training	2.73	26
12. Lightweight Flashing Paddles	2.69	26
13. Portable Rumble Strips	2.58	26
14. Lighting for Nighttime Activities	2.77	26
15. Traffic Citation Enforcement	2.92	26

Even with a larger sample size by performing a statistical analysis including all of the contractors who responded, the first ranking is rather congested with survey statements. However, Table 58 which displays the first ranking statistics has six statements due to the evaluation means only differing by as large as 0.08.

Table 58: Safety Survey - Entire State - Contractor - First

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.84	242	0.87	0.50
4. Auto-shutoff for Tractors	2.84	239		
9. First Aid Kits and CPR	2.78	241		
11. Flagmen Training	2.81	241		
14. Lighting for Nighttime Activities	2.86	239		
15. Traffic Citation Enforcement	2.84	241		

Statement 6, “We need two-way radio devices with longer range, longer battery life, and dedicated frequencies,” is the only method that was determined to be in the second ranking shown in Table 59. An evaluation mean difference of 0.09 was great enough to produce a level of significance of 0.07, thus causing statement 3 not to be included in this ranking.

Table 59: Safety Survey - Entire State - Contractor - Second

Question No.	Mean	N	F-Value	Significance
3. Closed Cabs for Tractors	2.67	240	3.43	0.07
<b>6. Two-way Radio Devices</b>	<b>2.76</b>	<b>242</b>		

For the third ranking in Table 60, responses from contractors across Kentucky determined that statements 3, 7, 8, and 12 were to be ranked in the same group. Statement 3, “Concerning mowing operations, we should use tractors with closed cabs to prevent flying debris from striking the operator,” with its 2.67 evaluation mean was viewed as having the greatest potential to improve safety within this ranking.

Table 60: Safety Survey - Entire State - Contractor - Third

Question No.	Mean	N	F-Value	Significance
3. Closed Cabs for Tractors	2.67	240	1.16	0.33
7. Procedure for Trench Box	2.59	237		

8. Availability and Selection of PPE	2.65	239
12. Lightweight Flashing Paddles	2.63	241

Through the ANOVA, a level of significance of 0.03, being beyond the 0.30 threshold, helped determine that only statement 10 made up the fourth ranking. An evaluation mean of 2.55 was associated with statement 10 as seen in Table 61.

Table 61: Safety Survey - Entire State - Contractor - Fourth

Question No.	Mean	N	F-Value	Significance
1. Sensors/Cameras for Blind Areas	2.42	238	4.65	0.03
<b>10. Yearly Physical Exams</b>	<b>2.55</b>	<b>241</b>		

### State Construction Statistical Analysis

Like the analysis done on the safety climate survey responses, the input from the KYTC construction employees was also broken down into one of the three geographic regions of the state. Only 37 of the state's western construction employees replied to the final safety survey. With such a low response, two separate rankings, not the desired four, could be achieved. For the first ranking in Table 62, twelve of the 15 statements were grouped with a level of significance of 0.51 before it dropped below the 0.30 criteria.

Table 62: Safety Survey - Western - Construction - First

Question No.	Mean	N	F-Value	Significance
1. Sensors/Cameras for Blind Areas	2.54	35	0.94	0.51
2. Alternating Back-up Alarms	2.67	36		
3. Closed Cabs for Tractors	2.66	35		
4. Auto-shutoff for Tractors	2.74	35		
6. Two-way Radio Devices	2.53	36		
7. Procedure for Trench Box	2.75	36		
8. Availability and Selection of PPE	2.58	36		
9. First Aid Kits and CPR	2.64	36		
11. Flagmen Training	2.78	36		
12. Lightweight Flashing Paddles	2.61	36		
14. Lighting for Nighttime Activities	2.78	36		
15. Traffic Citation Enforcement	2.81	37		

The second ranking, shown in Table 63, is basically just a listing of the remaining three statements. With a significance level of 0.98, there was no noticeable difference among their evaluation means.

Table 63: Safety Survey - Western - Construction - Second

Question No.	Mean	N	F-Value	Significance
5. Increased Crew Sizes	2.44	36	0.02	0.98
10. Yearly Physical Exams	2.42	36		
13. Portable Rumble Strips	2.44	36		

Moving to the central construction employees, there was a slight improvement with respect to sample size. However, the increase was only great enough to cause the creation of a third ranking. Also, as seen in Table 64, the first ranking is rather congested with six statements. Statement 4, “Concerning mowing operations, we should use tractors with auto-shutoff so that if the operator is thrown from the seat, the engine will be shutoff,” was determined to have an evaluation mean of 2.98, the highest within the first ranking.

Table 64: Safety Survey - Central - Construction - First

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.84	49	0.71	0.62
4. Auto-shutoff for Tractors	2.98	50		
7. Procedure for Trench Box	2.92	50		
11. Flagmen Training	2.94	51		
14. Lighting for Nighttime Activities	2.90	51		
15. Traffic Citation Enforcement	2.90	51		

With only 51 respondents from the central region, the difference between the highest and lowest evaluation mean within the second ranking was able to be 0.19. A significance level of 0.50 amongst the seven statements was reached before crossing the 0.30 limit.

Table 65: Safety Survey - Central - Construction - Second

Question No.	Mean	N	F-Value	Significance
3. Closed Cabs for Tractors	2.71	48	0.90	0.50
5. Increased Crew Sizes	2.58	50		
6. Two-way Radio Devices	2.76	50		
8. Availability and Selection of PPE	2.73	51		
9. First Aid Kits and CPR	2.69	51		
12. Lightweight Flashing Paddles	2.75	51		
13. Portable Rumble Strips	2.57	51		

Much like the final ranking for western KYTC construction workers, the third ranking is just a listing of the two remaining statements from the final safety survey. This fact can easily be seen in Table 66 that shows the level of significance as being 0.95.

Table 66: Safety Survey - Central - Construction - Third

Question No.	Mean	N	F-Value	Significance
1. Sensors/Cameras for Blind Areas	2.27	49	0.00	0.95
10. Yearly Physical Exams	2.27	51		

With the previous two geographic regions producing crowded rankings, it is rather surprising to see that a single statement contained in the first ranking for the responses from the eastern construction employees. In Table 67, statement 4, “Concerning mowing operations, we should use tractors with auto-shutoff so that if the

operator is thrown from the seat, the engine will be shutoff,” achieved separation from the other statements with an evaluation mean of 2.89 and a level of significance of 0.27.

Table 67: Safety Survey - Eastern - Construction - First

Question No.	Mean	N	F-Value	Significance
<b>4. Auto-shutoff for Tractors</b>	2.89	46	1.25	0.27
15. Traffic Citation Enforcement	2.79	47		

The desired distribution seen in the first ranking was short lived. In Table 68, the second ranking for the eastern construction workers contains 12 of the 15 survey statements. With the maximum evaluation mean difference being 0.31 and a level of significance of 0.36, an increase in the sample size could easily create some separation among the twelve statements.

Table 68: Safety Survey - Eastern - Construction - Second

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.65	46	1.10	0.36
3. Closed Cabs for Tractors	2.64	47		
5. Increased Crew Sizes	2.60	47		
6. Two-way Radio Devices	2.77	47		
7. Procedure for Trench Box	2.64	47		
8. Availability and Selection of PPE	2.78	46		
9. First Aid Kits and CPR	2.62	47		
11. Flagmen Training	2.70	47		
12. Lightweight Flashing Paddles	2.60	47		
13. Portable Rumble Strips	2.48	46		
14. Lighting for Nighttime Activities	2.70	47		
15. Traffic Citation Enforcement	2.79	47		

Continuing the trend established by the western construction respondents, the final ranking which happens to be the third ranking for the eastern portion contains the two remaining statements. Statement 10, “We need yearly physicals to monitor vision, hearing, and other construction sensitive activities,” received the lowest evaluation mean for the entire survey with a mean of 2.21. This can be seen in Table 69.

Table 69: Safety Survey - Eastern - Construction - Third

Question No.	Mean	N	F-Value	Significance
1. Sensors/Cameras for Blind Areas	2.27	44	0.15	0.70
10. Yearly Physical Exams	2.21	47		

Finally, analysis was done on all the KYTC construction worker responses across the entire state. Even with the larger sample size after combining the regional responses, five statements appeared in the first ranking as seen in Table 70. A level of significance of 0.40 was calculated from the analysis, so there is potential that more respondents could have caused separation amongst the statements.

Table 70: Safety Survey - Entire State - Construction - First

Question No.	Mean	N	F-Value	Significance
4. Auto-shutoff for Tractors	2.89	131	1.01	0.40
7. Procedure for Trench Box	2.77	133		
11. Flagmen Training	2.81	134		
14. Lighting for Nighttime Activities	2.80	134		
15. Traffic Citation Enforcement	2.84	135		

Problems displayed in the first ranking can also be seen in the second ranking located in Table 71. Statement 2, “We should use back-up alarms with alternating tones and/or sounds to keep workers attentive,” is the method viewed as having the greatest potential to improve safety among the six statements in this ranking with an evaluation mean of 2.73. A 0.88 significance level was obtained before plummeting at the 0.30 criteria.

Table 71: Safety Survey - Entire State - Construction – Second

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.73	131	0.35	0.88
3. Closed Cabs for Tractors	2.67	130		
6. Two-way Radio Devices	2.70	133		
8. Availability and Selection of PPE	2.71	133		
9. First Aid Kits and CPR	2.65	134		
12. Lightweight Flashing Paddles	2.66	134		

The next two rankings, third and fourth, display rather large differences between their evaluation means and those found in the ranking above them. In Table 72, statement 5 has an evaluation mean of 2.55 which is 0.10 lower than the lowest mean in the second ranking. The difference between the means in the third and fourth rankings is even greater. In Table 73, statement 1 has an evaluation mean of 2.34, the highest within the fourth ranking, which is 0.16 lower than the lowest mean found in the third ranking.

Table 72: Safety Survey - Entire State - Construction - Third

Question No.	Mean	N	F-Value	Significance
5. Increased Crew Sizes	2.55	133	0.31	0.58
13. Portable Rumble Strips	2.50	133		

Table 73: Safety Survey - Entire State - Construction - Fourth

Question No.	Mean	N	F-Value	Significance
1. Sensors/Cameras for Blind Areas	2.34	128	0.34	0.56
10. Yearly Physical Exams	2.29	134		

### State Maintenance Statistical Analysis

Like the safety climate survey, an analysis was done over just the KYTC maintenance employee responses in the three geographic regions across the state. The

congestion of statements within the first ranking of the western maintenance employees is not because of a small sample size. With a sample size of 234, it can be said that the evaluation means of the five statements, seen Table 74, are just too close to be considered to have any significant difference. A level of significance of 0.86 was calculated before the 0.30 point was reached.

Table 74: Safety Survey - Western - Maintenance - First

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.81	232	0.33	0.86
3. Closed Cabs for Tractors	2.82	232		
4. Auto-shutoff for Tractors	2.77	234		
6. Two-way Radio Devices	2.82	234		
15. Traffic Citation Enforcement	2.80	231		

In Table 75, the second ranking of the western maintenance employees has only one statement. Statement 8, “We need improved availability and selection of PPE such as gloves, safety glasses, reflective clothing, hardhats, ear protection, heights protection, foot protection, respiratory protection, and weather protection,” was shown to have an evaluation mean of 2.72 and created a 0.24 significance level. This level is below the 0.30 mark and caused the second ranking to be solely occupied by statement 8.

Table 75: Safety Survey - Western - Maintenance - Second

Question No.	Mean	N	F-Value	Significance
5. Increased Crew Sizes	2.66	234	1.39	0.24
<b>8. Availability and Selection of PPE</b>	<b>2.72</b>	<b>232</b>		

For the third ranking as shown in Table 76, statement 5, “We need increased crew sizes to accommodate lookout personnel and to improve quality of work,” was calculated to have an evaluation mean of 2.66, the largest within the ranking. With the other five statements, a level of significance of 0.44 was obtained. The largest difference between the means was 0.10, yet, it was not large enough to cause any further separation.

Table 76: Safety Survey - Western - Maintenance - Third

Question No.	Mean	N	F-Value	Significance
5. Increased Crew Sizes	2.66	234	0.94	0.44
9. First Aid Kits and CPR	2.65	231		
11. Flagmen Training	2.61	232		
12. Lightweight Flashing Paddles	2.56	230		
14. Lighting for Nighttime Activities	2.62	230		

Finishing out the western maintenance employee rankings, the fourth ranking contains only two statements. Evaluation means of 2.50 and 2.54 for statements 1 and 7 were able to create a significance level of 0.51 before inclusion of one the unranked statements forced it below the 0.30 criteria.

Table 77: Safety Survey - Western - Maintenance - Fourth

Question No.	Mean	N	F-Value	Significance
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1. Sensors/Cameras for Blind Areas	2.50	231	0.45	0.51
7. Procedure for Trench Box	2.54	230		

Even with less than half the sample size of the western maintenance rankings, the first ranking for the central maintenance employees has the majority of the statements that of the western maintenance first ranking. However, in Table 78, statements 8 and 14 replaced statement 2, which has dropped to the second ranking. A 0.38 significance level was determined for the six statements within the first ranking which leads to the conclusion that a larger sample size could have caused greater segregation amongst the statements.

Table 78: Safety Survey - Central - Maintenance - First

Question No.	Mean	N	F-Value	Significance
3. Closed Cabs for Tractors	2.82	118	1.07	0.38
4. Auto-shutoff for Tractors	2.76	118		
6. Two-way Radio Devices	2.88	120		
8. Availability and Selection of PPE	2.84	119		
14. Lighting for Nighttime Activities	2.79	118		
15. Traffic Citation Enforcement	2.83	116		

Besides statement 2, the second ranking also contains statements 5 and 9 shown in Table 79. An evaluation mean difference of 0.12 was needed to bring the 0.96 significance level to below 0.30 and separate these statements from those found in Table 80 which displays the third ranking.

Table 79: Safety Survey - Central - Maintenance - Second

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.75	119	0.04	0.96
5. Increased Crew Sizes	2.75	120		
9. First Aid Kits and CPR	2.73	118		

Table 80: Safety Survey - Central - Maintenance - Third

Question No.	Mean	N	F-Value	Significance
7. Procedure for Trench Box	2.58	119	0.07	0.93
11. Flagmen Training	2.59	119		
12. Lightweight Flashing Paddles	2.61	120		

The fourth ranking is made up of just the remaining three statements. These statements did not have a great enough difference between their evaluation means to be separated. As Table 81 shows, an evaluation mean difference of 0.02 and a level of significance of 0.98 does not create segregation.

Table 81: Safety Survey - Central - Maintenance - Fourth

Question No.	Mean	N	F-Value	Significance
1. Sensors/Cameras for Blind Areas	2.35	115	0.02	0.98

10. Yearly Physical Exams	2.34	120
13. Portable Rumble Strips	2.36	119

For the eastern maintenance employees' first ranking, statement 9 replaced statement 15 from the central maintenance employees' first ranking. Statement 9, "We need improved availability of first aid kits, as well as more personnel trained in first aid/CPR," also has the lowest evaluation mean of 2.79 within the first ranking. This fact helped to create a level of significance of 0.34 which is just barely above the 0.30 mark.

Table 82: Safety Survey - Eastern - Maintenance - First

Question No.	Mean	N	F-Value	Significance
3. Closed Cabs for Tractors	2.90	160	1.14	0.34
4. Auto-shutoff for Tractors	2.83	160		
6. Two-way Radio Devices	2.86	161		
8. Availability and Selection of PPE	2.83	162		
9. First Aid Kits and CPR	2.79	159		
14. Lighting for Nighttime Activities	2.81	162		

In the second ranking, it was determined that the four statements found in Table 83 did not difference from each other. With a significance level of 0.81, the evaluation mean difference between statements 11 and 15 of 0.05 was not large enough to further separate the statements.

Table 83: Safety Survey - Eastern - Maintenance - Second

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.74	160	0.33	0.81
5. Increased Crew Sizes	2.77	159		
11. Flagmen Training	2.73	162		
15. Traffic Citation Enforcement	2.78	162		

The third and fourth rankings for the eastern maintenance workers contain each two statements. As seen in Table 84 and Table 85, an evaluation mean difference of 0.13 was needed to separate the two groups at or below a 0.30 significance level.

Table 84: Safety Survey - Eastern - Maintenance - Third

Question No.	Mean	N	F-Value	Significance
7. Procedure for Trench Box	2.64	159	0.01	0.93
12. Lightweight Flashing Paddles	2.63	162		

Table 85: Safety Survey - Eastern - Maintenance - Fourth

Question No.	Mean	N	F-Value	Significance
1. Sensors/Cameras for Blind Areas	2.50	161	0.17	0.68
13. Portable Rumble Strips	2.47	162		

When an ANOVA was done on the entire group of 515 maintenance respondents, statements 3 and 6 were determined to be the methods receiving the strongest support amongst the group. Each received approximately the same evaluation mean of 2.85.

Table 86: Safety Survey - Entire State - Maintenance - First

Question No.	Mean	N	F-Value	Significance
3. Closed Cabs for Tractors	2.85	510	0.00	0.96
6. Two-way Radio Devices	2.85	515		

For each of the rankings determined for the KYTC maintenance respondents, a difference of 0.06 or 0.07 was needed to decrease the level of significance enough to be below the 0.30 mark. This fact can be seen in Tables 87 and 88. For example, 2.78, the lowest mean within the second ranking, is 0.06 higher than the highest mean within the third ranking, 2.72.

Table 87: Safety Survey - Entire State - Maintenance - Second

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.78	511	0.21	0.89
4. Auto-shutoff for Tractors	2.79	512		
8. Availability and Selection of PPE	2.78	513		
15. Traffic Citation Enforcement	2.79	509		

Table 88: Safety Survey - Entire State - Maintenance - Third

Question No.	Mean	N	F-Value	Significance
5. Increased Crew Sizes	2.72	513	0.01	1.00
9. First Aid Kits and CPR	2.71	508		
14. Lighting for Nighttime Activities	2.71	510		

Unlike many of the previous fourth rankings, the one for KYTC maintenance employees across the state is occupied by one statement shown in Table 89. Statement 11, “We need increased flagmen training and certification programs. All flagmen should be certified by the state, especially contractor’s flagmen. Also, all maintenance and construction workers should understand basic hand signals,” has an evaluation mean of 2.64 which is 0.04 greater than the next statement. As a result, a 0.25 significance level was determined.

Table 89: Safety Survey - Entire State - Maintenance - Fourth

Question No.	Mean	N	F-Value	Significance
<b>11. Flagmen Training</b>	2.64	513	1.31	0.25
12. Lightweight Flashing Paddles	2.60	512		

### Entire State Statistical Analysis

When looking at all of the responses received from the western part of the state, six statements were determined to be the same and the most agreed upon methods to improve safety. Statement 15, “We need to develop a traffic citation enforcement plan to follow up on citations written in work zones and apply pressure to the judicial system to

enforce all of these. Also, the plan needs to include severe penalties for repeat offenders,” received the highest evaluation mean within the first ranking of 2.81 shown in Table 90.

Table 90: Safety Survey - Western - All - First

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.80	318	0.42	0.80
3. Closed Cabs for Tractors	2.76	318		
4. Auto-shutoff for Tractors	2.80	320		
6. Two-way Radio Devices	2.80	321		
15. Traffic Citation Enforcement	2.81	318		

A significance level of 0.91 was calculated from the four statements located in the second ranking shown in Table 91. From highest to highest, the evaluation mean difference between the second and third rankings, shown in Table 92, was 0.10. This would explain how a level of significance of 0.91 could drop to below 0.30 when statement 5 was included in this group.

Table 91: Safety Survey - Western - All - Second

Question No.	Mean	N	F-Value	Significance
8. Availability and Selection of PPE	2.69	317	0.19	0.91
9. First Aid Kits and CPR	2.69	317		
11. Flagmen Training	2.66	318		
14. Lighting for Nighttime Activities	2.67	316		

Table 92: Safety Survey - Western - All - Third

Question No.	Mean	N	F-Value	Significance
5. Increased Crew Sizes	2.59	320	0.08	0.78
12. Lightweight Flashing Paddles	2.58	316		

Statement 1, “We should use sensors and/or cameras mounted on the rear of equipment and/or vehicles to detect objects in blind areas (mounted as not to distract the operator),” was the only method to make the fourth ranking, seen in Table 93. It separated itself from the remaining three statements with a 0.03 significance level.

Table 93: Safety Survey - Western - All - Fourth

Question No.	Mean	N	F-Value	Significance
<b>1. Sensors/Cameras for Blind Areas</b>	2.47	316	4.76	0.03
10. Yearly Physical Exams	2.34	319		

As in the western first ranking, statements 2, 4, and 15 were also listed in the first ranking for the central respondents. “We need improved lighting for nighttime construction and maintenance activities,” statement 14 which was in the western second ranking, turned out to be the statement with the highest evaluation mean among the central workers with 2.85.

Table 94: Safety Survey - Central - All - First

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.82	290	0.22	0.88
4. Auto-shutoff for Tractors	2.83	286		
14. Lighting for Nighttime Activities	2.85	290		
15. Traffic Citation Enforcement	2.83	290		

For the second ranking, the central respondents moved statement 14 to the first ranking and replaced it with statements 3 and 11. The other three statements, shown in Table 95, were also in the western second ranking. However, with only an evaluation mean difference of 0.03, a 0.97 level of significance was calculated.

Table 95: Safety Survey - Central - All - Second

Question No.	Mean	N	F-Value	Significance
3. Closed Cabs for Tractors	2.75	285	0.14	0.97
6. Two-way Radio Devices	2.77	291		
8. Availability and Selection of PPE	2.75	291		
9. First Aid Kits and CPR	2.74	291		
11. Flagmen Training	2.75	292		

The next two rankings only consist of three statements. In Table 96, the third ranking is made up of statements 7 and 12 with evaluation means of 2.64 and 2.62. With only a slight difference between them, a level of significance of 0.62 was determined from the analysis. In Table 97, statement 5 is the only method listed in the fourth ranking. An almost identical significance level to the one found for the western fourth ranking was found to be 0.03.

Table 96: Safety Survey – Central – All – Third

Question No.	Mean	N	F-Value	Significance
7. Procedure for Trench Box	2.64	287	0.25	0.62
12. Lightweight Flashing Paddles	2.62	293		

Table 97: Safety Survey - Central - All - Fourth

Question No.	Mean	N	F-Value	Significance
<b>5. Increased Crew Sizes</b>	2.54	290	4.92	0.03
10. Yearly Physical Exams	2.42	293		

The first ranking for the eastern respondents contains many of the statements that were located in each of the two previously discussed first rankings. However, statement 8, “We need improved availability and selection of PPE, such as gloves, safety glasses, reflective clothing, hardhats, ear protection, heights protection, foot protection, respiratory protection and weather protection,” has moved from the second ranking where it was for the western and central workers to the first ranking for eastern workers as seen

in Table 98. Such a change was accomplished because statement 8 received an evaluation mean of 2.81.

Table 98: Safety Survey - Eastern - All - First

Question No.	Mean	N	F-Value	Significance
3. Closed Cabs for Tractors	2.82	234	0.58	0.72
4. Auto-shutoff for Tractors	2.84	233		
6. Two-way Radio Devices	2.85	235		
8. Availability and Selection of PPE	2.81	234		
14. Lighting for Nighttime Activities	2.78	235		
15. Traffic Citation Enforcement	2.80	235		

Even with a sample size of 235, the first and second rankings appeared to be very congested. In Table 99, the second ranking contains five statements with evaluation means ranging from 2.65 to 2.74. The effect of such a wide range can be seen in the 0.46 significance level.

Table 99: Safety Survey - Eastern - All - Second

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.72	233	0.90	0.46
5. Increased Crew Sizes	2.73	233		
7. Procedure for Trench Box	2.65	233		
9. First Aid Kits and CPR	2.74	232		
11. Flagmen Training	2.72	235		

Instead of the fourth ranking like for the western and central areas of the state, the third ranking for the eastern portion of the state contains only statement 12. It was able to be by itself because the next closest statement, number 13 shown in Table 101, has an evaluation mean of 2.48, which is 0.15 less than the mean for statement 12 as shown in Table 100.

Table 100: Safety Survey - Eastern - All - Third

Question No.	Mean	N	F-Value	Significance
<b>12. Lightweight Flashing Paddles</b>	2.63	235	5.25	0.02
13. Portable Rumble Strips	2.48	234		

Table 101: Safety Survey - Eastern - All - Fourth

Question No.	Mean	N	F-Value	Significance
1. Sensors/Cameras for Blind Areas	2.45	231	0.23	0.63
13. Portable Rumble Strips	2.48	234		

With 890 respondents across the entire state, an evaluation mean difference greater than 0.03 was enough to separate statements into each of the four rankings. Four statements make up the first ranking for the entire state. Statements 4 and 15 have the highest evaluation mean of 2.82 as seen in Table 102.

Table 102: Safety Survey - Entire State - All - First

Question No.	Mean	N	F-Value	Significance
2. Alternating Back-up Alarms	2.79	884	0.84	0.47
4. Auto-shutoff for Tractors	2.82	882		
6. Two-way Radio Devices	2.80	890		
15. Traffic Citation Enforcement	2.82	885		

In Table 103, the two statements that make up the second ranking have almost identical evaluation means of 2.77. Such a similarity can be seen in the significance level of 0.87.

Table 103: Safety Survey - Entire State - All - Second

Question No.	Mean	N	F-Value	Significance
3. Closed Cabs for Tractors	2.77	880	0.03	0.87
14. Lighting for Nighttime Activities	2.77	883		

Third and fourth rankings for the entire state each have three statements. In Table 104, the third ranking contains statements 8, 9, and 11. Statement 8 has the highest evaluation mean within the ranking of 2.74. In Table 105, the fourth ranking consists of statements 5, 7, and 12. Statement 7, “We need a well known and understood Standard Procedure for how to obtain a trench box when needed,” with its evaluation mean of 2.61 is the highest of the fourth ranking, the final ranking to be discussed.

Table 104: Safety Survey - Entire State - All - Third

Question No.	Mean	N	F-Value	Significance
8. Availability and Selection of PPE	2.74	885	0.36	0.70
9. First Aid Kits and CPR	2.72	883		
11. Flagmen Training	2.71	888		

Table 105: Safety Survey - Entire State - All - Fourth

Question No.	Mean	N	F-Value	Significance
5. Increased Crew Sizes	2.60	886	0.10	0.91
7. Procedure for Trench Box	2.61	878		
12. Lightweight Flashing Paddles	2.60	887		

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