Integrated Risk Management for Improving Internal Traffic Control, Work-Zone Safety, and Mobility during Major Construction

CMAT
CONSTRUCTION MANAGEMENT
AND TECHNOLOGY

Final Report
October 2012

SWZDI
Smart Work Zone Deployment Initiative

IOWA STATE UNIVERSITY
Institute for Transportation

Sponsored by
Smart Work Zone Deployment Initiative (TPF-5(081))
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(InTrans Project 11-400)

About CMAT

The mission of the Construction Management and Technology (CMAT) Program is to improve the efficiency and cost-effectiveness of planning, designing, constructing, and operating transportation facilities through innovative construction processes and technologies.

About SWZDI

Iowa, Kansas, Missouri, and Nebraska created the Midwest States Smart Work Zone Deployment Initiative (SWZDI) in 1999 and Wisconsin joined in 2001. Through this pooled-fund study, researchers investigate better ways of controlling traffic through work zones. Their goal is to improve the safety and efficiency of traffic operations and highway work.

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INTEGRATED RISK MANAGEMENT FOR IMPROVING INTERNAL TRAFFIC CONTROL, WORK-ZONE SAFETY, AND MOBILITY DURING MAJOR CONSTRUCTION

Final Report
October 2012

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- Iowa (lead state)
- Kansas
- Missouri
- Nebraska
- Wisconsin

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EXECUTIVE SUMMARY

Problem Statement

Construction work zones are among the most dangerous places to work in any industry in the world. This is because many factors in construction, such as constant change in working environments and driver errors, contribute to a workplace with a higher number of accidents, injuries, property damage, and other losses when compared to other industries. Construction safety practices are essential to preventing loss on a job site and should be monitored during every project stage.

Background

Regulatory agencies such as the federal Occupational Safety and Health Administration (OSHA) have efforts to prevent unsafe work conditions, but regulatory agencies can only inspect a small percentage of job sites due to lack of resources. Therefore, safety agencies have expanded to the state level within the last 20 years. Local departments of transportation (DOTs) are also tasked with keeping statistical data to communicate safety trends within their own states and districts.

In addition to construction safety, work-zone mobility has a major effect on the safety of any highway construction job site and continues to be a topic of conversation for Iowa, Iowa DOT officials, utility companies, and contractors.

Highway construction sites differ from other construction sites in exposure to the traveling public, construction traffic, and heavy equipment. The safety of workers and project work zones are affected by nearly every person who is involved in the project. Managers and officials are tasked with developing site layouts and laborers and operators are held responsible for executing those plans. Without efforts from every individual level in the construction process, safety may be compromised.

To increase safety efforts, many perspectives must be considered to describe what is actually happening on job sites. A single set of data, in this case, will not suffice because of the nature of a highway construction site. It is very difficult to normalize data, make inferences on small sample sizes, and base policy on any one set of findings.

Several types of quantitative as well as qualitative assessments were performed in this study. Common conclusions that were discovered between multiple assessments allows for stronger conclusions, especially when a quantitative analysis is able to support a qualitative claim by experts.

Work-zone safety, mobility, and internal traffic control are addressed by nearly every state DOT and many policies are available for review in the Federal Highway Administration (FHWA) databases. Even with this accumulation of significant information, highway construction is still one of the most dangerous industries in the US.

Research Objectives

The objective of this research was to investigate the application of integrated risk modeling to internal traffic control and contractor operations in construction work zones. The ultimate goal is to reduce frequency and intensity of loss events related to equipment movement and contractor operations in and around construction work zones.

Research Methodology

Prior research funded by the Midwest Transportation Consortium (MTC) determined that using an integrated risk model could identify and mitigate potential hazards in construction work zones. Specifically, the integrated risk model could be adapted and expanded for use as a tool in managing internal traffic control, equipment movement and processes, and contractor operations more effectively.

To achieve the overall objective, the research team first did the following:

- Identified potential risk factors
- Evaluated loss severity
- Identified risk mitigation strategies that can be used to reduce losses

Justification for Mixed-Methods Research Approach

A mixed-methods approach was chosen given there are many difficulties that were encountered when setting up avenues to gather information that would help produce an outline of how activities on highway construction affect safety.

Qualitative and quantitative analyses were performed simultaneously with the intention of using each type to confirm or deny claims from the other method of research.

The quantitative research methods in this study included OSHA and Iowa OSHA statistics and analysis along with Iowa DOT crash database queries and analysis.

Qualitative research methods included the analysis of crash narratives, personal interviews with a range of construction personnel, an ingress and egress in construction work zones survey, and a work zone pilot project.

Literature Review

The literature review revealed many different ways to mitigate risk on highway construction projects. On a project level, workers and operators can train to be more aware of potentially-dangerous situations. On a city planner level, construction zones can be mapped and tracked to help mitigate effects of conflicting work zones.

The focus of this research project is to help mitigate risk on a project and managerial level. Policies and planning to help reduce risk and safety-related problems on these levels are of primary concern and are detailed in the final report.

Qualitative Assessments

To form a platform to conduct research on internal traffic control, work-zone safety, and mobility, a technical advisory committee (TAC) was formed. The TAC members are considered experts in highway construction and maintenance operations, represent various levels of management, and include local district managers and engineers.

Quantitative Assessments

Human factors, in certain instances, can be measured and looked at quantitatively. The Iowa DOT maintains a crash database in which reporting officers from each jurisdiction submit incident forms for crashes. Each incident form that is filed has a multitude of variables that are considered when describing the incident.

Database variables that were considered relevant to this study include vehicle configuration, whether the incident was work-zone related, and the location of the incident within the work zone.

Statistics were broken down into a spreadsheet of each variable according to its “Case Number” and a random sample of the cases was further investigated by reviewing the narratives of the sample cases to look for any trends that were not identified in the crash database statistics.

The narratives for each case provide a detailed description of the incident. Items that cannot be conveyed in the numerical data were included. Some examples of items that are included in these narratives are relative locations of vehicles, locations of exit and entrance ramps, and any other descriptive information that the reporting officer felt was important to the incident. This information could only be used as a qualitative or descriptive statistic and, like information provided by the TAC, would be used only to guide further investigations.

Data that were published by OSHA and Iowa OSHA were also carefully considered in this study. Two sets of data are published by OSHA and Iowa OHSA each year. The first dataset includes recordable case counts for each type of industry and the second dataset includes incident rates for each type of industry. The incident rates are used in this study because they display a relative statistic that can be compared to national rates and rates that are achieved by other states.

All of the statistical data considered in this study were obtained by means of empirical research. The most recent available data for OSHA and Iowa OSHA was 2010 and, for the Iowa DOT crash database, 2011. No means of theoretical research was considered in this study.

Pilot Project

A pilot project was used in this study. The goal of the pilot project was to gain more insight as to how changes are performed within traffic control, how work-zone mobility concerns are addressed, and how these items fit the “best practices” that are identified throughout this study.

The pilot project that was identified for this study was the Interstate 29 Expansion and Improvement project located in Sioux City, Iowa. Overall, the project includes widening the current interstate roadway, replacing several entry and exit ramps, and replacing several bridges. The focus of our study covers the Segment 1 portion that includes the widening of the current interstate system from four lanes to six lanes.

Key Findings

OSHA and Iowa OSHA

Based on the data provided by OSHA and Iowa OSHA, incident rates were compared using a linear regression model and an analysis of variance was performed for both sets of data. Given the category of highway, street, and bridge construction has a relatively small sample size for the total annual employment for Iowa, statistical variation was high in the Iowa data. Given a much larger population size is used for national incident rates, Iowa statistics can be compared to the linear model developed in this study.

In more than half the years included in the study, Iowa has had a higher incident rate in every major statistical category. These findings indicate that, due to many factors, Iowa is often a statistically more dangerous state to work in highway construction than the national average.

This finding could be due to many factors, such as extreme weather conditions in both summer and winter, types of construction projects performed, or types of safety programs that are implemented. The exact factors causing the higher rate are not able to be identified in this study alone and are likely a source for future research.

One positive that can be identified is that models for both Iowa and national incident rates are downward sloping. The model for total recordable cases offers the best evidence that overall incident rates for Iowa are improving from year to year. The linear models also display similar slopes in the downward trends for each analysis that was performed.

Iowa DOT Crash Database

The Iowa DOT crash database provided a way to categorize incidents that are considered by a reporting officer to be work-zone-related:

Zone 1 – Before advanced warning sign
Zone 2 – Between advanced warning sign and lane shift
Zone 3 – Within lane shift
Zone 4 – Within work zone
Zone 5 – Outside of work zone

The TAC anticipated that the Zone 3 lane shift category was the cause for the most incidents and the most problematic area for heavy equipment. However, with the database query, the research team found not much difference between the number of incidents associated with Zones 2 and 3. Zone 2 had 42 incidents and Zone 3 had 37 incidents.

The significant majority of incidents occurring for heavy equipment are in Zone 4, accounting for 139 of the 229 total incidents. Zones 1 and 5 accounted for the fewest incidents for heavy equipment, but still account for 19 of the 229 total incidents.

The discrepancy between the experiences of the expert panel and the data provided by the Iowa DOT crash database serve as conflicting information in this study. In this case, further examination must be considered when analyzing these data.

The discrepancy could be a due to many different factors. One possible contributing factor to the conflicting evidence is that reporting officers may not be identifying the Iowa DOT-defined zones in which a work-zone-related incident is occurring consistently or correctly. Training procedures on filling this section of the incident form may not be consistent between jurisdictions.

Another source of variance from the reporting officer may be that, given each highway construction project is unique, it would be difficult to identify comparable zones for each highway project.

Another likely factor for the significant majority of the incidents that occur in Zone 4 is the amount of exposure that the traveling public has in this zone. In a particularly long work zone, the relative sizes of Zones 3 and 4 may be drastically different. Zone 4 may not be any more dangerous than Zone 3 but, simply because Zone 4 accounts for a higher percentage of the overall job site length, it will have more incidents associated with it. This factor was identified as the most likely source of the discrepancy between expert panel experience and statistical data.

Incident Reports

Due to the conflicting evidence presented by the TAC and the Iowa DOT crash database, individual incident narratives were analyzed to supplement previous evidence. These individual reports included detailed information about each incident.

Within these narratives, it became clear that the Iowa DOT zone in which each incident occurred was not the only cause that leads to each incident. From the narratives, it became clear that the types of incidents that were occurring may be just as critical as the location in which they are happening.

For example, merging traffic in Zone 3 may cause traffic well beyond Zone 3 and into Zone 2 to form a large queue. This line up of vehicles could then potentially lead to an incident that occurs in Zone 2 but, in effect, is an incident caused by activity in Zone 3. This situation is not accounted for in the classification of the location of the incident in the crash database. The data pointed toward many of the incidents being caused by a typical Zone 3 activity.

The most relevant information that would need to appear in future incident reports is the location of the cause of the incident. This would allow for the analysis for the types of incidents to coincide directly with the location of the cause of the incident rather than the location of the incident itself.

Ingress and Egress Survey

Through the assessment of the Ingress and Egress Survey, several conclusions can be made about addressing concerns on ingress and egress points on highway construction sites. Given all except one respondent was a DOT respondent from either Iowa or a surrounding state, inferences can only be made about the owner's view of ingress and egress safety.

For the "closed" work zone, combining the counts for upgrade/additional equipment, markings and using correct, clean, and undamaged traffic control devices, nearly half of the responses address use of some type of equipment. Owners, and particularly inspectors, reported that improper use of traffic control equipment can be a major contributor that causes confusion for truck drivers, equipment operators, and the traveling public alike. Additional equipment and upgrading equipment often comes in the form of signage, arrow boards, message boards, and any other additional equipment that a contractor can provide to either protect the job site or communicate with the traveling public.

This assessment is supported by the insights provided by the traffic control contractor in the personal interviews. In their previous experience, the more devices that are provided to grab the attention of drivers in either a divided highway or interstate highway construction project, the more aware that drivers will be and, in turn, the safer the project will be.

The second major category of responses for the survey addressed problems with ingress and egress by means of either extending distances for ingress and egress, so that drivers and operators are able to accelerate or decelerate, or providing an alternate route that is less congested by the traveling public. If either of these techniques can be implemented on a project, they would certainly improve the interactions that truck drivers have with the traveling public. Not only can the safety of ingress and egress be improved by using alternate routes, items such as alternative delivery methods can be assessed on a project-specific basis to help minimize interactions and incidents involving the traveling public.

Many of the individual responses were very similar for addressing ingress and egress safety improvement from the survey with one exception. Many of the respondents provided many more unique answers for the "open" work zone. Individual answers did not agree as strongly on the "open" work zone improvements when compared to the "closed" work zone improvements.

Typical "closed" work zones are often set up in a very similar manner from project to project. The same types of channeling devices, barriers, and other traffic control devices are used in most “closed” work zones and standard traffic control plans are easier to implement. With an “open” work zone, many more unique situations that require an adapted traffic control plan are required.

Developing the Job-Site Communication Model

Through the solicitation of personal interviews and the insight provided by the TAC, a Lines of Communication Model was developed.

More specifically, job-site communication models are a concept derived in this study from the combination of the interview with the ready mix plant operator and the common theme of effective communication that was found in the qualitative data collection interaction.

Included in the model are the roles of DOT officials, project managers, project forepersons, plant operators, equipment dispatchers, and equipment operators. Solid lines represent primary lines of communication and dashed lines represent secondary lines of communication.

In all highway construction projects, it is essential that lines of communication are thoroughly established and open. Conflicts often arise from parties not knowing whom to contact, or parties not forwarding relevant information to the proper people. Because of the volatility and ever-changing conditions of a job site, it must be noted that each model that is developed for a project must be flexible and adaptable to changes.

It is the responsibility of project managers and project forepeople to receive input from all relevant parties included in the operation. Ideally, models would be developed with specific names of personnel, their contact information, and a secondary contact in case the primary contact is not available.

Implementation Readiness and Recommendations

Implementation of recommended risk mitigation processes and strategies will be the responsibility of the Iowa DOT and/or other transportation agencies. The possible mitigation techniques were developed as a part of the pilot project by using field observations and interviews with pilot project personnel.

- OSHA and Iowa OSHA data should be used as a basis to compare safety on a statewide and national level. Metrics are difficult to provide within individual states; however, individual states should compare incident rates to national averages and push to keep the trend of decreasing incident rates. Iowa, in the past 15 years, has not proven to have lower incident rates than the national average and more often than not have reported statistically higher incident rates than the national average.
- The Iowa DOT crash database has been an effective tool in analyzing incidents that are work-zone-related. At this time, incidents in the Iowa DOT Zone 4 within the work zone represent by far the highest percentage of incidents as far as location is concerned. Although this can be for a number of reasons, it represents the most problematic area with regards to

how contractors interact with the traveling public.

- The methods in which reporting officers identify the location of an incident within the Iowa DOT's defined Zones 1 through 5 in a work zone should be reviewed to ensure not only consistency in reporting, but also reporting of the Zone in which the cause of the incident occurred. In addition, the manner in which crash narratives are filled out for each incident is essential to identifying the major causes of each incident. Consistency is of the upmost importance when trying to normalize this data.
- Ingress and egress areas on construction job sites, as expressed by the TAC and during personal interviews, represent the most challenging areas to address work-zone safety and mobility. Although these areas do not represent the highest frequency of incidents, they were cited consistently by contractors, truck drivers, and Iowa DOT personnel throughout this study as the most difficult areas to control. Additional measures in preconstruction planning could provide additional work-zone safety and serve as a time to discuss alternate methods of ingress and egress. This planning can be done not only for vehicles, but for material deliveries as well.
- Personal interviews with experts of various technical backgrounds are essential to formulate the basis of highway construction research. Given highway construction is such a dynamic industry subjected to so many unique project-level difficulties, it is difficult to normalize data. A mixed-methods approach, where qualitative assessments are used, is valuable to confirm conclusions that are found. These same methods should also be used to identify and address discrepancies between common conceptions of highway construction safety and conclusions that statistical data provide.
- Effective job-site communication was a theme that was encountered in almost every stage of this research project. More specifically, the individual interactions between plant operators, dispatch, forepersons, and drivers are the most crucial interactions that pertain to on-the-job work-zone safety and internal traffic control. To support these interactions, effective training programs and project-specific communication models should be developed so that roles and responsibilities of each party are clear.
- Per the pilot project, contractors have the ability to make major changes to internal traffic control plans as well as address how work-zone vehicles interact with the traveling public. Alternative plans, although not always implemented, should always be considered if a potential for improvement in safety, productivity, or cost-effectiveness can be realized. Construction means and methods should be analyzed comparatively with the ability of contractors as well as DOT officials to be flexible in implementing traffic control plans.

Research Limitations

The Conclusions chapter details limitations of this research project.

Possible Future Research

Future research is often identified by the limitations or findings of previous research. Work-zone safety, mobility, and internal traffic control comprises a vast spectrum of topics that involve wide varieties of personnel, all of whom have an effect on project success. This project was framed around personal interviews with expert panel members and the analysis of general statistical data.

Normalizing Iowa DOT crash data with relation to mileage would be an important statistical backing feature that would help eliminate some of the ambiguities presented by the findings in this study.

Data for Zones 1 through 5 of the work zone are difficult to compare given relative lengths are extremely different within each zone and are unique to each job site. Normalizing this data would include collecting data that indicates the length of each zone for either every highway construction project or a representative sample of every highway construction project performed in a given year. Having this data would help to confirm or deny specific claims about which Iowa DOT Zone is the most dangerous and problematic for highway contractors.

An investigation in how reporting officers classify work-zone-related incidents would be valuable to perform, as well, given the discrepancies discovered in this study. Inconsistencies in how each Iowa DOT Zone is identified in individual incident reports may be a cause of some of the conflicting evidence in how work-zone-related incidents are reported.

A second source of inconsistencies lies in the way reporting officers fill out incident narratives. In certain cases, a very thorough narrative was discovered and the cause of the incident was very easy to identify and assign a classification. However, on the other end of the spectrum, a narrative was not provided for certain incidents at all, which led to the inability to classify the incident. Without consistent reporting from all jurisdictions, it is difficult to normalize data and therefore is difficult to analyze data statistically because of these limitations.

An extensive program-level safety implementation project would likely be of interest to build on the findings of this project. For example, a project related solely to ingress and egress on construction sites could provide research topics for future studies. From program-level implementation, a standardized mentoring program for drivers, operators, and laborers could also be explored.

1. INTRODUCTION

1.1. Overview

Construction work zones are among the most dangerous places to work in any industry in the world. This is because many factors in construction, such as constant change in working environments and driver errors, contribute to a workplace with a higher number of accidents, injuries, property damage, and other losses when compared to other industries. Construction safety practices are essential to preventing loss on a job site and should be monitored during every project stage.

Regulatory agencies such as the federal Occupational Safety and Health Administration (OSHA) have efforts to prevent unsafe work conditions, but regulatory agencies can only inspect a small percentage of job sites due to lack of resources. Therefore, safety agencies have expanded to the state level within the last 20 years. Local departments of transportation (DOTs) are also tasked with keeping statistical data to communicate safety trends within their own states and districts.

In addition to construction safety, work-zone mobility has a major effect on the safety of any highway construction job site and continues to be a topic of conversation for Iowa, Iowa DOT officials, utility companies, and contractors.

Highway construction sites differ from other construction sites in exposure to the traveling public, construction traffic, and heavy equipment. The safety of workers and project work zones are affected by nearly every person who is involved in the project. Managers and officials are tasked with developing site layouts and laborers and operators are held responsible for executing those plans. Without efforts from every individual level in the construction process, safety may be compromised.

To increase safety efforts, many perspectives must be considered to describe what is actually happening on job sites. A single set of data, in this case, will not suffice because of the nature of a highway construction site. It is very difficult to normalize data, make inferences on small sample sizes, and base policy on any one set of findings.

Several types of quantitative as well as qualitative assessments were performed. Common conclusions that were discovered between multiple assessments allows for stronger conclusions, especially when a quantitative analysis is able to support a qualitative claim by experts.

Work-zone safety, mobility, and internal traffic control are addressed by nearly every state DOT and many policies are available for review in the Federal Highway Administration (FHWA) databases. Even with this accumulation of significant information, highway construction is still one of the most dangerous industries in the US.

1.2. Research Objectives

The objective of this research was to investigate the application of integrated risk modeling to internal traffic control and contractor operations in construction work zones. The ultimate goal is to reduce frequency and intensity of loss events related to equipment movement and contractor operations in and around construction work zones. To achieve the overall objective, the research team first did the following:

- Identified potential risk factors
- Evaluated loss severity
- Identified risk mitigation strategies that can be used to reduce losses

Implementation of recommended risk mitigation processes and strategies will be the responsibility of the Iowa DOT and/or other transportation agencies. The possible mitigation techniques were developed as a part of the pilot project by using field observations and interviews with pilot project personnel.

1.3. Research Background

Prior research funded by the Midwest Transportation Consortium (MTC) determined that using an integrated risk model could identify and mitigate potential hazards in construction work zones. Specifically, the integrated risk model could be adapted and expanded for use as a tool in managing internal traffic control, equipment movement and processes, and contractor operations more effectively.

This research examines how an integrated risk model approach could be used as a tool for reducing exposure to hazards associated with internal traffic control and contractor operations on major projects in Iowa.

2. LITERATURE REVIEW

The literature review revealed many different ways to mitigate risk on highway construction projects. On a project level, workers and operators can train to be more aware of potentially-dangerous situations. On a city planner level, construction zones can be mapped and tracked to help mitigate effects of conflicting work zones.

The focus of this research project is to help mitigate risk on a project and managerial level. Policies and planning to help reduce risk and safety-related problems on these levels are of primary concern.

2.1. Internal Traffic Control and Worker Safety

The Roadway Safety Alliance (RSA) cited that the number one cause of worker fatality in the work zone is the backing of vehicles (The Roadway Safety Alliance 2008). There are several reasons why this is occurring. The RSA cites that the included safety measures such as back-up alarms are not always able to prevent incidents with pedestrian workers. This can be caused by alarms that are not working or a noisy job site that has alarms on several pieces of equipment so that workers cannot identify where vehicles are within their vicinity because of the multiple sound sources.

The Laborers' Health and Safety Fund of North America (LHSFNA) reported that highway construction had high rates of fatal injuries in highway construction compared to other construction activities and to all other industries zones (Laborers Health and Safety Fund of North America 2004). This same report also found that backing equipment, particularly dump trucks, accounted for half of the fatalities of pedestrian workers in work zones.

In Iowa, there are an average of 6.5 deaths per year, 136 injury crashes, and 224 property damage only (PDO) crashes, totaling an average of 366 work-zone crashes per year. Ninety percent of Iowa work-zone fatalities are motorists (Shane et al. 2009).

Effective internal traffic control plans (ITCPs) may help prevent deaths and injuries inside the work zone. The LHSFNA explored the dangers of internal hazards in work zones. They found that just as many workers were being injured or killed by incidents within the work zone as by the traveling public (Laborers Health and Safety Fund of North America 2004). When developing an ITCP, the following should be considered:

- Reduce the need for vehicles to back up
- Limit the access points to the job site or work zone
- Establish work-zone layouts according to the type of equipment involved
- Provide signs within the work zone to guide workers, equipment, and trucks
- Design buffer spaces to protect pedestrian workers from errant vehicles or equipment

The Roadway Safety Alliance also in their 2008 publication helped to develop a simple template for developing traffic control plans. Included in it are sample ITCPs for using spotters effectively, types of signage that should be used within the work zone, and also plans that specify exact No Pedestrian Zones to help prevent incidents between workers that are on the ground and mobile equipment. Not only are there No Pedestrian Zones included in these plans, several plans are shown with No Motor Vehicle signs as well to help designate safe areas for pedestrian workers.

2.2. Developing the Internal Traffic Control Plan

The responsibility of developing the ITCP lies with the contracting agency on the project. Guidelines for developing an ITCP include the following:

- The ITCP is developed by one or more members of the contracting staff and should be part of the overall project safety plan
- The ITCP should be prepared after the contract is awarded but prior to the start of construction
- The safety officer, if qualified, should be in charge of the development of the ITCP
- This officer should meet the OSHA requirements of a "competent person" (Graham et al. 2005)

Establishing personnel and their responsibilities, along with identifying common strategies that can be used on projects, is very important and can lead to consistent internal traffic control planning. However, on significant multi-year projects, a much larger framework must be developed to ensure safe and consistent practices.

Significant repair and replacement projects in Oregon have led Oregon DOT (ODOT) officials to re-think the process of developing traffic management plans (TMPs) for their highway and bridge construction projects. Given there was a large overhaul of highway systems that would affect major travel routes, freight travel became a significant priority in ODOT TMPs.

In the past, ODOT first designed projects and then addressed traffic control and mobility. In their new approach, ODOT considers mobility conflicts in the same way that it addresses environmental issues, by addressing problems throughout the design process (Oregon Department of Transportation 2011).

ODOT has developed TMPs on three different levels to address mobility problems:

- Program-Level: Address traffic management at higher levels and provide a framework for the corridor-level TMPs
- Corridor-Level: Traffic plans that are developed for specific key freight and major travel routes and if delay thresholds are exceeded, major reviews of staging, scheduling, and traffic management strategies are conducted
- Project-Level: Used to address problems on single projects, developed based on individual project details, and also used to coordinate multiple projects in a localized area

When evaluating internal traffic control and work-zone mobility it is important to identify practices and research within policies and procedures of governing bodies. Items such as processes in internal traffic control changes, addressing concerns and updating the Manual on Uniform Traffic Control Devices (MUTCD), and work-zone safety and mobility reviews are the key to addressing an ever-evolving highway construction zone.

Several provisions were made to the MUTCD (2003 Edition) to address mobility concerns. Included in the provisions were "E. Activity Area – Planning the internal work activity area to minimize backing-up maneuvers of construction vehicles should be considered to minimize exposure to risk." and "F. Worker Safety Planning – A competent person designated by the employer should conduct a basic hazard assessment for the work site… (to) determine whether engineering, administrative, or personal protection measures should be implemented." These provisions were made to address risks that were not identified specifically with regards to internal traffic control and worker mobility already (Graham et al. 2005).

A competent person is defined by ODOT and OSHA alike in that they should be "one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them" (OSHA 2012).

The Midwest Research Institute published a six-step ITCP development guide to address concerns in asphalt paving that can also be applied to other highway work-zone operations:

1. Review contract documents and model plans
2. Determine construction sequence and choose phases having site-specific ITCPs
3. Draw the basic work area layout
4. Plot pedestrian and vehicle paths
5. Locate utilities, storage, and staging areas
6. Prepare internal traffic control plan notes

Also conducted in this 2005 study were observations of paving operations. Conclusions derived from these operations include the following:

- The ITCP is a graphical method to inform vehicle operators and pedestrian workers of hazards inside the work area. The provision of an ITCP would have reduced hazards and observed conflicts at all four paving sites observed.
- A competent person was not available during all paving operations. The safety officer either was absent or visited the site for a very short time.
- Safety plans were generic and not specific to any of the sites.
- Truck drivers were often confused about how to access the site and most could not communicate with spotters, forepersons, or plant operators.
- At one site, material trucks and other services vehicles operated at relatively high speeds, even at night with little illumination.
- There was no reliable method of controlling the rate of truck arrivals at the work site.
- Lock-out, tag-out procedures were not always observed.

As developments occur and concerns are addressed on a national scale, individual state DOTs are always implementing new technologies to help improve work-zone interactions. A few of the most-innovative technologies that have been very effective are ones that help contractors and utility workers coordinate work.

The City of Baltimore, Maryland has implemented a software-based system to help reduce impacts on construction projects that affect the traveling public's right-of-way. The system they used was implemented over a two-year period and provides real-time information on infrastructure projects around the city (City of Baltimore 2011).

Included in the software are maps that show key details such as scope, location, schedule, costs, and major points of contact for individual projects. Three major stakeholders were included when addressing the needs of the system: Mayor's Office, City of Baltimore staff, and utility companies.

Benefits that were found in implementation included the following:

- Stakeholder engagement was improved: Awareness of each of the parties involved in all of the projects was vastly increased and with information provided proactively, there is less time wasted in trying to make individuals aware of project information
- Awareness of project impacts and enhancement of TMPs: The city is able to better predict impacts of construction because of the early identification of project details
- Increased data quality: Stakeholders are willing to contribute data from their own systems to better manage Baltimore's infrastructure network
- Longer pavement life: Reduction of the number of pavement cuts has led to an increase in pavement quality and significant cost savings have been realized in the form of better coordinated work, which allows for more seamless production

As of October 2011, the New York City DOT (NYCDOT) began using an online construction mapping system, guidance manuals, and incentive programs to help improve coordination of construction (New York City Department of Transportation 2011).

Agreements were established on the monthly sharing of data between contractors, utilities, and the city. These data include all active NYCDOT street excavation permits, NYC's list of "protected streets," and the NYCDOT roadway resurfacing schedule, which includes short-term utility needs and long-term utility project schedules.

The information is shared on the city's public online map called NYCityMap, which allows utility companies and contractors alike to identify current construction projects to coordinate work better.

The Pennsylvania DOT (PennDOT) is implementing technologies similar to those being used in Baltimore and New York City. Allegheny County was the first in the state to use mapping of construction projects to help coordinate efforts in both construction and utility work (Envista

2009). This system has helped warn DOT officials of potential conflicts of concurrent construction projects and has helped prevent many instances of re-work. This software is called Envista and is currently used in Baltimore, Colorado Springs, Sacramento, and Providence (Rhode Island).

2.3. Iowa DOT Work-Zone Safety and Mobility Process Review

A process review was conducted to address potential concerns with Iowa DOT Work Zone Policy with regards to 630 Subpart J (Work-Zone Safety and Mobility), 630 Subpart K (Temporary Traffic Control Devices), and 634 (Worker Visibility). In a 2011 survey, of 52 states/divisions, 85 percent had conducted a similar work-zone process review since 2009.

The final report was completed on September 7, 2010. Following are the findings of the review and the proposed solutions:

1. After reviewing existing TMPs, it appears some district and central office staff need assistance in developing effective TMPs for significant projects.

   Solution: The Division Office requested assistance from the Office of Transportation Operations and training workshops were conducted May 18-19, 2010 in eastern Iowa and May 20-21, 2010 in central Iowa.

2. After receiving TMPs from district offices, it appears that there is no format for Iowa DOT staff to aid in the development of comprehensive TMPs for significant projects.

   Solution: A draft TMP template will be piloted on projects in December 2010 with a final template in place by April 2011.

3. Some TMPs were created but the electronic copies were not able to be located when requested. The Iowa DOT does not have a standardized electronic storage location for significant project files, including TMPs and supporting documentation.

   Solution: The Information Technology Division will add folders under the project directory folders on the local area network (W: drive) for significant project files, including TMPs and supporting documentation by January 2011.

4. While exceptional training is provided to those who install, maintain, and inspect temporary traffic control in the field, training for those who design temporary traffic control plans is not available.

   Solution: ATSSA’s Traffic Control Supervisor course will be brought in for Iowa DOT employees and others who instruct the work-zone safety workshops by January 2011. ATSSA’s Traffic Control Design Specialist course will be brought in from Iowa DOT staff and consultants involved in the design of temporary traffic control plans by May 2011.

As listed above, suggested resolutions to the findings were identified and were to be implemented by early to late 2011. The FHWA Iowa Division has worked closely with the Iowa DOT in resolving the above issues.

3. METHODOLOGY

3.1. Qualitative Assessments

To form a platform to conduct research on internal traffic control, work-zone safety, and mobility, a technical advisory committee (TAC) was formed. The following Iowa DOT staff members were included: Mark Bortle, Doug Clark, Dean Herbst, Mark Jackson, Dwight Jenkins, Roxanne Seward, John Smythe, and Dan Sprengler. These individuals are considered experts in highway construction and maintenance operations, represent various levels of management, and include local district managers and engineers.

Also included in the TAC were three representatives from contracting agencies: Steve Jackson, president of Cedar Valley Corp.; Craig Hughes, vice president of Field Operation for Cedar Valley Corp.; and Robert Cramer, president of Cramer and Associates, Inc.

The TAC supported the research team in initial research direction, provided further insight into highway construction, reviewed initial findings, and provided feedback. The committee was gathered on two separate occasions and was consulted throughout the project on incremental findings of this study.

Personal interviews were conducted with construction personnel ranging from Iowa DOT staff to heavy equipment operators. The people who were interviewed included Jason Hankins, project manager for Cedar Valley Corp.; Jeff Koudelka, vice president of Iowa Plains Signing Inc.; Roxanne Seward, traffic technician for District 3 of the Iowa DOT; and Dave Webb, plant operator for Central Iowa Ready Mix. These individuals were identified by the TAC as relevant sources to provide insight to job site conditions and how they relate to work-zone safety and mobility.

The types of interviews conducted were Informal Conversation Interview and General Interview Guide. These two interview types were best suited due to the range of construction experience of those interviewed and the differing topics that were covered in each interview. (Standardized, Open-Ended Interview and Closed, Fixed-Response Interview types were not used, given it was not intended to compare results to a standardized set of questions. These two styles of interview are also not conducive to follow up questions, which were essential in the interview process.)

3.2. Quantitative Assessments

Human factors, in certain instances, can be measured and looked at quantitatively. The Iowa DOT maintains a crash database in which reporting officers from each jurisdiction submit incident forms for crashes. Each incident form that is filed has a multitude of variables that are considered when describing the incident.

Database variables that were considered relevant to this study include vehicle configuration, whether the incident was work-zone related, and the location of the incident within the work zone. These variables and their descriptions are included in Appendix A.

Statistics were broken down into a spreadsheet of each variable according to its "Case Number" and a random sample of the cases was further investigated by reviewing the narratives of the sample cases to look for any trends that were not identified in the crash database statistics.

The narratives for each case provide a detailed description of the incident. Items that cannot be conveyed in the numerical data are included. Some examples of items that are included in these narratives are relative locations of vehicles, locations of exit and entrance ramps, and any other descriptive information that the reporting officer feels is important to the incident. This information then can only be used as a qualitative or descriptive statistic and, like information provided by the TAC, would be used only to guide further investigations.

Data that were published by OSHA and Iowa OSHA were also carefully considered in this study. Two sets of data are published by OSHA and Iowa OHSA each year. The first dataset includes recordable case counts for each type of industry and the second dataset includes incident rates for each type of industry. The incident rates are used in this study because they display a relative statistic that can be compared to national rates and rates that are achieved by other states.

All of the statistical data considered in this study were obtained by means of empirical research. The most recent available data for OSHA and Iowa OSHA was 2010 and, for the Iowa DOT crash database, 2011. No means of theoretical research was considered in this study.

3.3. Pilot Project

A pilot project was used in this study. The goal of the pilot project was to gain more insight as to how changes are performed within traffic control, how work-zone mobility concerns are addressed, and how these items fit the "best practices" that are identified throughout this study.

The pilot project that was identified for this study was the Interstate 29 Expansion and Improvement project located in Sioux City, Iowa. Overall, the project includes widening the current interstate roadway, replacing several entry and exit ramps, and replacing several bridges. The focus of our study covers the Segment 1 portion that includes the widening of the current interstate system from four lanes to six lanes.

3.4. Justification for Mixed-Methods Research Approach

A mixed-methods approach was chosen given there are many difficulties that were encountered when setting up avenues to gather information that would help produce an outline of how activities on highway construction affect safety.

One method of collection for a single research topic is to gather information reported by highway construction contractors on incidents to insurance providers to determine the interactions within the construction site. However, this is not a practical solution for this research provided that construction companies and insurance companies are often hesitant to report this type of information because of its sensitive nature.

Therefore, for this project, broader statistics, such as gathering OSHA information, must be relied upon in conjunction with qualitative data, such as personal interviews or analysis of specific incident reports.

Data from within the work zone on the construction site is provided by OSHA and Iowa OSHA statistics. This information provides the quantitative data and supports the other statistical analysis. The OSHA and Iowa OSHA data provides information on all accidents that happen within a job site. These reported accidents include those that involve construction equipment and vehicles as well as falls, electrocution, and other job site accidents.

With the Iowa DOT crash database, information about the traveling public can be compiled by the task of a database query with selected variables. A major gap, however, surfaces in how the traveling public interacts directly with construction vehicles. As it is detailed later for this study, a survey was designed to address concerns with ingress and egress areas in work zones. These areas were to be the final piece of the puzzle to show how internal traffic control, safety, and mobility could be addressed.

Due to limitations of the quantitative data, the research also relies on qualitative assessments, a questionnaire, and TAC meetings to support the quantitative assessments. The mixed-methods research approach was best suited to address the concerns that were associated with the quantitative data and were implemented as such in this study.

The overall research methodology is summarized in Figure 3.1.

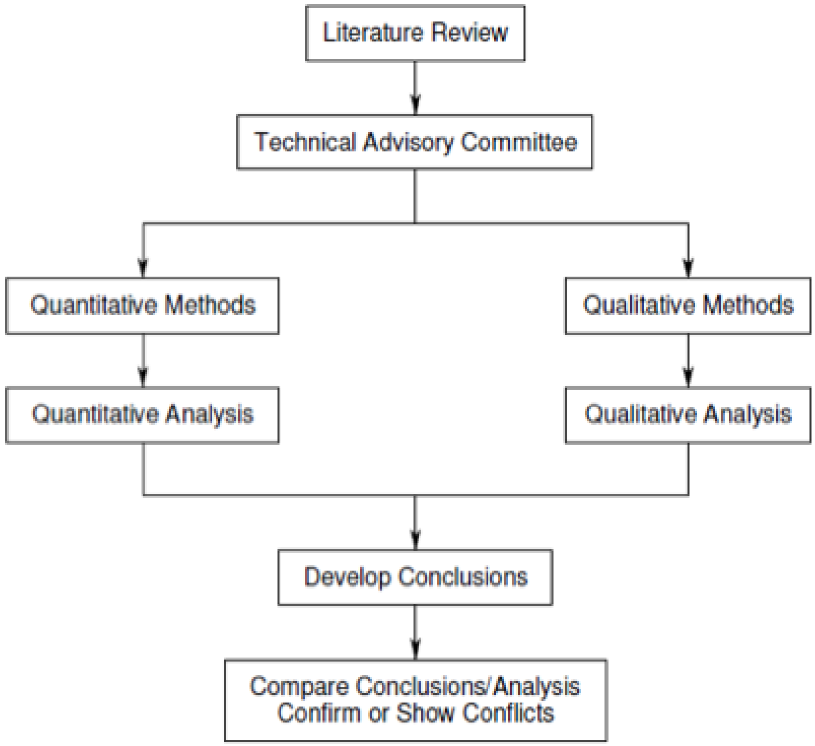


Figure 3.1. Research method diagram

This figure is a method diagram that illustrates which tasks were performed and in what order. Qualitative and quantitative analyses were performed simultaneously with the intention of using each type to confirm or deny claims from the other method of research.

The quantitative research methods in this study include OSHA and Iowa OSHA statistics and analysis along with Iowa DOT crash database queries and analysis.

Qualitative research methods include the analysis of crash narratives, personal interviews with a range of construction personnel, an ingress and egress in construction work zones survey, and the pilot project.

4. DATA COLLECTION AND ANALYSIS

4.1. Overview

Data collection or compilation is essential to a research project and data must be analyzed carefully. Data can be presented in many different ways as explained in the previous methodology chapter.

The quantitative data in this study includes descriptive statistics from the Iowa DOT crash database, statistics released by OSHA, and statistics released by Iowa OSHA. Qualitative data included TAC reviews, personal interviews, ingress and egress survey results, and crash incident narrative summaries.

Also within any study, a thorough data analysis must be performed to ensure that conclusions can be provided and that inferences about data can be either confirmed or rejected. Some of the data that is included in this study can be analyzed statistically using typical analysis of variance testing and others by observational comparison. Items that were addressed in both the TAC meetings and personal interviews can only be used to confirm or show difference between perception in work-zone safety and mobility and statistical findings.

Statistical results that coincide with claims by either the expert panel or claims made during personal interviews offer strong evidence of patterns in highway construction safety and mobility. The claims identified, when backed by both statistics and expert knowledge, are said to be triangular in nature. However, when encountering statistical evidence that is contrary to expert panel or interview claims, an anomaly occurs.

4.2. OSHA and Iowa OSHA Incident Rates

OSHA produces annual safety reports on nearly every type of industry in the US and uses incident rates to serve as a baseline for states to compare to national averages. These national averages incorporate all hours worked by all states.

Incidence rates represent the number of injuries and illnesses per 100 full-time workers and were calculated as follows:

$$(N/EH) \times 200{,}000$$

where:

N = number of injuries and illnesses
EH = total hours worked by all employees during the calendar year
200,000 = base for 100 equivalent full-time workers (working 40 hours per week, 50 weeks per year).

Figure 4.1 shows the Iowa OSHA annual highway, street, and bridge construction employment data (in thousands of hours) for 1996 through 2010 (accessible from http://www.bls.gov/iif/state_archive.htm#IA).

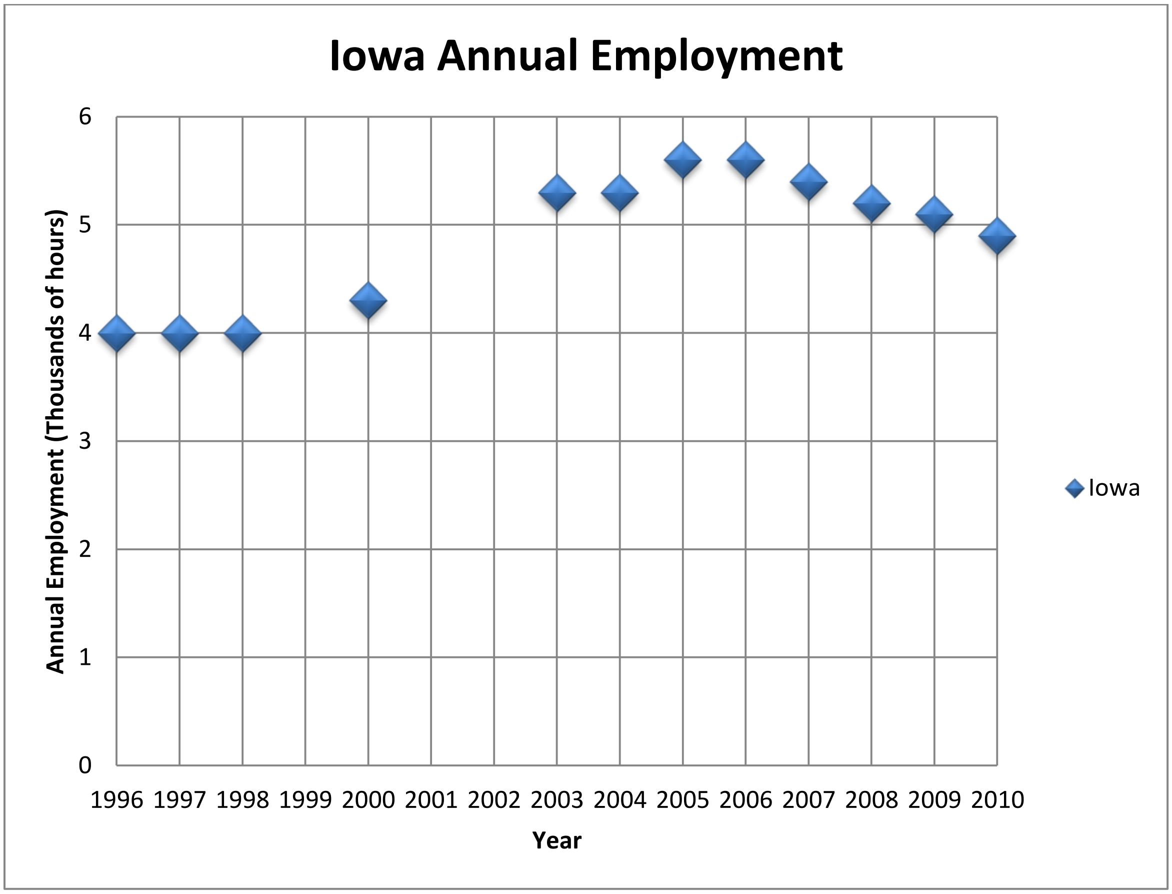


Figure 4.1. Iowa annual employment for highway, street, and bridge construction

The data are reported in thousands of hours. Annual employment is an aggregation of all construction operations within the state of Iowa that are not considered building or other civil construction (Bureau 2011).

Figure 4.2 compares incident rates (calculated as shown on the first page of this chapter) for total recordable cases in each given year.

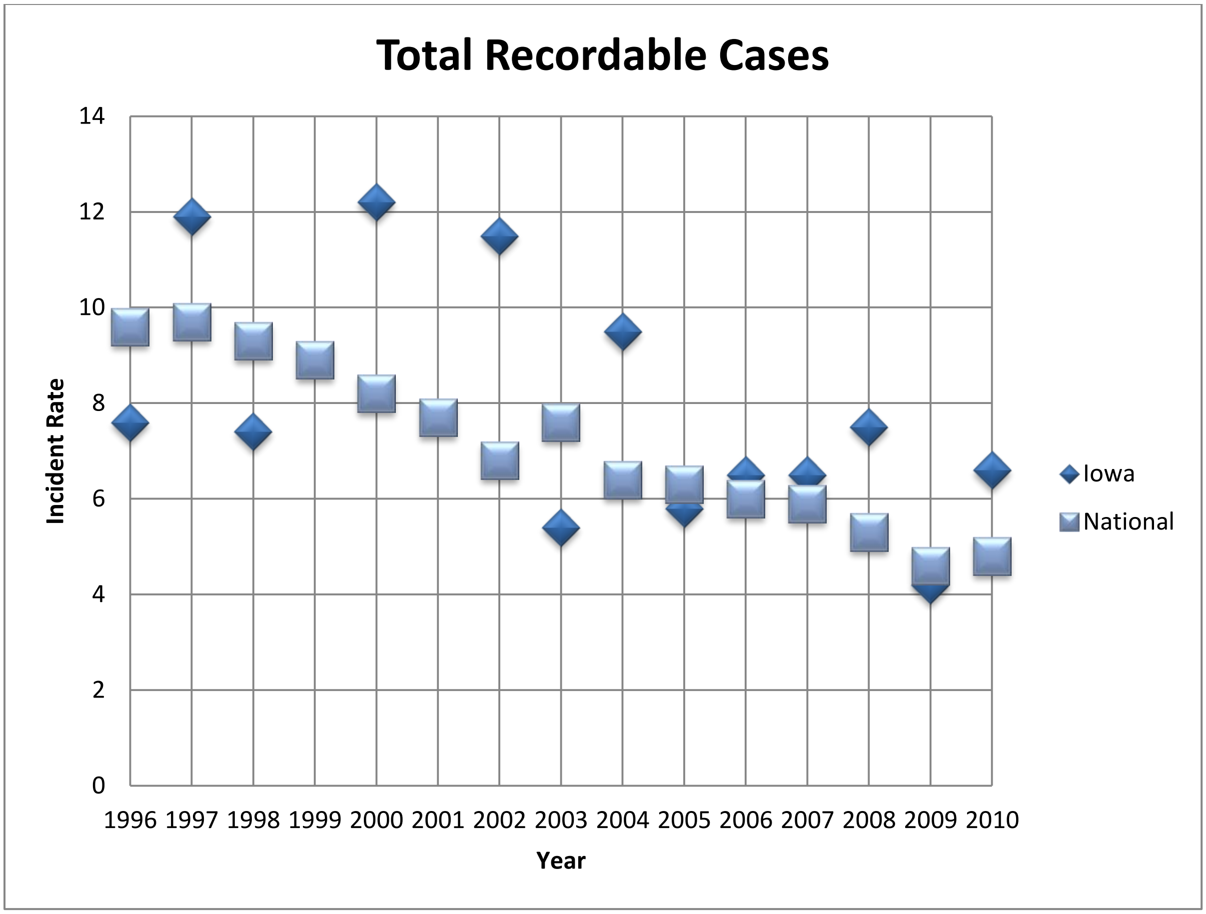


Figure 4.2. Total recordable cases for highway, street, and bridge construction

Items that are considered recordable by OSHA and Iowa OSHA standards include incidents involving death, loss of consciousness, days away from work, restricted activity or job transfer, and any incident that requires medical treatment beyond first aid. Cases that involve an incident of death are not included in Figure 4.2.

Figure 4.3 compares incident rates (calculated as shown on the first page of this chapter) for cases with days away from work, job restriction, or job transfer in each given year.

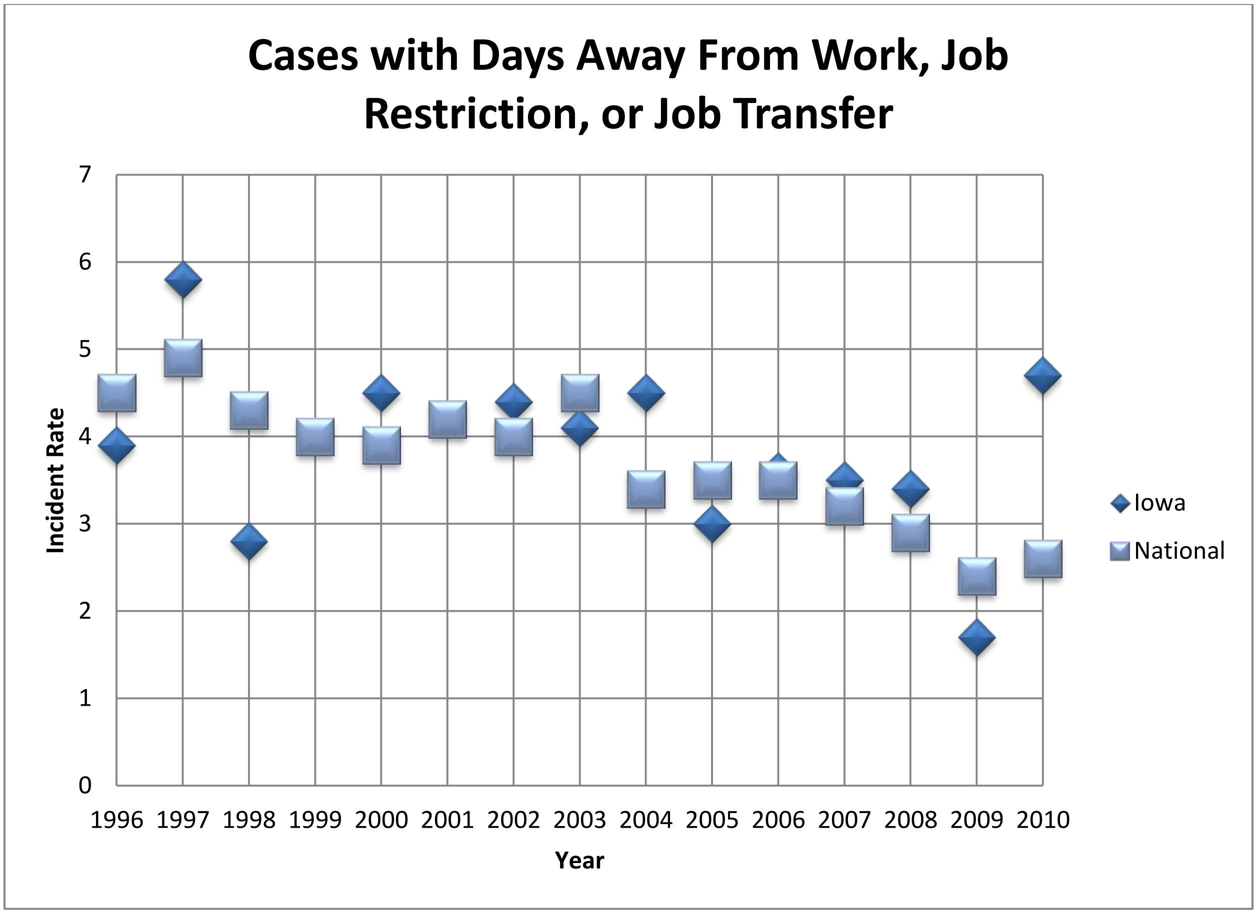


Figure 4.3. Cases with days away from work, job restriction, or job transfer for highway, street, and bridge construction

Cases that involve an incident where a death occurred are not included in Figure 4.3.

Figure 4.4 compares incident rates (calculated as shown on the first page of this chapter) for other recordable cases.

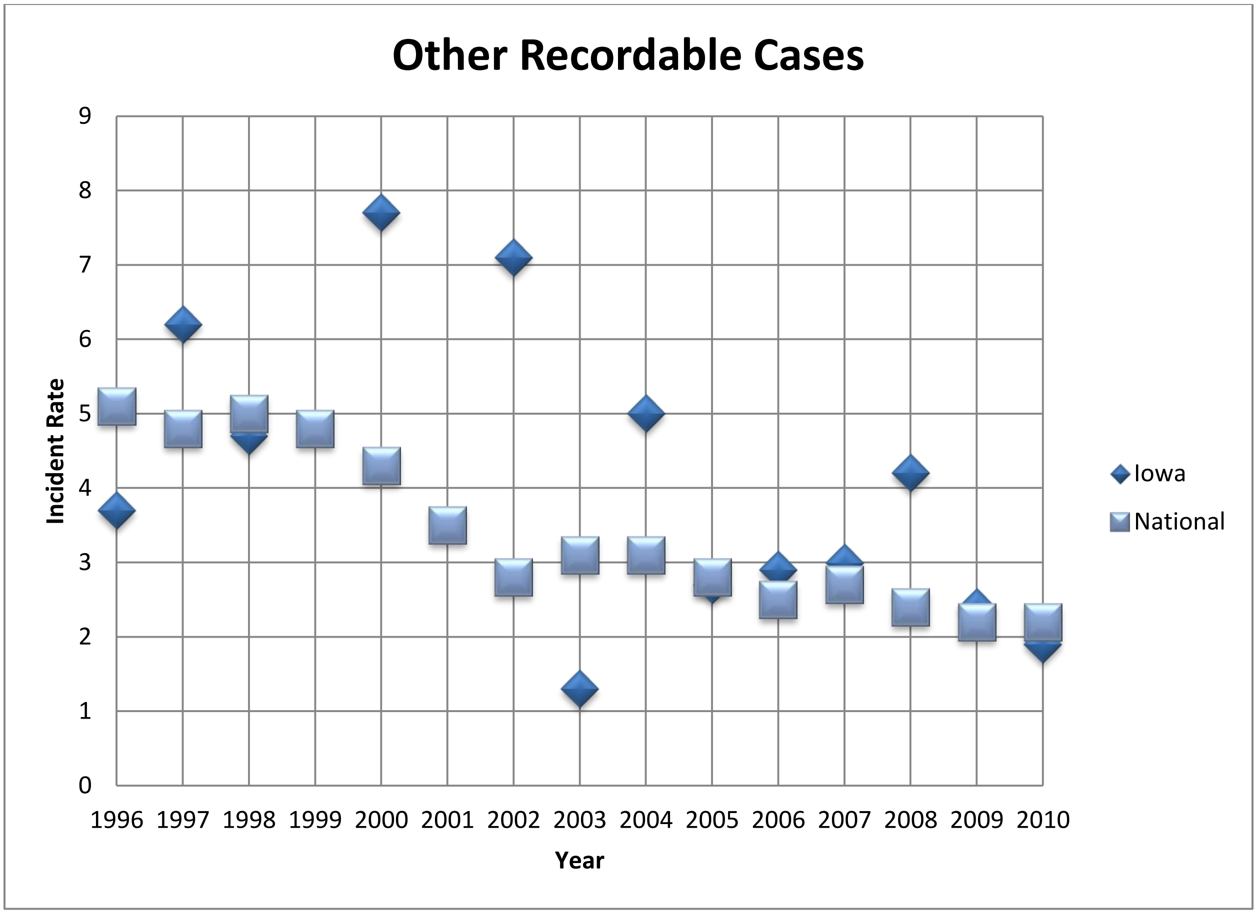


Figure 4.4. Cases with days away from work, job restriction, or job transfer for highway, street, and bridge construction

Other recordable cases include incidents with injuries or illnesses not severe enough for job restriction, job transfer, or days away from work.

It is important that Iowa use these metrics effectively to help reduce incidents within its own boundaries. If statistics such as these are ignored, it can be detrimental to the identification of major problems within the highway construction industry in Iowa. As the national standard in safety enforcement, these statistics provide the best snapshot of how each state is doing on the whole with regards to safety in industry.

4.3. Analysis of OSHA and Iowa OSHA Data Analysis

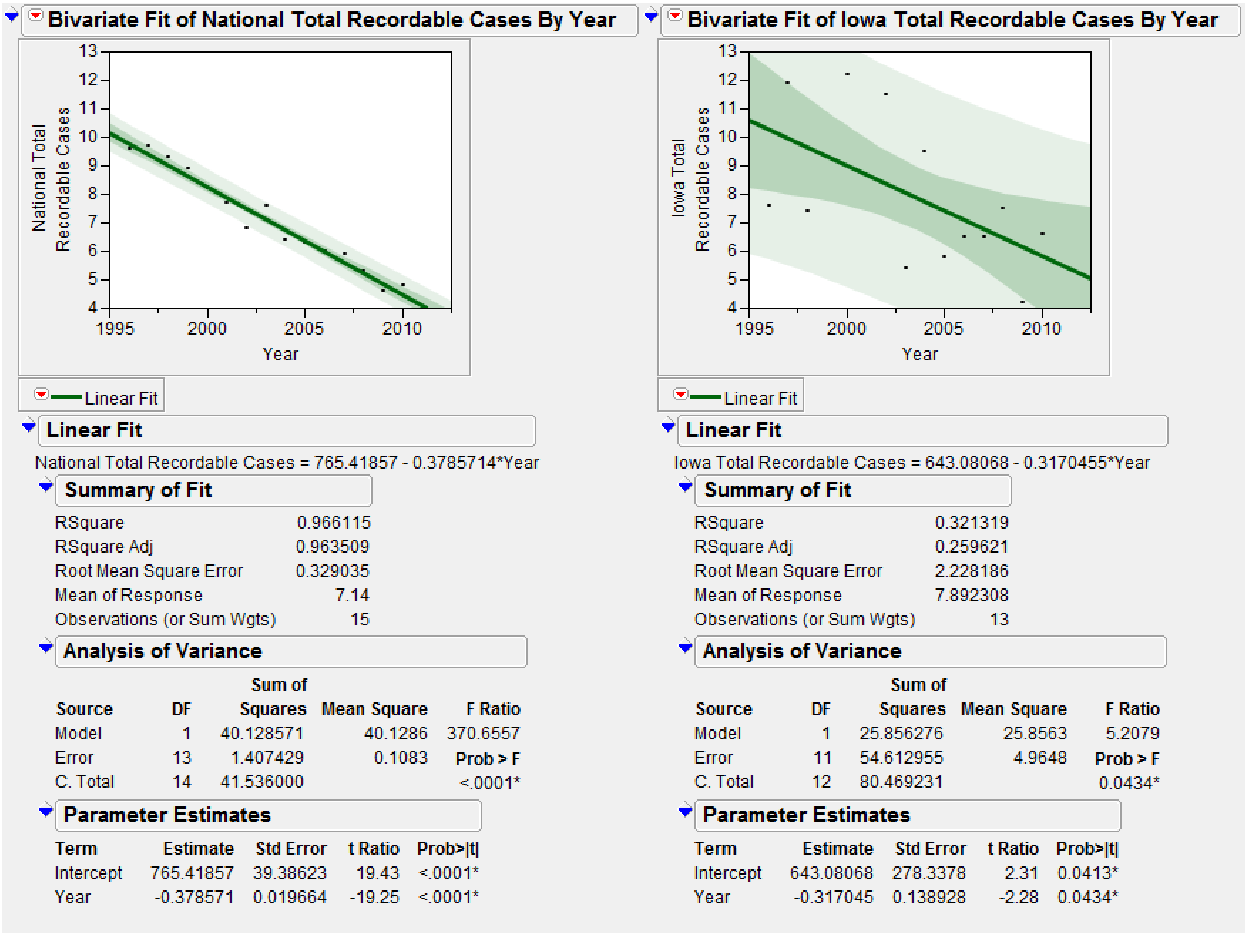
Data collection for highway, street, and bridge construction began in 1996 for Iowa OSHA and most recent data dates to 2010. This dataset includes information on incident rates for total recordable cases; total cases with days away from work, job restriction, or job transfer; and other recordable cases. Years that were not included in either statistical model were 1999 and 2001. Data for these years were not included only for Iowa, but were considered for national rates.

Linear regression models were performed for each of these categories to compare Iowa incident rates to national incident rates. A 95 percent confidence level was used for both the regression fit and the individual value range. It must be noted that Iowa data is included in the national data. Given it represents an extremely small percentage of the total national annual employment, it was determined that it would not affect the national linear models.

As seen in Figures 4.5 through Figure 4.7, a 95 percent confidence level is displayed for both the model and the individual value ranges. The darker ranges represent the linear model confidence interval, whereas the lighter ranges represent the individual value confidence ranges.

The model confidence interval can be interpreted in that the actual predictive linear model has a 95 percent chance of falling within the range provided. The individual value confidence interval can be interpreted in that actual individual values for incident rates for any given year have a 95 percent chance of falling within the range provided without being considered outliers.

Figure 4.5 includes the JMP version 8 output of an analysis of variance test as well as a linear regression model for national and Iowa rates for total recordable cases (JMP is statistical analysis software that is used in this study to perform both the linear model analysis and analysis of variance tests.)



Linear Fit

National Total Recordable Cases = 765.41857 - 0.3785714*Year

Summary of Fit

RSquare	0.966115
RSquare Adj	0.963509
Root Mean Square Error	0.329035
Mean of Response	7.14
Observations (or Sum Wgts)	15

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	40.128571	40.1286	370.6557
Error	13	1.407429	0.1083	Prob > F
C. Total	14	41.536000		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	765.41857	39.38623	19.43	<.0001*
Year	-0.378571	0.019664	-19.25	<.0001*

Linear Fit

Iowa Total Recordable Cases = 643.08068 - 0.3170455*Year

Summary of Fit

RSquare	0.321319
RSquare Adj	0.259621
Root Mean Square Error	2.228186
Mean of Response	7.892308
Observations (or Sum Wgts)	13

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	25.856276	25.8563	5.2079
Error	11	54.612955	4.9648	Prob > F
C. Total	12	80.469231		0.0434*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	643.08068	278.3378	2.31	0.0413*
Year	-0.317045	0.138928	-2.28	0.0434*

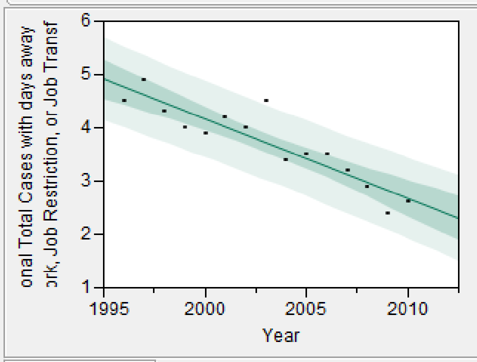
Figure 4.5. Linear fit for total recordable cases rate (national and Iowa)

When analyzing the national yearly rates, there is a clear downward trend with a very tight confidence interval. The coefficient of determination of the national data is extremely high at 0.966, which means that the linear model of [*Recordable Case Rate = (756.42) – (0.379 * Year*)] is a very accurate and predictive model.

Iowa yearly rates, however, are not as readily able to predict an accurate yearly rate for total recordable cases. With an R-square value of 0.321, the model is a very poor predictor of total recordable cases. This model also has a standard error that is seven times as large as the national rate. Because of this, there is such a large overlap that it cannot be said that the two models are significantly different.

Figure 4.6 includes the JMP version 8 output of an analysis of variance test as well as a linear regression model for national and Iowa rates for cases with days away from work, job restriction, or job transfer.

Bivariate Fit of National Total Cases with days away from work, Job Restriction, or Job Transfer By Year



Linear Fit

National Total Cases with days away from work, Job Restriction, or Job Transfer = 302.02393 - 0.1489286*Year

Summary of Fit

RSquare	0.827601
RSquare Adj	0.81434
Root Mean Square Error	0.315458
Mean of Response	3.72
Observations (or Sum Wgts)	15

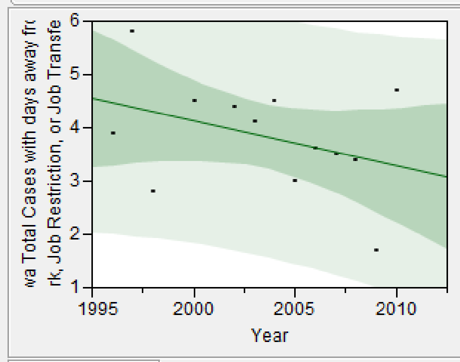
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	6.2103214	6.21032	62.4067
Error	13	1.2936786	0.09951	Prob > F
C. Total	14	7.5040000		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	302.02393	37.76108	8.00	<.0001*
Year	-0.148929	0.018852	-7.90	<.0001*

Bivariate Fit of Iowa Total Cases with days away from work, Job Restriction, or Job Transfer 2 By Year



Linear Fit

Iowa Total Cases with days away from work, Job Restriction, or Job Transfer 2 = 172.31136 - 0.0840909*Year

Summary of Fit

RSquare	0.144697
RSquare Adj	0.066942
Root Mean Square Error	0.988655
Mean of Response	3.838462
Observations (or Sum Wgts)	13

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.818951	1.81895	1.8609
Error	11	10.751818	0.97744	Prob > F
C. Total	12	12.570769		0.1998

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	172.31136	123.4995	1.40	0.1905
Year	-0.084091	0.061643	-1.36	0.1998

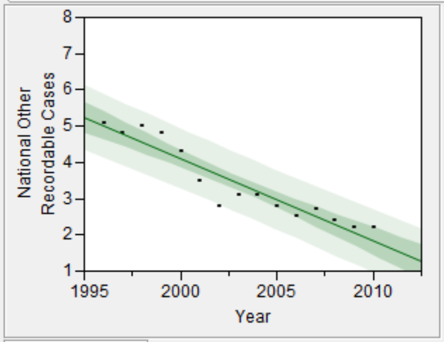
Figure 4.6. Linear fit for total recordable cases with days away from work, job restriction, or job transfer (national and Iowa)

When analyzing the national yearly rates, there is a clear downward trend with a very tight confidence interval. The coefficient of determination of the national data is high at 0.828, which means that the linear model of [*Recordable Case Rate = (302.02) – (0.149 * Year)*] is an accurate and predictive model.

Iowa yearly rates, however, are not as readily able to predict an accurate yearly rate for cases with days away from work, job restriction, or job transfer. With an R-square value of 0.145, the model is a very poor predictor of cases with days away from work, job restriction, or job transfer. This model also has a standard error that is three times as large as the national rate. Because of this, there is such a large overlap that it cannot be said that the two models are significantly different.

Figure 4.7 includes the JMP version 8 output of an analysis of variance test as well as a linear regression model for national and Iowa rates for other recordable cases.

Bivariate Fit of National Other Recordable Cases By Year



Linear Fit

Linear Fit

National Other Recordable Cases = 459.81786 - 0.2278571*Year

Summary of Fit

RSquare	0.893832
RSquare Adj	0.885665
Root Mean Square Error	0.364451
Mean of Response	3.42
Observations (or Sum Wgts)	15

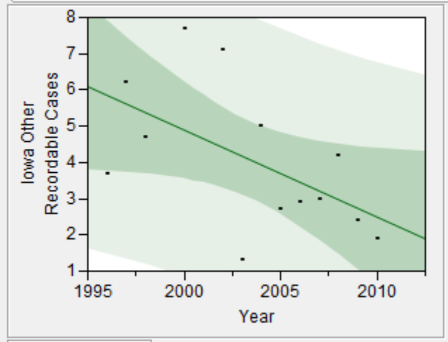
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	14.537286	14.5373	109.4476
Error	13	1.726714	0.1328	Prob > F
C. Total	14	16.264000		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	459.81786	43.62561	10.54	<.0001*
Year	-0.227857	0.02178	-10.46	<.0001*

Bivariate Fit of Iowa Other Recordable Cases By Year



Linear Fit

Linear Fit

Iowa Other Recordable Cases = 482.04049 - 0.2385766*Year

Summary of Fit

RSquare	0.30585
RSquare Adj	0.242745
Root Mean Square Error	1.738063
Mean of Response	4.061538
Observations (or Sum Wgts)	13

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	14.641260	14.6413	4.8467
Error	11	33.229510	3.0209	Prob > F
C. Total	12	47.870769		0.0500*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	482.04049	217.1132	2.22	0.0483*
Year	-0.238577	0.108369	-2.20	0.0500*

Figure 4.7. Linear fit for other recordable cases (national and Iowa)

When analyzing the national yearly rates, there is a clear downward trend with a very tight confidence interval. The coefficient of determination of the national data is high at 0.893, which means that the linear model of [*Recordable Case Rate = (459.82) – (0.228 * Year)*] is a very accurate and predictive model.

Iowa yearly rates, in this case as well, are not as readily able to predict an accurate yearly rate for other recordable cases. With an R-square value of 0.306, the model is a poor predictor of other recordable cases. This model also has a standard error that is five times as large as the national rate. Because of this, there is such a large overlap that it cannot be said that the two models are significantly different.

4.4. Summary of OSHA and Iowa OSHA Data

When analyzing the predictive models using a linear regression in this chapter, it is found that it is extremely difficult to identify the source of the large variances within the Iowa OSHA data. There is a lot of statistical "noise" in the Iowa OSHA data that is likely attributed to having a smaller sample size than that of national levels.

Iowa annual employment hours for highway, street, and bridge construction in 2010 accounted for 4,900 of the 288,600 hours of the total annual employment, which represents about two percent of all hours worked. Because of this small sample size, it is likely that variance can be attributed to the type of work that is being performed each year.

Iowa OSHA statistics are much more elastic because of this smaller sample size as well. A single incident will cause a much larger increase in the incident rate of an individual state more so than on the incident rate on a national level. In 2010, a single incident has 67 times more of an effect on the Iowa incident rate than a single incident that is accounted in national incident rate. This is due to the large difference in total annual employment.

National OSHA data for highway, street, and bridge construction offers a very predictive model in all three categories that were explored. Given there were large sample sizes, it is more likely that a useful model will be provided in these cases. These models also have narrow confidence intervals, which allow us to compare Iowa OSHA statistics to the national model. Given there are no useful measures when comparing Iowa data to other Iowa data because of the poor models, we can only compare individual Iowa values to the national OSHA model to show statistical similarities or differences.

4.5. Comparing National and Iowa Statistics

A 95 percent confidence range can be calculated as such for models with a given standard error:

Upper 95% Limit = (Model National Rate) + (Standard Error)*(1.96)

Lower 95% Limit = (Model National Rate)-(Standard Error)*(1.96)

For total recordable cases, the standard error is equal to 0.0197, which gives a 95 percent confidence interval as follows:

(Model National Rate)(+/-)(0.0385)

Using this confidence interval, five of 13 years included in the sample for total recordable cases are considered statistically lower than the national incident rate; whereas, eight of 13 years are considered to be statistically higher than the national incident rate. There were zero years where the Iowa and national rates were not considered to be statistically different.

For total cases with days away from work, job restriction, or job transfer, the standard error is equal to 0.0189, which gives a confidence interval as follows:

(Model National Rate)(+/-)(0.0370)

Using this confidence interval, five of 13 years included in the sample for cases with days away from work, job restriction, or job transfer are considered statistically lower than the national incident rate; whereas, eight of 13 years are considered statistically higher than the national incident rate. There were zero years where the Iowa and national rates were not considered to be statistically different.

For other recordable cases, the standard error is equal to 0.0218, which gives a confidence interval as follows:

(Model National Rate)(+/-)(0.0427)

Using this confidence interval, four of 13 years included in the sample for other recordable cases are considered statistically lower than the national incident rate; whereas, nine of 13 years are considered statistically higher than the national incident rate. There were zero years where the Iowa and national rates were not considered to be statistically different.

4.6. Iowa DOT Crash Database Query

The Iowa DOT maintains a crash database that includes information about each type of vehicle crash that occurs in Iowa. Within the data that is kept by the Iowa DOT, a large set of variables are used by the reporting officer to describe the conditions in which the incident occurred. Based on these variables, a query can be performed to filter different types of conditions to explore the make-up of crashes within Iowa.

The variables that were considered for our study are included in Appendix A and contain information regarding the following: the assigned case number for the incident was assigned, the vehicle configuration in the incident, and the work zone location in which the incident occurred.

In this study, the interactions between these variables are of particular interest because of how the work zone interacts with each area. After relevant data is collected through the crash database query, an analysis of each work zone can be performed to see which areas are particularly dangerous or which zones need to be addressed.

The case number was important to identify so that a sample of the total incidents could later be investigated further through the incident narratives. The vehicle configuration of each case was considered because it was important to find out what, if any, types of large construction vehicles are involved in incidents.

The work zone location variable is especially important in this study as it pertains directly to how and at which locations construction operations are interfacing with the traveling public. The zones that are identified as work-zone-related are illustrated in Figure 4.5.

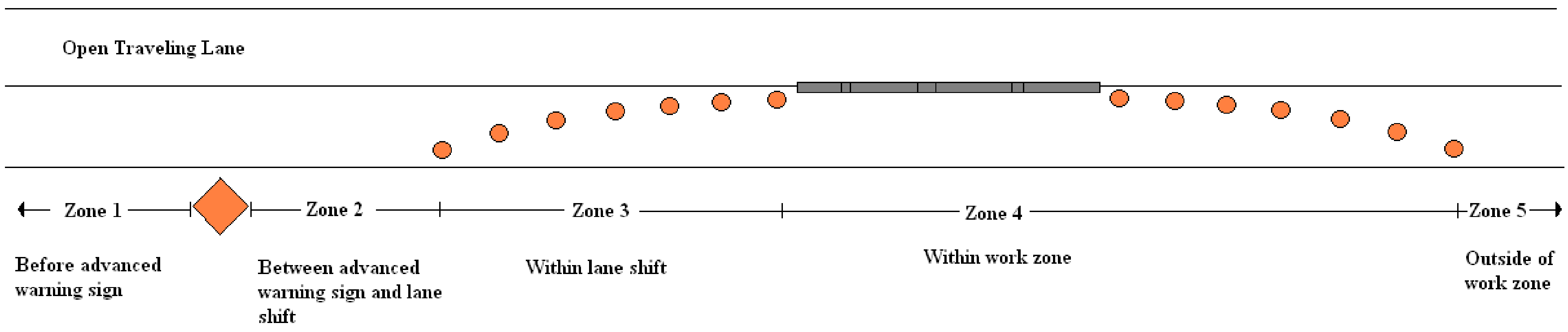


Figure 4.8. Construction “zones” as defined by the Iowa DOT

These “zones” are defined by the Iowa DOT and are used specifically in incident reports by the reporting public officer of each incident:

Zone 1 – Before advanced warning sign
Zone 2 – Between advanced warning sign and lane shift
Zone 3 – Within lane shift
Zone 4 – Within work zone
Zone 5 – Outside of work zone

The work zone locations that were identified by the TAC to be the most problematic were Zone 3, within the lane shift, and the egress from the work zone in Zone 4. TAC members reported it is often extremely difficult for trucks and other heavy equipment to enter and exit a work zone and that, in turn, creates dangerous conditions for both the truck driver and the traveling public. The query of the Iowa DOT crash database for 2008 through 2011 (four years) produced the results shown in Table 4.1.

Table 4.1 produces information that pertains to each work zone, how many incidents are occurring in each zone, and also what types of vehicles are involved in these incidents. Zone 4 has an overwhelming number of the incidents included it its category whereas Zones 2 and 3 each have a large portion of the incidents as well.

Table 4.1. Incidents by vehicle type and work zone location 2008 through 2011

Vehicle Type	Number of Incidents by Work Zone Location 1	2	3	4	5	Total
Passenger car	97	171	184	515	27	994
Four-tire light truck (pick-up/panel)	18	71	65	176	9	339
Van or mini-van	17	27	37	99	8	188
Sport utility vehicle	22	55	54	136	13	280
Single-unit truck (2-axle/6-tire)	3	7	5	26	-	41
Single-unit truck (≥ 3 axles)	-	4	4	19	1	28
Truck/trailer	-	3	6	6	1	16
Truck tractor (bobtail)	-	2	0	0	0	2
Tractor/semi-trailer	5	26	22	80	9	142
Tractor/doubles	-	1	1	4	1	7
Tractor/triples	-	-	-	-	-	0
Other heavy truck (cannot classify)	-	-	-	-	-	0
Motor home/recreational vehicle	3	1	2	2	-	8
Motorcycle	1	5	12	36	2	56
Moped/All-Terrain Vehicle	-	-	-	1	-	1
School bus (seats > 15)	-	1	-	-	1	2
Small school bus (seats 9-15)	-	-	-	-	-	0
Other bus (seats > 15)	1	-	3	8	-	12
Other small bus (seats 9-15)	1	-	-	1	-	2
Farm vehicle/equipment	-	1	1	1	-	3
Maintenance/construction vehicle	1	-	-	8	-	9
Train	-	-	-	-	-	0
Other (explain in narrative)	-	-	-	-	-	0
Not reported	-	2	2	1	1	6
Unknown	-	-	-	-	-	0
Total	**169**	**377**	**398**	**1,119**	**73**	**2,145**
Total Heavy Equipment	**8**	**42**	**37**	**139**	**11**	**229**

4.7. Crash Narratives

It is difficult to determine the cause of many incidents only by the data that are included in the Iowa DOT crash database without also reviewing the crash narratives.

The crash narratives provide additional information that the reporting officer deemed necessary to include in the incident report. The narrative portion of the incident report form includes space for additional information about road conditions, direction of travel of any vehicles involved in the incident, and illustrative diagrams showing the types of road systems and relative distances.

These conditions were then analyzed and categorized by either the major cause of the incident or the environmental factor that led to the incident.

All crash narratives for incidents involving heavy equipment were analyzed and categorized to obtain deeper understanding of these work-zone crashes. The database included crash narratives for 211 of the 229 heavy equipment incidents. The categorization of these narratives is summarized in Table 4.2.

Table 4.2. Summary of categorization of heavy equipment crash narratives

Cause/Condition from Narrative	**Count**
Merging traffic	50
Rear end/too fast to slow down	42
Striking traffic control devices/items in traveling lane	23
Backing up	18
Shoulder drop off	15
Loss of control/distracted driving	15
Intersections	10
Slick conditions/weather	8
U-turn	7
Vehicle too tall/wide	7
Brakes/equipment malfunction	5
Crossing centerline	4
Other/unique	4
Swerving to miss an animal in the roadway	3
Total	**211**

A description of the categories that emerged in analyzing the information in the heavy equipment crash narratives is provided in Table 4.3.

As shown in Table 4.2, a significant number of incidents fell into the following categories: merging traffic, rear-end collisions, striking traffic control devices, backing up, shoulder drop offs, and loss of control.

These types of incidents can almost always be attributed to driver error except in a few of the cases of traffic control devices that have been pushed into the traveling lane and are struck by vehicles. Within each of these categories, there is a large association with the general lack of awareness of the drivers in each incident. Many of the incidents that involved large vehicles included driver testimony stating that they were not aware that they had even struck another vehicle or piece of equipment and continued traveling.

Table 4.3. Description of categories for heavy equipment crash narratives

Category	Description
Merging traffic	Any incident caused by either a lane shift, merging traffic, or an on-ramp merger into traffic
Rear end/too fast to slow down	An incident caused by a vehicle traveling too fast or not seeing traffic stopping ahead, causing a rear end collision
Striking traffic control devices/items in traveling lane	An incident with a vehicle striking cones, guardrails, or any inanimate object that is in the traveling lane or nearby
Backing up	An incident caused by a vehicle backing up and striking another vehicle
Shoulder drop off	Incidents caused by vehicles either driving or unloading on a shoulder and falling off of the edge of the road
Loss of control/distracted driving	Any incident that involves a driver losing control within the traveling lane due to reasons such as distracted driving
Intersections	Incidents that occur due to the nature of the interaction at an intersection, usually involving the inadequate turning radius of a vehicle
Slick conditions/weather	An incident caused by environmental factors such as icy roads, wet roads, or glare from sunlight
U-turn	Incidents caused by an improper U-turn within the traveling lane or construction zone
Vehicle too tall/wide	Incidents caused by wide or tall loads, which strike traffic control devices, overhead signs, or any other object
Brakes/equipment malfunction	Any incident that involves a mechanical failure of some sort such as a brake failure or tire blow out
Crossing centerline	An incident caused by a vehicle crossing the line of a traveling lane and striking another vehicle or piece of equipment
Other/unique	Incidents that do not coincide with any other category identified (the incidents included are each unique and do not have a common cause with other types of incidents)
Swerving to miss an animal in the roadway	An incident caused by a driver swerving to miss any type of animal to avoid property damage or striking the animal

Driving strategies often include having an escape route and following at a reasonable distance relative to the speed at which the driver is traveling, but these basic strategies seem to be ignored in many of these cases. Especially in the U-turn category, a maneuver such as this is particularly dangerous, but drivers do not seem to apply the proper checks before proceeding, causing an incident.

Finally, given the Iowa DOT crash database did not specifically consider the egress from the construction site as its own zone, a survey was conducted to address these locations. This survey is covered later in this chapter and serves to address problems with not only the egress zone shown in Zone 5 (in Figure 4.8), but also the one in Zone 3.

4.8. Personal Interviews

In this study, personal interviews served as a means to explore in-depth topics with personnel who have particular expertise. Four personal interviews were conducted including interviews of Roxanne Seward, traffic technician for District 3 of the Iowa DOT; Jason Hankins, project manager for Cedar Valley Corp.; Jeff Koudelka, vice president of Iowa Plains Signing Inc.; and Dave Webb, plant operator for Central Iowa Ready Mix.

These four people were identified as experts in each of their fields and offered a wide variety of experiences to traffic control, work-zone safety and mobility, and internal traffic control.

Roxanne Seward. Traffic Technician for District 3 of the Iowa DOT

As a traffic technician, Roxanne's experience includes implementation of Iowa DOT traffic control policies and procedures, and Roxanne is a member of the Tri-State Incident Management Group that includes Iowa, Nebraska, and South Dakota.

The Tri-State Incident Management Group is a formation of several local DOT districts within the Siouxland area including northwestern Iowa. The goal of the group is to compile all relevant contacts within each district and have response plans if incidents such as traffic accidents or required shut downs are anticipated to affect more than one state's municipality.

All of these operations are performed as a part of the Siouxland Interstate Metropolitan Planning Council (SIMPCO). SIMPCO is a council of governments that serve the tri-state area of Iowa, Nebraska, and South Dakota by using effective regional planning, promoting regional economic growth, and serving as a model for other similar multi-jurisdictional planning agencies.

The Tri-State Incident Management Group is considered to be a "best practice" within the Iowa DOT District 3 and Siouxland area.

Another best practice that was addressed in this interview was the reception of public concerns on traffic control and other construction-related items. The Iowa DOT District 3 office fully supports feedback from individuals and works actively to solve problems and concerns that emerge as a result of any work that is performed.

All concerns that are brought to the District 3 office are documented and reviewed and then forwarded and addressed by the proper personnel, whether it be a State Representative, City Council member, or even local law enforcement.

Jason Hankins – Project Manager for Cedar Valley Corp.

As a project manager for Cedar Valley Corp., Jason addresses the daily work-zone difficulties associated with highway construction. During the interview, a number of topics were of particular interest.

The first topic covered was the process of changing a traffic control plan. Any major change that is considered when making a change to traffic control plans must be formally submitted by the project manager to the Iowa DOT's resident construction engineer (RCE).

Upon review, the RCE may approve of changes or make additional ones. Oftentimes on major traffic switches, changes are approved ahead of time. Schematic diagrams and other paper submittals are often required of the contracting agency, which leads to better documentation of the change. However, this can also lead to added design time for the contractor if changes are not approved.

Minor changes that affect small portions of a job site such as a single ingress point or cone set up often need only the approval of an Iowa DOT inspector, rather than the RCE. Meetings on minor changes are usually performed on the job site and do not need schematic plans or diagrams.

When designing changes, the safety of all construction personnel are considered. All traffic control devices and traffic control plans must adhere to MUTCD plans and policies. This also means any changes to traffic control plans must adhere to these standards unless an exemption is granted by the RCE.

However, internal traffic control (traffic within the jobsite) is developed by the contracting agency on the highway project. There is no standard design that addresses internal traffic control, but final approval of internal traffic control plans by the RCE is required.

Input from all contractors and subcontractors who are affected is considered closely when developing internal traffic control plans. Any superintendents, such as those who manage major portions of work, are also asked for input.

Regular meetings are held with Iowa DOT inspectors as well to address internal traffic control plans, along with items such as haul routes and planned closures. Changes to internal traffic control plans are addressed much in the same manner as regular traffic control plans, in that minor changes are typically approved by the Iowa DOT inspector and major changes are approved by the RCE.

Along with the general process of changes to traffic and internal traffic control plans, a few challenges were also addressed. The aspect of the change process that was identified as being one of the most difficult was trying to make the case that proposed contractor changes to traffic control and internal traffic control plans are indeed safer, more convenient for the traveling public, as well as construction operations, and offer a schedule benefit to the construction project.

Contractors often push to limit the amount of time they are in one area to help limit the total exposure time of the construction to the traveling public. The more schedule-driven projects with higher flexibility in closures offer the best situation for contractor operations. The contractor often feels it is best for safety and exposure to the public to have one mobilization of construction operations into an area and one de-mobilization from the job site once work is completed. It is rarely in the interest of the contractor to perform work in smaller segments.

To help reduce exposure to the traveling public, contractors prefer to work on larger projects. This is due to the economies of scale that provide for higher productivity and reduce unit prices when performing work. Safety is believed to be improved because of this higher productivity because it reduces the overall time that is spent on construction per mile, thus limiting the total exposure to the public of hazards that are associated with highway construction.

Jeff Koudelka – Vice President of Iowa Plains Signing, Inc.

Iowa Plains Signing is a traffic control contractor/subcontractor that can provide nearly every traffic control device or service desired for a highway or urban construction project. The interview conducted with Jeff Koudelka worked particularly to identify difficulties and best practices associated with MUTCD plans and specifications.

MUTCD plans and specifications are used in highway construction projects to standardize traffic control and interactions between the traveling public and construction equipment and personnel. These plans and specifications depict items explicitly such as minimum and maximum distances on advanced warning signs, types of job site barriers to use, and typical ingress and egress distances. An example of a standard traffic control plan is included in Appendix B.

The primary concern that Jeff expressed with relation to construction operations is the ability to attract driver attention and driver ability to identify and respect the work zone. Jeff feels driver distraction causes many more incidents than any failure of the construction contractor to adhere to safety standards.

To help address the issue of drivers not paying attention to changing roadway conditions, strobe-type warning lights have been installed on all Iowa Plains Signing vehicles to help warn the traveling public. This is not a DOT safety standard; rather, it is a best practice implement by Iowa Plains Signing that goes above and beyond the typical standard.

Another best practice that Jeff identified was the use of different strategies for getting driver attention on highway projects. These strategies coincide with two types of highway construction projects: two-way, two-lane construction and interstate and divided highway projects.

Jeff cited that it is detrimental to project safety to have excessive vehicles and attention-grabbing devices around the job site because it distracts drivers from paying attention to other drivers and the actual construction itself. However, with interstate and divided highway construction, it is detrimental to project safety to have fewer vehicles and attention-grabbing devices, and it is encouraged to use optional allowed devices.

Another point of emphasis that was discussed in the interview was the clarity of diagrams in the Iowa DOT traffic control diagram and the inability to go above and beyond the standards shown. Several of the diagrams (such as TC-431) include graphics of vehicles that are to be used in the fleet, but near them is an indicator that the piece of equipment is optional. Jeff reasoned that if it is included in the road standard, the piece of equipment should not be optional and should always be included. Iowa Plains Signing never allows a piece of equipment or sign to be optional in an operation if it is shown as so on the Iowa DOT Traffic Control Standard.

In addition, oftentimes the vehicles that are depicted in the diagrams do not accurately show the realistic footprint of a piece of equipment. For example, a rumble strip grinder may be shown to be working outside of the traveling lane on the diagram but, in reality, the grinder may be sitting a few feet into the lane or even entirely in the lane of travel.

Another major aspect of concern on Iowa DOT standards is that, given the standards are very specific in how they should be implemented (number of signs, number of trucks, etc.), contractors feel they cannot go above and beyond the standards without being liable for damages outside of their work zone. Standards often constrict the contractor to perform to a standard that does not allow for additional safety measures.

Past litigation that Iowa Plains Signing has been faced with for not adhering to the Traffic Control Standards has forced the dilemma of either risking liability because of extra safety measures or potentially risking injury or property damage. The result is not being willing to provide additional signage and other safety equipment.

The last main topic of discussion with Jeff was the lack of willingness to accept new safety products and implement them in DOT standards. One item that Jeff identified specifically was temporary rumble strips (see Appendix C). Temporary rumble strips have the ability to grab the attention of drivers and alert them to the potential hazardous situations ahead and can be included in operations that require temporary set up in a specific area.

On the other hand, some innovative items, have been adopted in the Iowa DOT standards as recently as 2011. The latest equipment being used in traffic control are temporary automated signal lights, which replace standard flagging controls. These signal lights allow for two fewer laborers to be outside of a vehicle and exposed to moving traffic.

Dave Webb – Plant Operator for Central Iowa Ready Mix

Dave Webb is a ready mix plant operator who has 30 years of experience in the highway construction industry, and he has a wide variety of equipment operator and driver experience. Dave is one of the individuals credited with the development of the Central Iowa Ready Mix comprehensive driver safety and training program.

A mentor/mentee relationship between drivers and operators is the backbone of the training program. Six major categories of safety and training are included in the program:

- A mentoring program where a younger, inexperienced driver is paired with an older, more experienced driver

- A driver recognition safety course that helps train divers on identifying hazards near the vehicle they are operating
- A look-ahead program in which drivers are trained to actively identify potential problems on the roadways
- Escape-route training where drivers are trained to have an alternate plan of action if differing conditions are experienced other than those planned in previous communications
- Training on hazard identification within job sites
- Hand signal training in which drivers learn standard hand signals that are given by spotters

This training program is coupled with practices that include commentary driving, establishing communication lines, and job-site drive-throughs.

Commentary driving is a concept that was developed to allow drivers to assess job site conditions actively with the help of a mentor in the cab with them. The inexperienced driver gets to operate the vehicle with the help of an experienced driver and is encouraged to actively seek out potential problems and communicate them with the mentor. This helps establish consistent behavior in active hazard identification.

Establishing communication lines have contributed vastly to the feedback loop that equipment operators and dispatch share. Given that drivers are encouraged to actively seek out hazards and report back, the dangerous effects of differing conditions are mitigated. Drivers are trained to be 100 percent sure, or don’t go, meaning that, if the driver is not completely confident about the safety of the desired route that is to be taken, they should not proceed. Plant operators and dispatch are then tasked with communicating information to all drivers, including those who are en-route to the specified job site. Driving and route descriptions on dispatch tickets are changed and these new instructions are reviewed. If a change is major, the next step of the process is completed, which is the job-site drive-through.

A job-site drive-through is a major part of the safety program in that it allows managers to show operators and drivers the haul routes and potential hazards directly. These drive-throughs are performed generally during all major changes in haul routes and job-site traffic rotes. By using a large passenger van to accommodate many drivers and operators, discussions can be held between the drivers themselves and, in effect, another form of commentary driving is established.

4.9. Ingress and Egress Survey

A survey was performed as a result of the TAC identifying that ingress and egress of equipment into and from job sites was among the most dangerous activities associated with highway construction work zones. Public awareness, as well as items such as congested job sites and short acceleration and stopping distances, were cited as some of the most critical problems that drivers and operators face.

The TAC also determined there are two distinct types of highway construction work zones. The first is a closed work zone, meaning the work zone is protected in some manner, usually by a concrete barrier rail that provides additional protection from the traveling public within the job site. The second is an open work zone, which is used generally for short-term lane closures and does not use any physical barriers to protect the workers or construction equipment, only cones to mark lane closures.

For the survey, each respondent was asked to identify three best practices for both closed and open work zones. The population identified included Iowa DOT officials, officials from adjacent state DOTs, and contractors. A total of 19 responses were recorded for each type of work zone and the results are categorized in Table 4.4.

Table 4.4. Summary of Ingress and Egress Survey results for “closed” and “open” work zones

Best Practice	“Closed”	“Open”
Upgrade/additional equipment, markings	20	18
Additional distance for ingress and egress	6	6
Using correct, clean, and undamaged traffic control devices	6	3
Use alternative ingress and egress points	4	4
Better protection, communication with, and training of workers	4	3
Have public officer on site	2	1
Use of pilot car	0	2
Other	10	12
Did not respond	5	8

4.10. Pilot Project

The pilot project that was used in this study was the Segment 1 update for Interstate 29 in Sioux City, Iowa. The Segment 1 portion of this project begins south of 8th Street in Sargent Bluff, Iowa and extends north toward the Missouri River. Segment 1 is a part of a three-segment interstate highway system improvement.

The ultimate goals of the project are to improve safety, improve traffic operations, provide for better driver expectancy, and improve future roadway infrastructure conditions. (Iowa DOT 2012). The Segment 1 improvement project includes expanding both northbound and southbound lanes from a four-lane system to a six-lane system.

Despite its adjacency to the Missouri River, a categorical exclusion was approved for environmental constraints within the Segment 1 area. This meant that the cumulative environmental effects of the project would not be significant.

The major difficulties that were faced in this project were a combination of existing rail transport lines as well as geographical landscape constraints. On the eastern side running parallel with Segment 1, there is both an existing bike path as well as the Missouri River. Within this segment, sections of I-29 lie within 15 yards of the river bank. Equally close, along the western side of Segment 1, lies an existing railway that is still in use.

Another major difficulty, in addition to the physical constraints, is the inability for complete closure of the highway. The accumulation of these conditions led to a very difficult project to complete safely. Given travel lanes could not be restricted completely, the Iowa DOT proposed performing construction at night and allowing a single-lane closure, keeping one lane open in each direction. However, the contractor that was awarded the project developed an alternative proposal plan that would allow them to work during the day.

The major components of the proposal included the following:

- Narrow the work zone where the additional lanes were to be constructed
- Shift traveling lanes for both north and southbound lanes outward from the centerline of the highway so both travel lanes could remain open
- Perform work during the day so it can be performed at their highest production rates to minimize the construction schedule and, in turn, minimize exposure of the work zone to the traveling public

The goals of the new traffic control and work zone plan were to allow construction operations to be performed during the day at peak production, allow minimal disruption to traffic flow, and limit the duration of the total construction time. This proposal was approved by the District 3 RCE and construction proceeded per the contractor’s proposal.

Adequate planning and preparation by the contractor allowed for the internal traffic control plan, as well as the public traffic control plan, to be adapted successfully per the contractor’s request. Because of the newly-implemented traffic control and work zone control plan, the project was able to be completed in a productive manner that helped to reduce the total exposure time of the construction project to the traveling public.

5. CONCLUSIONS

5.1. OSHA and Iowa OSHA

Based on the data provided by OSHA and Iowa OSHA, incident rates were compared using a linear regression model and an analysis of variance was performed for both sets of data. Given the category of highway, street, and bridge construction has a relatively small sample size for the total annual employment for Iowa, statistical variation was high in the Iowa data. Given a much larger population size is used for national incident rates, Iowa statistics can be compared to the linear model developed in this study.

In more than half the years included in the study, Iowa has had a higher incident rate in every major statistical category. These findings indicate that, due to many factors, Iowa is often a statistically more dangerous state to work in highway construction than the national average.

This finding could be due to many factors, such as extreme weather conditions in both summer and winter, types of construction projects performed, or types of safety programs that are implemented. The exact factors causing the higher rate are not able to be identified in this study alone and are likely a source for future research.

One positive that can be identified is that models for both Iowa and national incident rates are downward sloping. The model for total recordable cases offers the best evidence that overall incident rates for Iowa are improving from year to year. The linear models also display similar slopes in the downward trends for each analysis that was performed.

5.2. Iowa DOT Crash Database

The Iowa DOT crash database provided a way to categorize incidents that are considered by a reporting officer to be work-zone-related. Table 4.1 provides a summary of the crash data and the zones shown in the table are as follows:

Zone 1 – Before advanced warning sign
Zone 2 – Between advanced warning sign and lane shift
Zone 3 – Within lane shift
Zone 4 – Within work zone
Zone 5 – Outside of work zone

The TAC anticipated that the Zone 3 lane shift category was the cause for the most incidents and the most problematic area for heavy equipment. However, with the database query, the research team found not much difference between the number of incidents associated with Zones 2 and 3. Zone 2 had 42 incidents and Zone 3 had 37 incidents.

The significant majority of incidents occurring for heavy equipment are in Zone 4, accounting for 139 of the 229 total incidents. Zones 1 and 5 accounted for the fewest incidents for heavy equipment, but still account for 19 of the 229 total incidents.

The discrepancy between the experiences of the expert panel and the data provided by the Iowa DOT crash database serve as conflicting information in this study. In this case, further examination must be considered when analyzing these data.

The discrepancy could be a due to many different factors. One possible contributing factor to the conflicting evidence is that reporting officers may not be identifying the Iowa DOT-defined zones in which a work-zone-related incident is occurring consistently or correctly. Training procedures on filling this section of the incident form may not be consistent between jurisdictions.

Another source of variance from the reporting officer may be that, given each highway construction project is unique, it would be difficult to identify comparable zones for each highway project.

Another likely factor for the significant majority of the incidents that occur in Zone 4 is the amount of exposure that the traveling public has in this zone. In a particularly long work zone, the relative sizes of Zones 3 and 4 may be drastically different. Zone 4 may not be any more dangerous than Zone 3 but, simply because Zone 4 accounts for a higher percentage of the overall job site length, it will have more incidents associated with it. This factor was identified as the most likely source of the discrepancy between expert panel experience and statistical data.

5.3. Incident Reports

Due to the conflicting evidence presented by the TAC and the Iowa DOT crash database, individual incident narratives were analyzed to supplement previous evidence. These individual reports included detailed information about each incident.

Within these narratives, it became clear that the Iowa DOT zone in which each incident occurred was not the only cause that leads to each incident. From the narratives, it became clear that the types of incidents that were occurring may be just as critical as the location in which they are happening.

For example, merging traffic in Zone 3 may cause traffic well beyond Zone 3 and into Zone 2 to form a large queue. This line up of vehicles could then potentially lead to an incident that occurs in Zone 2 but, in effect, is an incident caused by activity in Zone 3. This situation is not accounted for in the classification of the location of the incident in the crash database. The data pointed toward many of the incidents being caused by a typical Zone 3 activity.

The most relevant information that would need to appear in future incident reports is the location of the cause of the incident. This would allow analysis for the types of incidents to coincide directly with the location of the cause of the incident rather than the location of the incident itself.

5.4. Ingress and Egress Survey

Through the assessment of the Ingress and Egress Survey, several conclusions can be made about addressing concerns on ingress and egress points on highway construction sites. Given all except one respondent was a DOT respondent from either Iowa or a surrounding state, inferences can only be made about the owner's view of ingress and egress safety.

For the "closed" work zone, combining the counts for upgrade/additional equipment, markings and using correct, clean, and undamaged traffic control devices, nearly half of the responses address use of some type of equipment. Owners, and particularly inspectors, reported that improper use of traffic control equipment can be a major contributor that causes confusion for truck drivers, equipment operators, and the traveling public alike. Additional equipment and upgrading equipment often comes in the form of signage, arrow boards, message boards, and any other additional equipment that a contractor can provide to either protect the job site or communicate with the traveling public.

This assessment is supported by the insights provided by the traffic control contractor in the personal interviews. In their previous experience, the more devices that are provided to grab the attention of drivers in either a divided highway or interstate highway construction project, the more aware that drivers will be and, in turn, the safer the project will be.

The second major category of responses for the survey addressed problems with ingress and egress by means of either extending distances for ingress and egress, so that drivers and operators are able to accelerate or decelerate, or providing an alternate route that is less congested by the traveling public.

If either of these techniques can be implemented on a project, they would certainly improve the interactions that truck drivers have with the traveling public. Not only can the safety of ingress and egress be improved by using alternate routes, items such as alternative delivery methods can be assessed on a project-specific basis to help minimize interactions and incidents involving the traveling public.

Many of the individual responses were very similar for addressing ingress and egress safety improvement from the survey with one exception. Many of the respondents provided many more unique answers for the "open" work zone. Individual answers did not agree as strongly on the "open" work zone improvements when compared to the "closed" work zone improvements.

Typical "closed" work zones are often set up in a very similar manner from project to project. The same types of channeling devices, barriers, and other traffic control devices are used in most “closed” work zones and standard traffic control plans are easier to implement. With an “open” work zone, many more unique situations that require an adapted traffic control plan are required.

5.5. Developing the Job-Site Communication Model

Through the solicitation of personal interviews and the insight provided by the TAC, a Lines of Communication Model was developed as shown in Figure 5.1.

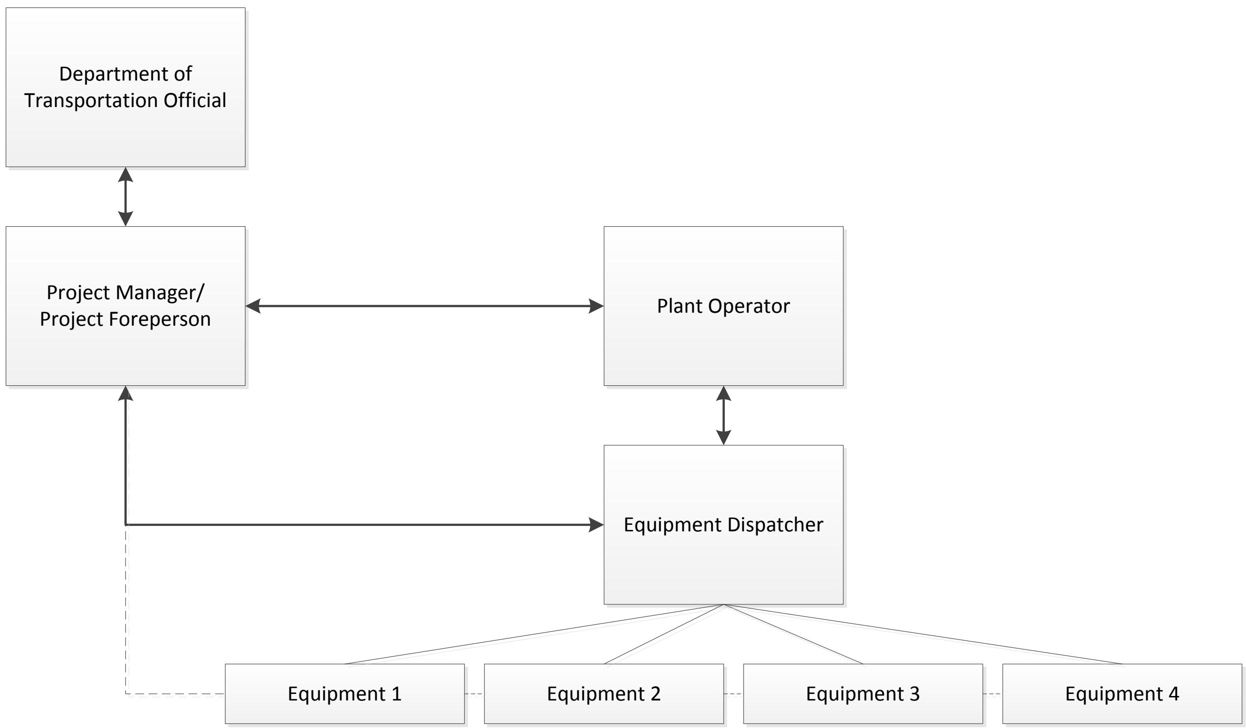


Figure 5.1. Sample job-site communication model

More specifically, job-site communication models are a concept derived in this study from the combination of the interview with the ready mix plant operator and the common theme of effective communication that was found in the qualitative data collection interaction.

Included in the model are the roles of DOT officials, project managers, project forepersons, plant operators, equipment dispatchers, and equipment operators. Solid lines represent primary lines of communication and dashed lines represent secondary lines of communication.

In all highway construction projects, it is essential that lines of communication are thoroughly established and open. Conflicts often arise from parties not knowing whom to contact, or parties not forwarding relevant information to the proper people. Because of the volatility and ever-changing conditions of a job site, it must be noted that each model that is developed for a project must be flexible and adaptable to changes.

It is the responsibility of project managers and project forepersons to receive input from all relevant parties included in the operation. Ideally, models would be developed with specific names of personnel, their contact information, and a secondary contact in case the primary contact is not available.

Communicating Major Changes

If there are major changes to ingress and egress points, a project manager must consult with the RCE within the district. After any major changes or modifications are approved by the RCE, this information must be passed clearly and concisely to both plant operators and equipment dispatchers.

Once this exchange has been completed, the dispatcher is responsible for communicating changes to the equipment operators. This communication can be done in a number of ways.

A job-site drive-through may be performed using a large passenger van to show operators the new haul route or roadway within the job site. If the changes are known ahead of time by the equipment operators or the changes are minor, radio communication between dispatch and operators may suffice. However, if a more hands-on approach is taken with regards to communication, it is much more likely that relevant information will be passed on.

Communicating Differing Conditions

Given a job site is dynamic in so many ways, not only must there be a line of communication from a management level to an operator or laborer level, operators and laborers must be able to communicate changes in job-site conditions up the channel to management personnel. Along with communicating to their own dispatch and plant operator, operators and laborers must also be able to communicate to the project manager or project foreperson. An active approach by any driver, operator, or laborer must be taken to ensure that any differing condition be communicated to other drivers and laborers, as well as management personnel. A sample model is provided in Figure 5.2.

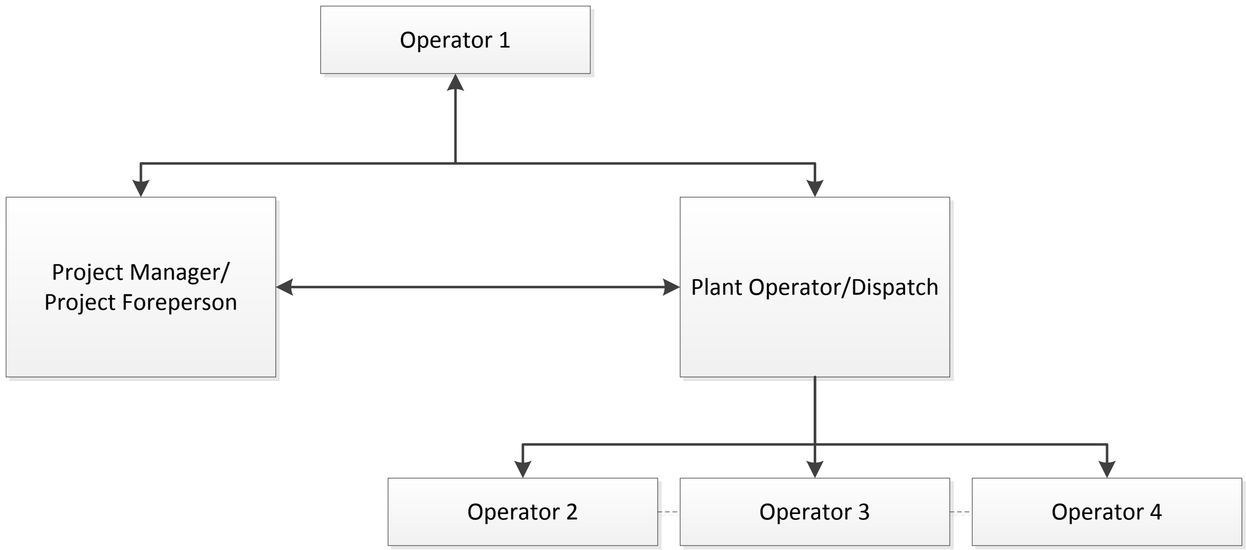


Figure 5.2. Differing conditions communication model

Coordination of Equipment Deliveries

Often, a communication model needs to be adjusted or modified. If a new equipment delivery is to arrive on-site, a communication model that is developed may resemble the model in Figure 5.3.

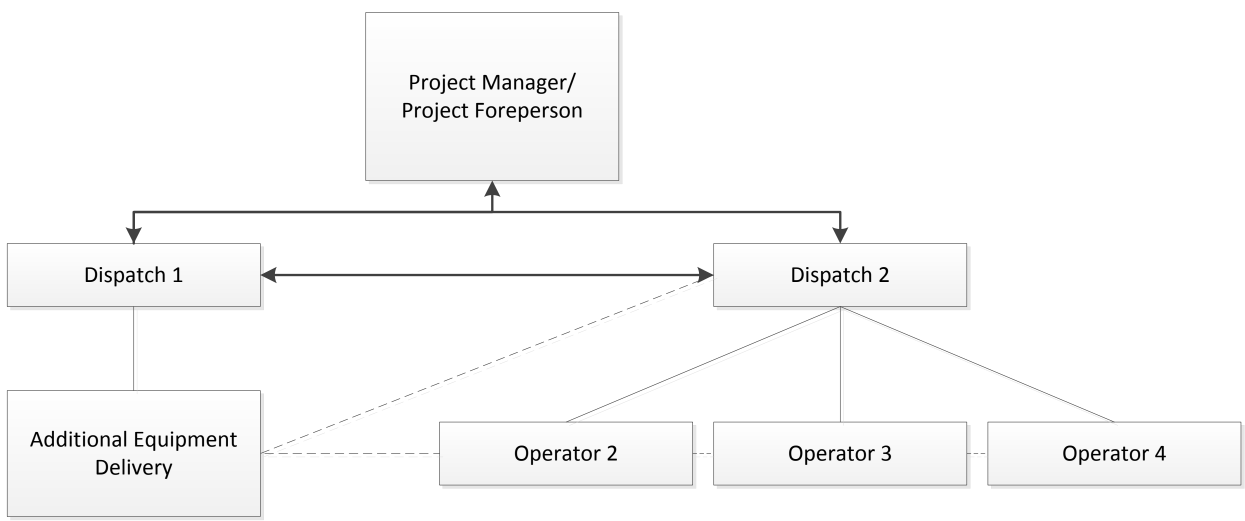


Figure 5.3. Communication model for major equipment delivery

If multiple points of dispatch need to be considered, the dispatchers will often need to work closely to coordinate the delivery, especially in congested work zones. To ensure mobility of both the additional equipment and the existing operations, it is likely that many more secondary lines of communication must be established.

5.6. Implementation Readiness and Recommendations

- OSHA and Iowa OSHA data should be used as a basis to compare safety on a statewide and national level. Metrics are difficult to provide within individual states; however, individual states should compare incident rates to national averages and push to keep the trend of decreasing incident rates. Iowa, in the past 15 years, has not proven to have lower incident rates than the national average and more often than not have reported statistically higher incident rates than the national average.

- The Iowa DOT crash database has been an effective tool in analyzing incidents that are work-zone-related. At this time, incidents in the Iowa DOT Zone 4 within the work zone represent by far the highest percentage of incidents as far as location is concerned. Although this can be for a number of reasons, it represents the most problematic area with regards to how contractors interact with the traveling public.

- The methods in which reporting officers identify the location of an incident within the Iowa DOT's defined Zones 1 through 5 in a work zone should be reviewed to ensure not only consistency in reporting, but also reporting of the Zone in which the cause of the incident occurred. In addition, the manner in which crash narratives are filled out for each incident is essential to identifying the major causes of each incident. Consistency is of the upmost importance when trying to normalize this data.

- Ingress and egress areas on construction job sites, as expressed by the TAC and during personal interviews, represent the most challenging areas to address work-zone safety and mobility. Although these areas do not represent the highest frequency of incidents, they were cited consistently by contractors, truck drivers, and Iowa DOT personnel throughout this study as the most difficult areas to control. Additional measures in preconstruction planning could provide additional work-zone safety and serve as a time to discuss alternate methods of ingress and egress. This planning can be done not only for vehicles, but for material deliveries as well.

- Personal interviews with experts of various technical backgrounds are essential to formulate the basis of highway construction research. Given highway construction is such a dynamic industry subjected to so many unique project-level difficulties, it is difficult to normalize data. A mixed-methods approach, where qualitative assessments are used, is valuable to confirm conclusions that are found. These same methods should also be used to identify and address discrepancies between common conceptions of highway construction safety and conclusions that statistical data provide.

- Effective job-site communication was a theme that was encountered in almost every stage of this research project. More specifically, the individual interactions between plant operators, dispatch, forepersons, and drivers are the most crucial interactions that pertain to on-the-job work-zone safety and internal traffic control. To support these interactions, effective training programs and project-specific communication models should be developed so that roles and responsibilities of each party are clear.

- Per the pilot project, contractors have the ability to make major changes to internal traffic control plans as well as address how work-zone vehicles interact with the traveling public. Alternative plans, although not always implemented, should always be considered if a potential for improvement in safety, productivity, or cost-effectiveness can be realized. Construction means and methods should be analyzed comparatively with the ability of contractors as well as DOT officials to be flexible in implementing traffic control plans.

5.7. Research Limitations

Iowa and National OSHA Statistics

The population included in these datasets include years 1996 through 2010. In most years, the statistic that is relevant to highway construction work zones is included in the highway, street, and bridge construction category. Any year that was not categorized specifically this way was not included in this study, because it did not include all of the data necessary to normalize these data. Years that were not included in either statistical model were 1999 and 2001. Data for these years were not included only for Iowa, but were considered for national rates.

The data analysis performed on the Iowa OSHA statistics revealed that a suitable predictive model could not be developed because of the large variances within the data. This finding makes it difficult to compare data within the Iowa statistics other than to compare it to a simple average. However, if it is assumed that incident rates should be decreasing every year and not just below average, a comparison to a statistical model must be performed. A statistical model for incident rates on a national level was able to be developed, so this may lend as a comparative tool for incident rates in Iowa.

Iowa Department of Transportation Crash Database

The Iowa DOT keeps a database of all incidents involving motor vehicle crashes in Iowa from year to year. Each incident is covered by a reporting officer and an incident report is filled out describing all of the major variables included in the incident. A sample incident report is included in Appendix D.

Within the incident report are variables such as time of the incident, types of vehicles involved, age of drivers, and whether or not the incident was work-zone-related. One variable that was particularly relevant to this study and included in the Iowa DOT crash database query is whether the incident was work-zone-related. However, this statistic was not recorded until 2008. This limits the research population sample to include data from 2008 through 2011.

Furthermore, one difficulty associated with collecting these data is that many of the variables included in the incident report depend on the discretion of the reporting officer. Officers are trained to fill out the reports, but many incidents are open to interpretation and feedback about the incident from the drivers themselves. Although the incident forms are standardized, there are still areas that are open to inconsistencies.

Another item that must be noted with each incident is that the individual report includes all vehicles involved in the incident. This means that each incident likely has more than one driver and vehicle involved. Because of this, data can underrepresent how much property damage or the types of injuries reported in the statistics alone. An incident report, which covers a crash that only involves a single vehicle, can have the same influence on the data as an incident that involves five vehicles. A strategy used to mitigate this was the review of the incident reports of each individual crash. By doing this, the researchers were able to identify specifically which incidents may cause these inconsistencies.

Finally, one of the inconsistencies found within the incident reports is the location within the work zone that the incident occurred. Sometimes it is unclear when comparing the type of incident that occurred to the location of the incident that is indicated within the incident report.

For example, an incident that occurred because of merging traffic is often associated with the Iowa DOT Zone 3, within the lane shift, but may have been considered by the reporting officer to be a Zone 4 incident, or one within the work zone.

The research sample of incident reports for heavy equipment incidents covers about 10 percent of the total incidents considered in the study allowing more detailed information to be revealed about each incident. A larger sample may have led to more consistencies between the incident reports and the incident statistics.

Technical Advisory Committee

The TAC was composed of two university professors, several Iowa DOT officials and employees, and several heavy equipment and highway construction contractors. Although there is a diverse and a wide range of expertise, the suggestions and guidance of the TAC is limited to their collective expertise.

Although these limitations were mitigated by having several meetings and interactions, items such as pilot projects, job-site tours, and any unique experiences may contribute in an unrepresentative manner to the study. With that, however, expertise from highway construction experts was essential to this project. The TAC’s experiences and insight led to many of the research objectives that are addressed in this study.

Personal Interviews

The personal interviews performed in this study were completed in a combination of two different interview methods. The first is an Informal Conversation type interview and the second, a General Interview Guide. Questions were prepared before each interview was conducted, but questions were not standardized.

The intent of the study was not to interview several personnel over the same subject but to develop many different views of the same types of problems to depict a broad picture of the problems facing highway construction safety.

For example, a traffic control technician was interviewed to explore difficulties when interfacing with the traveling public. Information about difficulties that contractors face on DOT projects, on the other hand, was covered in an interview with a project manager from a contracting agency.

This interview style was performed deliberately to allow the flexibility in the answers provided by each individual to open up new ideas to address highway construction safety, mobility, and internal traffic control.

Many of the same challenges that were presented by the TAC arose again during personal interviews. The insights provided by an individual's interview are limited to their personal experiences and training. However, given those interviewed in this study are considered experts and a wide range of highway construction personnel were interviewed, any individual bias is also mitigated. Quantitative statistics, as well as other qualitative research, were used to confirm individual experiences.

Pilot Project

A full safety implementation program was not performed as a part of this study. However, unique items regarding safety and job-site mobility were addressed. The pilot project was not designed to implement new practices but served as a comparison to the "ideal" approach for work-zone safety, mobility, and internal traffic control.

The basis of the pilot project was to identify either a typical or complex highway construction project and help identify unique processes and how those processes can be incorporated into a new safety program.

5.8. Possible Future Research

Future research is often identified by the limitations or findings of previous research. Work-zone safety, mobility, and internal traffic control comprises a vast spectrum of topics that involve wide varieties of personnel, all of whom have an effect on project success. This project was framed around personal interviews with expert panel members and the analysis of general statistical data.

Normalizing Iowa DOT crash data with relation to mileage would be an important statistical backing feature that would help eliminate some of the ambiguities presented by the findings in this study.

Data for Zones 1 through 5 of the work zone are difficult to compare given relative lengths are extremely different within each zone and are unique to each job site. Normalizing this data would include collecting data that indicates the length of each zone for either every highway construction project or a representative sample of every highway construction project performed in a given year. Having this data would help to confirm or deny specific claims about which Iowa DOT Zone is the most dangerous and problematic for highway contractors.

An investigation in how reporting officers classify work-zone-related incidents would be valuable to perform, as well, given the discrepancies discovered in this study. Inconsistencies in how each Iowa DOT Zone is identified in individual incident reports may be a cause of some of the conflicting evidence in how work-zone-related incidents are reported.

A second source of inconsistencies lies in the way reporting officers fill out incident narratives. In certain cases, a very thorough narrative was discovered and the cause of the incident was very easy to identify and assign a classification. However, on the other end of the spectrum, a narrative was not provided for certain incidents at all, which led to the inability to classify the incident. Without consistent reporting from all jurisdictions, it is difficult to normalize data and therefore is difficult to analyze data statistically because of these limitations.

An extensive program-level safety implementation project would likely be of interest to build on the findings of this project. For example, a project related solely to ingress and egress on construction sites could provide research topics for future studies. From program-level implementation, a standardized mentoring program for drivers, operators, and laborers could also be explored.

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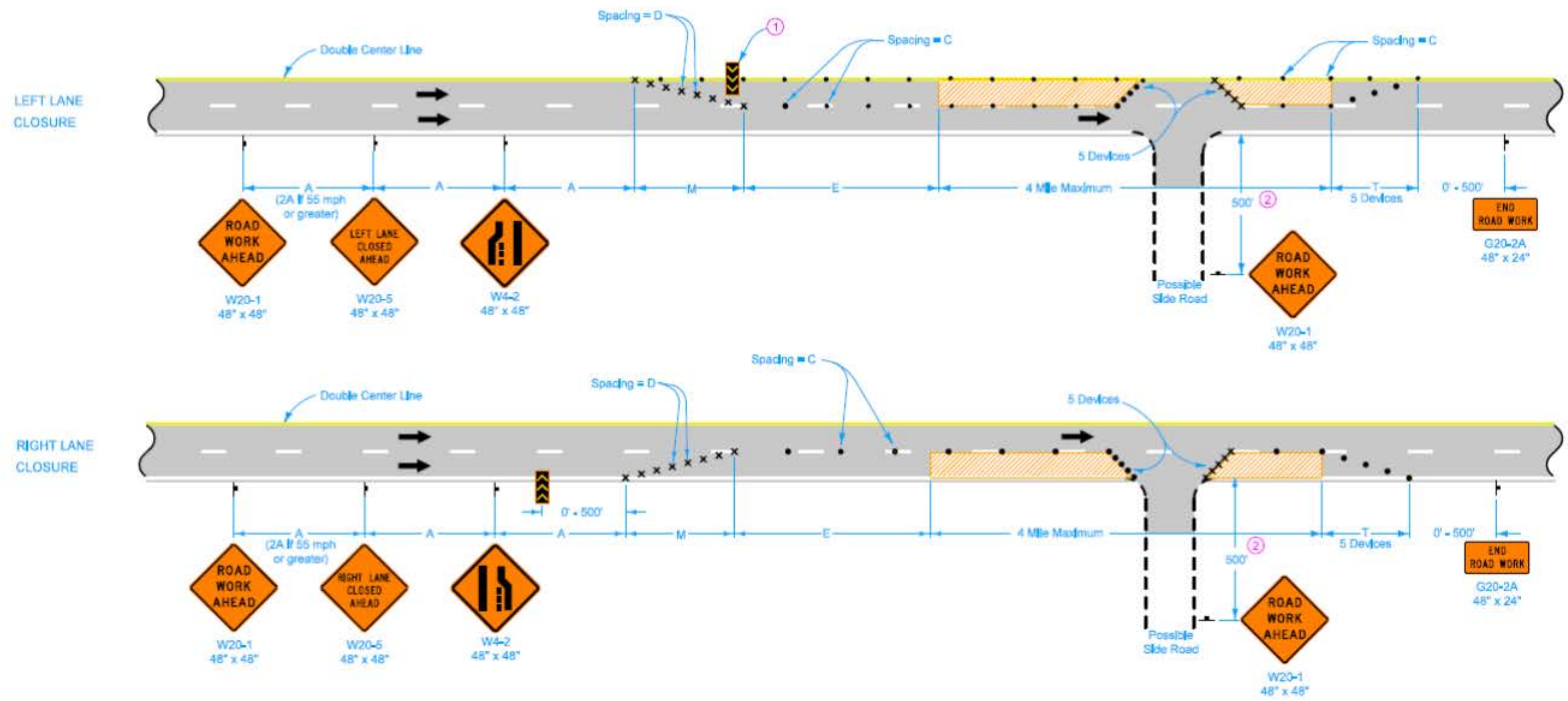
APPENDIX A. VARIABLES USED FOR IOWA DOT CRASH DATABASE QUERY

Field Name	Field Description	Values	Values Descriptions	Field Type
CaseNumber	Case Number. Iowa DOT		4 digit year + number assigned by MVD (e.g., 2001002534)	Numeric: Integer
VConfig	Vehicle Configuration	1	Passenger car	Numeric: Integer
		2	Four-tire light truck (pick-up/panel)	
		3	Van or mini-van	
		4	Sport utility vehicle	
		5	Single-unit truck (2-axle/6-tire)	
		6	Single-unit truck (>= 3 axles)	
		7	Truck/trailer	
		8	Truck tractor (bobtail)	
		9	Tractor/semi-trailer	
		10	Tractor/doubles	
		11	Tractor/triples	
		12	Other heavy truck (cannot classify)	
		13	Motor home/recreational vehicle	
		14	Motorcycle	
		15	Moped/All-Terrain Vehicle	
		16	School bus (seats > 15)	
		17	Small school bus (seats 9-15)	
		18	Other bus (seats > 15)	
		19	Other small bus (seats 9-15)	
		20	Farm vehicle/equipment	
		21	Maintenance/construction vehicle	
		22	Train	
		23	Other (explain in narrative)	
		77	Not reported.	
		99	Unknown	
WZ_Related	Workzone Related?	1	Yes	Character
		2	No	
WZ_Loc	Location	1	Before work zone warning sign	Numeric: Integer
		2	Between advance warning sign and work area	
		3	Within transition area for lane shift	
		4	Within or adjacent to work activity	
		5	Between end of work area and End Work Zone sign	
		8	Other work zone area (explain in narrative)	
		9	Unknown	
		77	Not reported.	

APPENDIX B. SAMPLE TRAFFIC CONTROL PLANS



Possible Contract Item:
Traffic Control

LEGEND

- Traffic Sign
- Drum
- 42" Channelizer
- Arrow Board
- Work Area
- Direction of Traffic

SPEED LIMIT (mph)	A	C	D	E	M	T
35 or less	250'	40'	35'	0'-200'	245'	50'
40	500'	80'	40'	0'-300'	320'	50'
45	700'	80'	45'	0'-400'	630'	100'
50	700'	80'	45'	400'	630'	100'
55 - 60	1000'	100'	55'	600'	770'	100'

Where there is a lane line drop-off or rise, do not allow traffic to cross over the drop-off or rise, except for ramp locations where a BUMP (W8-1) sign is placed.

Drop-offs greater than a nominal 4 inches are not allowed during non-working hours.

① Place arrow board within the closed lane behind the drums and as close to the beginning of the taper as practical.

② Where side road speed limit is 40 mph or less, a distance of 200 feet is allowed.

Iowa Department of Transportation

STANDARD ROAD PLAN

REVISION	
5	10-16-12

TC-419

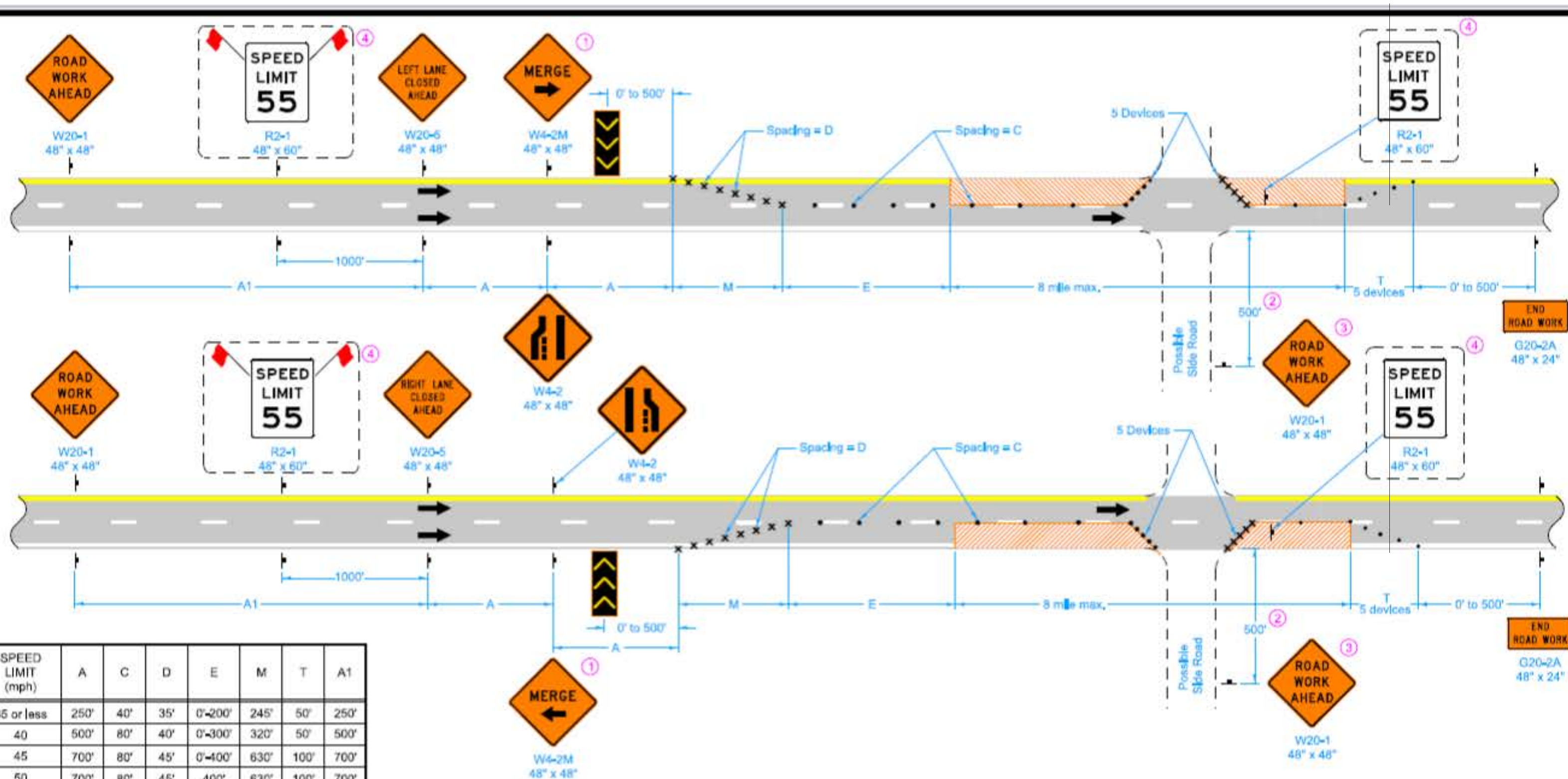
SHEET 1 of 1

REVISIONS: Changed Arrow Panel to Arrow Board to comply with changes to MUTCD.

Deanna Maifield

APPROVED BY DESIGN METHODS ENGINEER

LANE CLOSURE ON UNDIVIDED HIGHWAY



SPEED LIMIT (mph)	A	C	D	E	M	T	A1
35 or less	250'	40'	35'	0'-200'	245'	50'	250'
40	500'	80'	40'	0'-300'	320'	50'	500'
45	700'	80'	45'	0'-400'	630'	100'	700'
50	700'	80'	45'	400'	630'	100'	700'
55 - 60	1000'	100'	55'	600'	770'	100'	2000'
65 - 70	1000'	100'	65'	700'	910'	100'	2000'

LEGEND

- Direction Of Traffic
- Traffic Sign
- × Drum
- • 42" Channelizer
- Arrow Board
- Work Area

When the Average Daily Traffic (ADT) exceeds 20,000 vehicles per day or when a traffic queue extends beyond the advanced signing, place RIGHT/LEFT LANE CLOSED 4 MILES and RIGHT/LEFT LANE CLOSED 2 MILES signs (W20-5) on both sides of the roadway 4 miles and 2 miles in advance of the lane closure, respectively, as appropriate.

Where there is a lane line drop-off or rise, do not allow traffic to cross over the drop-off or rise, except for ramp locations where a BUMP (W8-1) sign is placed.

Drop-offs greater than a nominal 4 inches are not allowed during non-working hours.

1. Refer to SI-881 for sign details.
2. Where side road speed limit is 40 mph or less, a distance of 200 feet is allowed.
3. Place a ROAD WORK AHEAD sign on the opposite side of the intersection in a similar location.
4. For roadways with a posted speed limit of 60 mph or greater before road work:

   Place SPEED LIMIT 55 signs prior to the lane closure as shown.

   When the length of closure is greater than 1 mile, install SPEED LIMIT 55 signs in the closed lane at 1-mile intervals.

   Remove or cover all existing signs that conflict with 55 mph speed limit while 55 mph speed limit is in effect.

Possible Contract Item:
Traffic Control

Iowa Department of Transportation

STANDARD ROAD PLAN

REVISION	
7	10-16-12

TC-418

SHEET 1 of 1

REVISIONS: Changed Arrow Display to Arrow Board to comply with changes to MUTCD. Removed W3-5 sign.

Deanna Maifield
APPROVED BY DESIGN METHODS ENGINEER

LANE CLOSURE ON DIVIDED HIGHWAY

APPENDIX C. EXAMPLES OF INNOVATIVE TECHNOLOGIES FOR FUTURE IMPLEMENTATION

Figure C.1. Temporary rumble strips

Figure C.2. Temporary signal lighting

Figure C.3. Water-filled barrier system for interim-term use

APPENDIX D. SAMPLE INCIDENT REPORT

COURTESY, SERVICE, PROTECTION

IOWA STATE PATROL

IOWA STATE PATR
DEPARTMENT OF PUBLIC SAF

Crash Information

LOCATION

Date of Accident	Time of Accident	County	Accident occurred within corporate limits of (city)	Law Enforcement Case Number:
5/11/2012	12:10 PM	Pottawattamie - 78		[redacted]

Literal Description	Legal Intervention?	Private Property
NB/EB INTERSTATE 0029 UNDERPASS OF INTERSTATE 0680 MEASURING 284 FEET SOUTH FROM INTERSTATE 0029 (MILEPOST 62)	No	No

X-Coordinate:	Y-Coordinate
257377.8	4582163.

UNIT 1

Driver's Name - Last	First	Middle	Suffix
[redacted]	[redacted]	[redacted]	

City	State	Zip
SOUTH SIOUX CITY	NE - Nebraska, US	687760000

Driver's Age	Citation Charge Code 1	Citation Charge 1
22	321.285	FAILURE TO STOP WITHIN THE ASSURED CLEAR DISTANCE

Gender	State	Class	Endorsements	Restrictions	Citation Charge Code 2	Citation Charge 2
Female	NE - Nebraska, US		None	None		

Alcohol Test Given?	Drug Test Given?	Citation Charge Code 3	Citation Charge 3
1 - None	1 - None	Citation Charge Code 4	Citation Charge 4

Seating Position	Injury Status	Occupant Protection	Airbag Deployment	Airbag Switch Status	Ejection	Ejection Path	Trapped
01 - Front: Left Side / Motorcycle Driver	5 - Uninjured	2 - Shoulder and lap belt used	5 - Not deployed	3 - No ON/OFF switch present	1 - Not ejected		1 - Not trapped

Transported to:	Transported by:
NA	NA

Insurance Co. Name

Year	Make	Model	Style	Approximate Cost to Repair Replace
2003	Ford - FORD	TAURUS	SES	5000

Initial Travel Direction	Vehicle Action	Speed Limit	Point of Initial Impact	Most Damaged Area	Extent of Damage	Underride/Override
1 - North	01 - Movement essentially straight	65	01 - Front	01 - Front	3 - Functional damage	1 - None

Total Occupants	Traffic Controls	Vehicle Config.	Cargo Body Type	Vehicle Defect	Driver Condition	Vision Obscured	Contributing Circumstances, Driver (up to 2)
01	01 - No controls present	01 - Passenger car	01 - Not applicable	01 - None	1 - Apparently normal	01 - Not obscured	

SEQUENCE OF EVENTS	First Event	Second Event	Third Event	Fourth Event	Most Harmful Event (by vehicle)
	06 - Evasive action (swerve, panic braking, etc.)	21 - Vehicle in traffic			21 - Vehicle in traffic

Emergency Vehicle Type	Emergency Status
1 - Not applicable	3 - Not Applicable

Carrier Name	City	State	Zip

UNIT 2

Driver's Age 53					Citation Charge Code 1	Citation Charge 1		
Gender Male	State NE - Nebraska, US	Class	Endorsements None	Restrictions F - Outside Mirror	Citation Charge Code 2	Citation Charge 2		
Alcohol Test Given? 1 - None			Drug Test Given? 1 - None		Citation Charge Code 3	Citation Charge 3		
					Citation Charge Code 4	Citation Charge 4		
Seating Position 01 - Front: Left Side / Motorcycle Driver	Injury Status 5 - Uninjured	Occupant Protection 2 - Shoulder and lap belt used		Airbag Deployment 5 - Not deployed	Airbag Switch Status 3 - No ON/OFF switch present	Ejection 1 - Not ejected	Ejection Path	Trapped 1 - Not trapped
Transported to: NA					Transported by: NA			
Insurance Co. Name								

Year 2008		Make Ford - FORD		Model F150		Style PU	Approximate Cost to Repair Replace 2000
Initial Travel Direction 1 - North	Vehicle Action 01 - Movement essentially straight	Speed Limit 70	Point of Initial Impact 05 - Rear	Most Damaged Area 05 - Rear	Extent of Damage 2 - Minor damage	Underride/Override 1 - None	
Total Occupants 01	Traffic Controls 01 - No controls present	Vehicle Config. 02 - Four-tire light truck (pick-up, panel)	Cargo Body Type 01 - Not applicable	Vehicle Defect 01 - None	Driver Condition 1 - Apparently normal	Vision Obscured 01 - Not obscured	Contributing Circumstances, Driver (up to 2)
SEQUENCE OF EVENTS			First Event 21 - Vehicle in traffic	Second Event	Third Event	Fourth Event	Most Harmful Event (by vehicle) 21 - Vehicle in traffic
Emergency Vehicle Type 1 - Not applicable					Emergency Status 3 - Not Applicable		
Carrier Name			City		State		Zip
Number of Axles			Gross Vehicle Weight Rating		Placard #		Hazardous Materials Releas

ACCIDENT ENVIRONMENT		ROADWAY CHARACTERISTICS Major Contributing Circumstances:	WORKZONE RELATED?	SEQUENCE OF EVENTS
Location of First Harmful Event 1 - On Roadway	Weather Conditions (up to two) 01 - Clear	Environment 1 - None apparent	Location	First Harmful Event of Cra (use codes 11-42 only) 21 - Vehicle in tra
Manner of Crash/Collision 3 - Rear-end		Roadway 01 - None apparent	Type	
Light Conditions 1 - Daylight	Surface Conditions 1	Type of Roadway Junction/Feature 01 - No special feature	Workers Present?	

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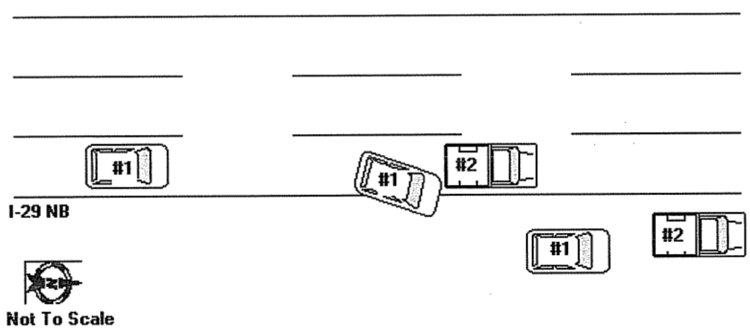

NARRATIVE

VEHICLE #2 WAS NB ON I 29. VEHICLE #1 ENTERED ON TO I-29 FROM 680 ON RAMP AND CONTIUNED NORTH O
I-29. TRAFFIC IN FRONT OF VEHICLE #1 AND 2 BEGAN TO SLOW, VEHICLE #2 SLOWED FOR TRAFFIC, VEHICLE
TRIED TO SLOW BUT WAS UNABLE TO AVOID STRIKING VEHICLE #2 IN THE RIGHT REAR WITH VEHICLE #1'S LE
FRONT. VEHICLE #1 DID HIT BRAKES AND ATTEMPTED TO SWERVE IN AN ATTEMPT TO MISS VEHICLE #2.

Officer **MOORE**	Badge No. **418**	Time Officer Notified of Accident **12:32**	Time Officer Arrived At Scene **13:04**
Name of Agency **P03**	Date of Report **5/11/2012**	Investigation made at scene? **Yes**	T.I. #