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To the Graduate Council:

I am submitting herewith a thesis written by Travis Strong entitled "Injury rates and the effect of project scheduling on highway and street construction." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Civil Engineering.

Harold Deatherage, Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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and recommend its acceptance:

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Thesis
2003
.S876

Injury Rates and the Effect of Project Scheduling on Highway and Street Construction

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Travis Strong
December 2003

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Abstract

In this study, the high injury rate in the construction industry is analyzed to identify trends. The study specifically addresses injuries that occurred in highway and street construction from 2002 to 2003 in Tennessee. Injury rates were established for injuries that occurred in overtime and during weeks of accelerated work. Injury rates by day of the week and craft were also established. This study found that days with greater than 8 hours worked and weeks with high percentages of over time pay affected injury rates.

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Chapter 1

Introduction

1.1 Background

The construction industry is distinctive in that it generally produces a unique product for each project, as opposed to manufacturing. This ever-changing work environment leads to a disproportionate number of construction worker injuries relative to worker injuries in other industries. Coping with accidents is costly and time-consuming for construction personnel and managers, as well as for project owners who ultimately pay for the cost of injuries.

The University of Tennessee was involved in a research project funded by The National Institute for Occupational Safety and Health (NIOSH) through the Center to Protect Workers Rights (CPWR) to examine injuries that occurred on highway construction. Specifically this project was examining the relationship between work scheduling and injury rates. The goal of this study was to determine if injury rates were significantly affected by overtime status and project acceleration. Injury rates by day of the week and craft were also examined, as well as the percentage of injuries resulting in days away from work.

1.2 Construction Industry Injury Statistics

The Bureau of Labor Statistics (BLS) has compiled massive databases on occupational injuries in the United States. BLS data on the construction industry over the past twenty years indicates that there is a much higher incident of accidents per 100 full time workers than the national average for all other industries. The construction industry had the distinction of having the highest rate of accidents per 100 full time workers of all industries from 1981 through 1993. In 1993 the construction industry incident rate fell below that of manufacturing and has not had regained the highest rate since, although in 2001 (the last year of available data) construction and manufacturing injury rates were nearly equal (1). The construction industry is divided into three categories: general building construction, heavy construction, and specialty construction. Heavy construction is further divided into two divisions, which are highway and street construction and heavy construction, except highway. From 1996 through 2001, the national average injury rate per 100 full time workers was 8.9 and 7.9 for highway and street construction and heavy construction, except highway, respectively. The BLS also provides incident rates for all fifty states. For the six-year period noted, Tennessee's highway and street construction had an average of 7.3 accidents per 100 full time workers, which were 1.6 accidents per 100 full time workers lower than that of the national average (2). Incident rates are shown in Table A1 and Figures

A1 through A5[1]. The scope of this project will only include accidents occurring during highway and street construction in Tennessee.

1.3 Objective

The main objective of this thesis was to investigate whether there were significant differences in injury rates due to project scheduling and days of the week. Accident data from contractors participating in the study and payroll data maintained by the Tennessee Department of Transportation (TDOT) were analyzed. Specific relationships between project scheduling and injuries that were analyzed were as follows:

1. Injury rates of workers in regular time and overtime status.
2. Injury rates of workers on projects in accelerated and non-accelerated status.
3. Injury rates of workers by day of the week.

An employee was in overtime status on any day with paid overtime on that day or the preceding calendar day, and on any day with “daily overtime” (hours worked in excess of eight hours) on that day or the preceding calendar day. Work in other days was defined as regular time status. A project in an accelerated status was defined as any week that the percentage of paid overtime exceeded the percentage of paid overtime for the entire project, as well as any week that the percentage of “daily overtime” exceeded the percentage of “daily overtime” for the entire project. Injury rates by day of the

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[1] All figures are located in the Appendix.

week were defined as all injuries on all jobs occurring on a specific day of the week divided by all hours on all jobs on the specific day.

1.4 Methodology

Various highway and street construction contractors in East Tennessee were contacted and asked to participate in the study. Any works performed on contracts let by TDOT that are federally funded require certified payrolls to be submitted to TDOT in accordance with the Davis-Bacon Act. The Davis-Bacon Act applies to contractors and subcontractors who are performing work on federally funded or assisted contracts in excess of $2,000 for the construction, alteration, or repair (including painting and decorating) to public buildings or public works. The Act requires those contractors and subcontractors to pay at least minimum wage—the prevailing wage—and fringe benefits to anyone working directly at the site. Davis-Bacon prevailing wages are determined by the Secretary of Labor and are based on wages and fringe benefits paid to laborers working on similar projects in the same area. The seven contractors who participated in the study provided information on worker injuries by providing access to their Occupational Safety & Health Administration, OSHA 300 logs. These logs contain specific information on injuries that occur in a calendar year. Fifty-nine injuries that occurred on twenty-eight TDOT projects during 2001 through 2003 were used in the study. These projects had a cumulative value of work estimated to be 316 million dollars, based on contract amounts. Since some of the projects are still ongoing, the study did not examine any injury rates related to monetary cost of work performed. The certified payrolls maintained by TDOT for the twenty-eight projects of interest were obtained from the various TDOT offices that managed the projects. The payrolls provided the number of hours worked by an employee on a given day over the span of the project. The data on the payrolls were then converted to electronic form in a database. Various analyses were then performed on the information in the database to identify trends in project scheduling and injury rates present in Tennessee highway and street construction work. The results of the analysis are presented herein.

Chapter 2

Literature Review

2.1 Introduction

There is a vast amount of literature dealing with work related accidents in the construction industry. Many published studies have common themes, such as injury prevention and costs of injuries. However, there was very few studies found that dealt specifically with injuries and overtime. A brief overview of published works on construction injuries is presented in this section.

2.2 Lowery, *et al.*, Glazner, *et al.*

The construction of the Denver International Airport (DIA) provided a unique opportunity to study risk factors for injuries and injury rates on a large construction project. The city of Denver, the owner, implemented an Owner Controlled Insurance Program (OCIP). This program provided all workers compensation and general liability insurance for the entire project, and established an on-site medical clinic and physician referral system as designated provider for all work-related injury and illnesses. All worker's compensation claims for the project were recorded in a centralized database along with denominator data in the form of payroll. The DIA was built between September 1989 and August 1994 with 2,843 contracts awarded to

769 contractors. Of these, 74 contractors held 128 prime contracts and hired subcontractors as necessary. Work-related injury and illness in a group consisting of 32,081 individual employees were retrospectively examined to determine injury rates on the project. From claims and person-hours, injury rates per 200,000 hours at risk were calculated. One hundred full time employees (as reported by the BLS) are comparable to 200,000 person-hours per year. For the time period of 1991 to 1994, it was found that the incident of work-related injury and illness for on-site workers building the DIA were as much as 2.3 times the BLS's published rates for the construction industry for the same time period. The authors believe that the difference between the DIA's injury rates and the BLS's is largely attributable to underreporting to the BLS survey (3).

Another study, which identified risk factors for injury on the construction of the DIA, had findings that were relevant to this thesis. From claims and payroll data linked with employee demographic information, injury rates were calculated. Poisson regression models were used to examine contract-specific risk factors in relation to total injuries, lost-work-time (LWT), and non-LWT injuries. It was found that injury rates were highest during the first year of construction, at the beginning of contracts, and among older workers. Risk for total and non-LWT injuries were higher for building construction contracts, contracts with payrolls over $1 million, and those with overtime payrolls greater than 20 percent of total payroll. The authors were not able to link overtime payroll to individuals to determine whether injuries were more common among workers paid for overtime, and it was not found that risk of LWT injury increased with increased overtime. One possible explanation offered between the lack of association between overtime and LWT injury in the analysis was that workers earning high overtime wages were reluctant to miss work (4).

2.3 Everett and Frank

In addition to moral or humanitarian commitment, owners have an economic incentive to employ safe contractors because the owners bear the cost of construction injuries. In 1979, the Business Roundtable (BR) commissioned a study to determine the true cost of accidents and injuries in the construction industry. At the time of the study, the BR concluded that accidents and injuries account for 6.5% of the total cost of industrial, commercial, and utility construction. The BR is an organization comprised of more than 200 chief executives of major corporations who meet to focus and act on a wide range of public issues. The aim of the BR in construction has been to promote quality, efficiency, and cost-effectiveness. John G. Everett and Peter B. Frank Jr. have reexamined the total cost of injuries and accidents in the construction industry. Since the time of the original study, much has changed in the construction industry. The cost of worker's compensation insurance has skyrocketed and there has been a rash of third-party lawsuits as a result of accidents on construction sites. Everett and Frank have recalculated the cost of accidents using assumptions that are varied over a range of values, resulting in an upper and lower bound on the cost of accidents and injuries rather than a single value. Their paper showed that the costs of accidents and injuries have risen from a level of 6.5% of construction costs in 1982 to between 7.9% and 15% in 1996 (5).

2.4 Levitt and Samelson

Raymond E. Levitt and Nancy M. Samelson have done extensive work and research on accidents and injuries in the construction industry. In their book *Construction Safety Management*, they outline how to safely manage construction work at every level and phase of a project. The first part of the book explains how safety saves lives and money. They state that paying less for workers compensation insurance creates the biggest single cost saving. The savings come from lowering the experience modification rating (X-Mod), which is calculated from accident claims experience for the three years prior to the immediate past year. Calculations show that a general contractor with a $5 million dollar work volume whose X-Mod was 150 could save 9% of payroll and 2.2% of total revenue by reducing the X-Mod to 50 through effective safety management. In addition to workers' compensation claims costs, accidents have liability claims and other indirect costs. Though indirect costs are difficult to measure, they are often many times that of the workers' compensation claims cost of an accident. Some examples of hidden costs of an accident are costs to teach replacement workers, costs incurred because of delays resulting from the accident, costs to reschedule work, and cost for safety or clerical personnel as a result of the accident. From 1979 to 1989 accident costs rose from $8.9 billion annually to $17.1 billion, and the cost of worker's compensation insurance rose from $2.74 billion annually to $5.26 billion. According to Levitt and Samelson, construction companies can realize a minimum net savings of 4% of direct labor costs by implementing their safety management techniques (6).

2.5 Simpson

Mitchell Simpson conducted a study that investigated several variables associated with highway and street construction injuries in Tennessee. He analyzed the Tennessee Road Builders Association (TRBA) Workmen's Compensation Trust containing data for 1,225 accidents from twenty-seven contractors. Also, surveys were sent to individual contractors to gain additional information on the accident data. Some of the variables analyzed that are of specific interest to this thesis were the influence of days of the week on accidents, influence of the job classification of workers on accidents, and the severity of accidents. From the TRBA Workmen's Compensation Trust, Simpson found that if the level of work remained constant throughout the week the accidents were uniformly distributed. For the five-year period, approximately 19% of the accidents occurred each day Monday through Friday, with 5% occurring on Saturday and Sunday's. From the information provided by the surveys, results from 235 accidents showed 40% of the injured workers were laborers. Carpenters were the next highest with 17.9%

of the injuries. In the trust each accident was classified according to its severity. Medical-only accidents were claims where less than seven days were lost from work. Simpson found that approximately 70% of the injuries were in the medical-only category (7).

Chapter 3

Data Analysis

3.1 OSHA 300 Logs

The Occupational Safety and Health Act of 1970 requires employers to prepare and maintain records of work related injuries. The OSHA Form 300 *Log of Work-Related Injuries and Illnesses* is used to classify work-related injuries and illnesses and to note the extent and severity of each case. An injury is considered work-related if an event or exposure in the work environment caused or contributed to the injury or illness. Injuries that are required to be recorded are injuries or illnesses that result in:

- Death
- Loss of consciousness
- Days away from work
- Restricted work activity or job transfer
- Medical treatment beyond first aid

The information on the logs provided by the participating contractors that was used in the study was the name of the injured individual (to track overtime status), the date of the injury, and whether or not the injury resulted in time away from work. Only injuries that occurred on TDOT projects were used in this study. The information contained on the logs generally did not include whether or not the injured individual was working on a specific TDOT job. This information was obtained directly from the participating contractors' safety personnel as needed. Initially, when the data-gathering portion of the project concluded, the sample size consisted of 59 injuries from seven contractors working on 28 different TDOT projects. After converting the hard copy certified payrolls to electronic form for analysis, it was noted that some of the injuries were not usable in the analysis. For unknown reasons, there were some discrepancies between the information provided by the contractors and the information on the certified payrolls. Some examples of the discrepancies that made an injury unusable for analysis included:

- Payroll showed zero hours worked by injured individual on the day of reported injury
- Injured individual not on the TDOT project's payroll on which he/she was reported to be working
- No payroll available for reported date of injury

The final sample size consisted of 43 injuries that occurred during 1.2 million hours of work from five contractors and 23 different TDOT projects.

3.2 Classification of Injury

Sections G through L of the OSHA 300 log concern the classification of the injury or illness. The result of the injury or illness can be classified as death, days away from work, or remained at work. Remained at work can be further broken down into job transfer or restriction and other recordable cases. Injuries in this study were classified as resulting in either days away from work or remained at work, as recorded on the OSHA 300 logs. Of the injuries examined in this study, 66% of the injured workers remained at work. This was in good agreement with Simpson's (7) findings on the severity of injuries. Lowery (4) suggested that construction workers could be reluctant to miss work when injured because they do not want to give up the overtime pay.

3.3 TDOT Maintained Certified Payrolls

TDOT maintains payrolls for all contractors and subcontractors performing work on federally funded highway construction in Tennessee. TDOT manages highway construction from four regions, which are further broken down into districts. These regions and districts are shown in Figures A6 through A9. The certified payrolls used in this study came from 23 construction projects in regions 1, 2, and 3. The contract value of the various projects ranged from $0.5 to $30 million. Since some of the projects used in the study are still under construction, the payrolls used in the study were not necessarily for the entire project. The duration of the projects (defined as the number of weeks of payrolls available for each project) ranged from 27 to 152 weeks. The certified payrolls from the various contractors all provided the same basic information: employee name, craft, number of hours worked, and pay rate. Some payrolls also listed number of hours worked on other projects during the week. Since this information was not available on all payrolls, only hours worked on the specific projects of interest were used in the analysis.

As hard copies of payrolls were obtained from the various TDOT offices, the payrolls were entered into a large electronic database to assist with the analysis. For the purpose of this study, the hours worked by employees were sorted into more categories than what was shown on the payrolls. “Regular time” is hours worked that are paid at straight time rate. “Paid overtime” is hours worked that are paid at a premium rate of time and a half. “Straight time” is eight or fewer hours worked in a day, regardless of pay status. “Daily overtime” is any hours worked in excess of eight hours in a day, regardless of pay status. All hours worked on all projects can be found in Tables A2 and A3.

3.4 Injuries in Overtime and Accelerated Status

For the purpose of this study, employees with injuries that occurred in an overtime status and/or in a week that the project was in an accelerated status had to meet these criteria. An employee injured in:

- paid overtime (P.OT) status is defined as an employee who was paid overtime the day of or the day prior to their injury
- daily overtime (D.OT) status is defined as an employee who worked more than 8 hours the day of or the day prior to their injury
- paid project acceleration (PAC) is defined as any week that the percent of paid overtime (total paid overtime hours for that week divided by total hours worked in that week) exceeds the percent of paid overtime for the duration of the project

- daily project acceleration (DAC) is defined as any week that the percent of daily overtime (total daily overtime hours for that week divided by total hours worked in that week) exceeds the percent of daily overtime for the duration of the project

Of the 43 injuries analyzed in this study, the injuries that occurred in the categories defined above are shown in Table 3.1. The number of injuries is the number that occurred in a given category. The percent of injuries is the number that occurred in a category divided by the total number of injuries. The rate is the number of injuries divided by the total number of hours fitting the criteria of the category. Injury rates as reported by the BLS are in injuries per 100 full time workers. This is equivalent to injuries per 200,000 hours, which is calculated from 100 employees working 40 hours a week, 50 weeks a year. For comparison purposes, the injury rates in this study were also reported in injuries per 200,000 hours. The total injury rate in this study was 43 injuries per 1.2 million hours, which is equivalent to 7.1 injuries per 200,000 hours. This is an increase from the last year data was available from the BLS. The BLS reported a rate of 5.1 injuries per 100 full time workers on highway and street construction in Tennessee in 2001. Each category of overtime and project acceleration was considered independently of each other. The injuries that did not occur in overtime or accelerated state are shown in Table 3.2. The denominator for the D.OT injury rate was the total number of hours from all days that employees worked more than eight hours in that day. The

Table 3.1: Overtime and Project Acceleration Injuries.

	EE OT Status		*Project Acceleration*	
	D.OT	*P.OT*	*% P.OT*	*% D.OT*
Number	35	8	26	18
Percent	81.4	18.6	60.5	41.9
Rate	10.2	6.7	9.5	6.6

Table 3.2: Regular Time and Non-Accelerated Injuries

	EE Reg. Status		*Project Non-Acceler.*	
	NO D.OT	*NO P.OT*	*% P.OT*	*% D.OT*
Number	8	35	17	25
Percent	18.6	81.4	39.5	58.1
Rate	3.1	7.2	5.1	7.5

denominator for the P.OT injury rate was the total number of hours from all days that had over time pay. The denominators for the two definitions of project acceleration were all hours worked during all weeks meeting the criteria for acceleration. The denominators for the regular time and non-accelerated injuries were the total number of hours with no daily overtime, no paid overtime, and hours with weeks not meeting the criteria for P.OT and D.OT. The number of hours used as denominators for all categories can be found in Table A4. The rate of injuries that occurred in the employee D.OT status and the P.OT project acceleration status were compared to the rate of non-overtime/accelerated injuries in both categories. The hypothesis was that D.OT and P.OT project acceleration affected injury rates. Using a normal distribution and the 95% significance point of 1.96 (9), it was found that employee D.OT and P.OT project acceleration did affect the rate of injuries. This agrees with Lowery's (4) findings that there is increased risk of injury when overtime payroll exceeds 20 percent of the total payroll. The remaining categories of overtime and project acceleration were not found to significantly affect injury rates.

3.5 Injuries by Day of the Week

The occurrence of injuries by day of the week was established from the date of the injury noted on the OSHA 300 logs provided by the contractors that participated in the study. The greatest number of injuries occurred on

Monday through Friday, with no injuries occurring on Sunday. Tuesday had the highest number and rate of injuries of any day of the week. The injuries were evenly distributed throughout the rest of the Monday through Friday workweek, with an average and maximum deviation of 3 and 5 percent, respectively. The injuries by day of the week are shown in Table 3.3.
Where:

- The number of injuries is the number that occurred on that day of the week
- The percent of injuries is the number of injuries that occurred on that day divided by the total number of injuries
- The rate of injuries is the number of injuries that occurred on that day divided by the total number of hours worked on that day

The number of hours used as denominators for each day of the week can be found in Table A4. The rate is in injuries per 200,000 hours. It should be noted that Monday and Friday had the lowest rate of injuries for the week, excluding Sunday. This contrasts with the idea that more injuries occur on Mondays and Fridays in the construction industry. Graphs of injuries by day of the week can be found in figures A10 through A13. The higher occurrence of injuries on a particular day of the week does not agree with the work done by Simpson (7). Simpson analyzed 1,225 accidents over five years, and found a uniform distribution of accidents in a Monday through Friday workweek where 19% of the accidents occurred each day. With 95%

Table 3.3: Injuries by Day of the Week

	Injuries by Day of the Week						
	Sun.	*Mon.*	*Tues.*	*Wed.*	*Thurs.*	*Fri.*	*Sat.*
Number	0	5	13	8	9	6	2
Percent	0	11.6	30.2	18.6	20.9	14.0	4.7
Rates	0	4.4	10.4	7.1	7.3	5.4	10.1

confidence, the difference between the two samples of injuries that occurred on Tuesday is between 3 and 25 percent (8).

3.6 Injuries by Craft

The Davis-Bacon Act requires that any construction contract over $2,000 which is funded in whole or part by the Federal government shall contain a clause setting forth the minimum wages to be paid to various classes of laborers and craftsmen employed under the contract. Under the provisions of the Act, contractors or their subcontractors must pay workers employed directly on the site of the work no less than the locally prevailing wages and fringe benefits paid on projects of a similar type. The certified payrolls maintained by TDOT that were used in this study contained the craft of every employee who worked on the project. The crafts of the injured workers were examined to determine if there was a prevalence of injury by craft. The injuries by craft are shown in Table 3.4.

Table 3.4 Injuries by Craft

	Laborer	Equipment Operator	Carpenter	Concrete Finisher	Other
Number	25	7	6	3	2
Percent	58.1	16.3	14.0	7.0	4.7
Rate	13.3	3.5	4.5	11.6	3.9

Where:

- The number of injuries is the number that occurred in that craft category
- The percent of injuries is the number of injuries in the category divided by the total number of injuries
- The rate of injuries is the number of injuries divided by the total number of hours worked by employees in that craft

The denominators used in establishing the rate of injuries by class included all hours worked by all job classes meeting the craft categories listed above. The denominators used can be found in Table A4. The rate of injuries is in injuries per 200,000 hours. The category of laborers consisted of all hours worked by skilled and unskilled laborers. Equipment operators included all hours worked by employees who operated heavy machinery or equipment. This category included backhoe, bull dozer, crane, milling machine, asphalt paver and raker, drill, end loader, motor patrol rough and finish, roller, scraper, and sweeper operators. The category of carpenters and concrete finishers had no sub-categories. The category of others included welders, truck drivers, surveyors, pipe layers, oilers, mechanics, ironworkers, foremen and estimators. Simpson (7) analyzed 235 accidents to identify trends of injury by craft. He examined twelve skill levels including Laborer, Carpenter, Concrete Finisher, and Operator. He found laborers had 40 percent of the accidents, followed by carpenters and operators with 17.9 and 11.5 percent, respectively. Concrete finishers had only 4.7 percent. Simpson's findings are similar to those in this study. However, the rate of accidents presented in this study provided more insight on injuries by craft than just the percent of accidents. Laborer's still had the highest rate, but the difference between laborer's injury rates and the other categories was not as overwhelming as the difference in percents. As in Simpson's study, concrete finishers only accounted for a small percentage of the injuries, but this study showed they had the second highest rate of injury of all crafts.

Chapter 4

Conclusions and Recommendations

4.1 Conclusions

The conclusions of this study are as follows:

1. The majority of injuries, 66%, that occurred on highway and street construction in Tennessee were not severe enough to result in time away from work.
2. Injuries occur more frequently when more than 8 hours are worked in a day.
3. Injuries occur more frequently in weeks of project acceleration defined as weeks where the percent of paid overtime that week exceeds the percent of paid overtime for the duration of a project.
4. Monday and Friday have the lowest rate of injury of the Monday through Saturday workweek, and Tuesday and Saturday had the highest rate of injury. Injuries did not occur on Sundays.
5. Laborers had the highest rate of injury among all crafts, closely followed by concrete finishers. In comparison, equipment operators, carpenters, and other crafts had a low rate of injury.

4.2 Recommendations

The main objective of this study was to determine if injury rates were significantly affected by project scheduling. This study determined that there was a direct affect of daily overtime and project acceleration on injury rates. Project managers and safety directors should consider the extra risk and costs associated with injury when utilizing work days in excess of 8 hours and weeks where there is to be a large amount of paid overtime. In addition, greater steps may need to be taken to protect laborers from injury. Additional safety training, more direct safety-minded supervision, and greater emphasis on personal protective equipment may be needed. Although Tuesday's and Saturdays had the highest rate of injury, the value of an injury free workday should be stressed every day of the week.

4.3 Limitations of the Data

The main problem with the data used in this study was that the projects used in this study might not have provided the total number of hours that an employee actually worked. Because only hours on TDOT projects were used as denominators, there may be some error in the injury rates reported. For example, an employee not injured in an overtime status according to the hours worked on the TDOT payroll may have in fact met the criteria with hours worked on other jobs that were not analyzed in this study. Using data with all hours worked on all jobs by all employees may provide a more accurate analysis of injury rates due to overtime and project acceleration. The conversion of the hard copy certified payroll to an electronic form also introduced an insignificant amount of error into the data used.

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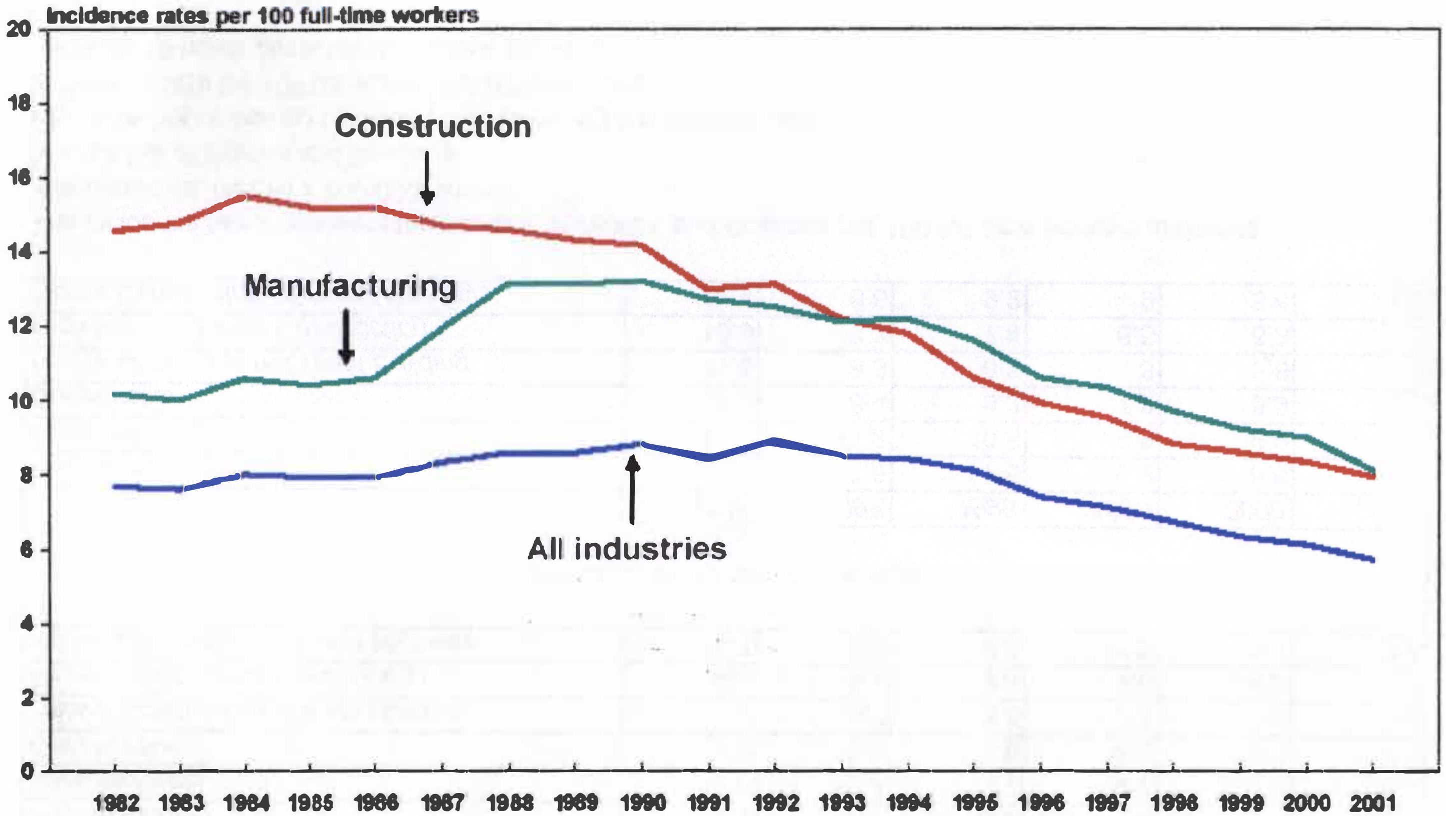
Appendix



In contrast to the 1994 to 2000 period when the construction rates were lower than those for manufacturing, the rates in construction and manufacturing were about the same for 2001.

Source: Bureau of Labor Statistics, U.S. Department of Labor
December 2002

Figure A1. Historical Injury Rates

Table A1: BLS Injury Rates

National Injury and Illness Rates

	1996	1997	1998	1999	2000	2001
Private Industry	7.4	7.1	6.7	6.3	6.1	5.7
Manufacturing	10.6	10.3	9.7	9.2	9	8.1
Construction	9.9	9.5	8.8	8.6	8.3	7.9
Heavy Construction, Except Building	9	8.7	8.2	7.8	7.6	7.8
Highway and Street Construction	9.6	9.7	9.3	8.9	8.2	7.7
Heavy Construction, Except Highway	8.7	8.3	7.8	7.3	7.3	7.8

Tennessee Injury and Illness Rates

	1996	1997	1998	1999	2000	2001
Private Industry	8	7.6	7.6	6.8	6.6	6.1
Manufacturing	11.7	11.2	10.8	9.9	9.9	8.9
Construction	9.9	8.4	8.2	7.2	6.9	3.7
Heavy Construction, Except Building	11.8	8.3	8.5	8	5.8	2.9
Highway and Street Construction	10.9	7.7	7.4	6.5	6.3	5.2
Heavy Construction, Except Highway	12.4	8.6	9.2	9	5.4	1.5

The incidence rates represent the number of injuries and illnesses per 100 full-time workers and were calculated as: (N/EH) x 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).

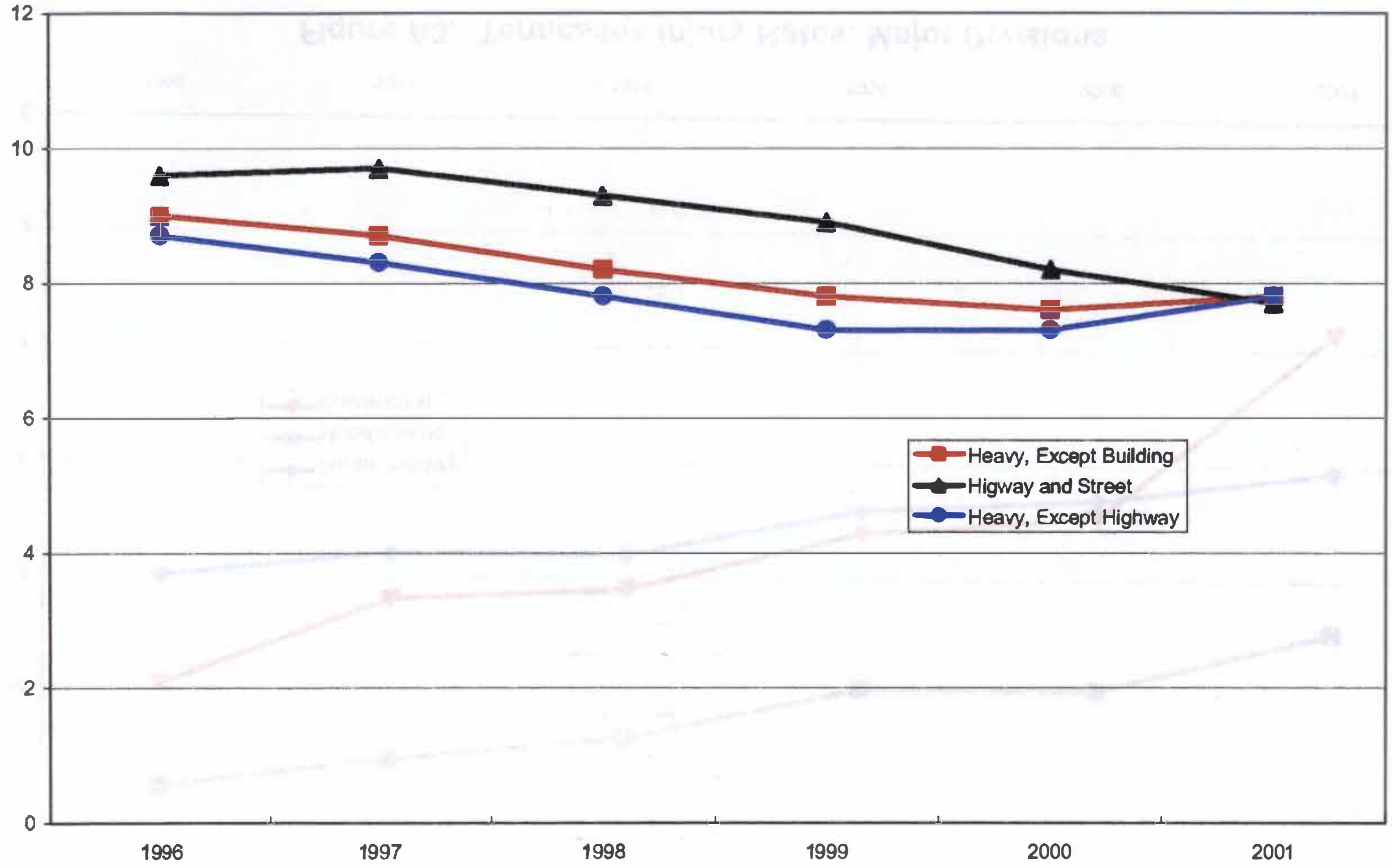


Figure A2. National Injury and Illness Rates, Construction Division

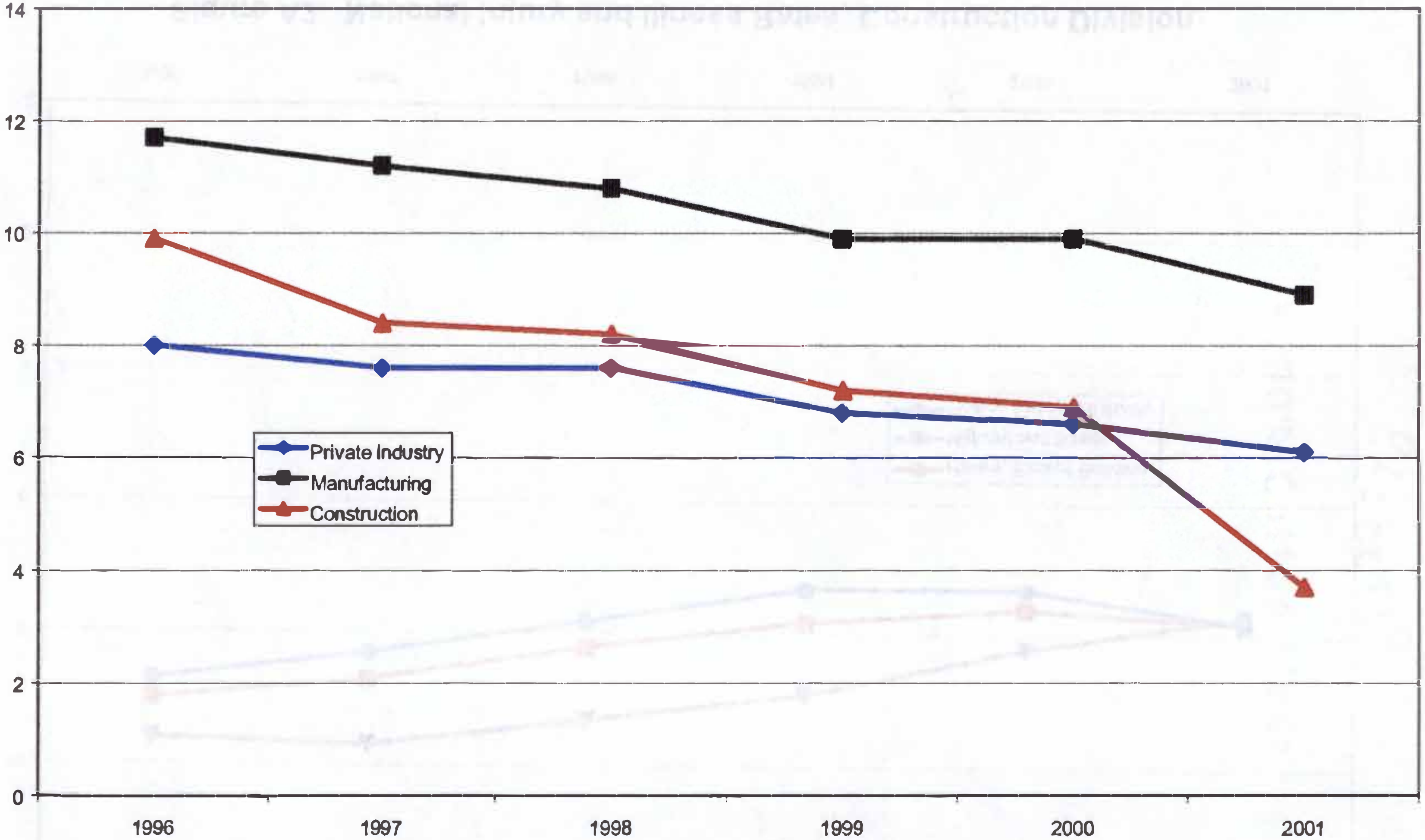


Figure A3. Tennessee Injury Rates, Major Divisions

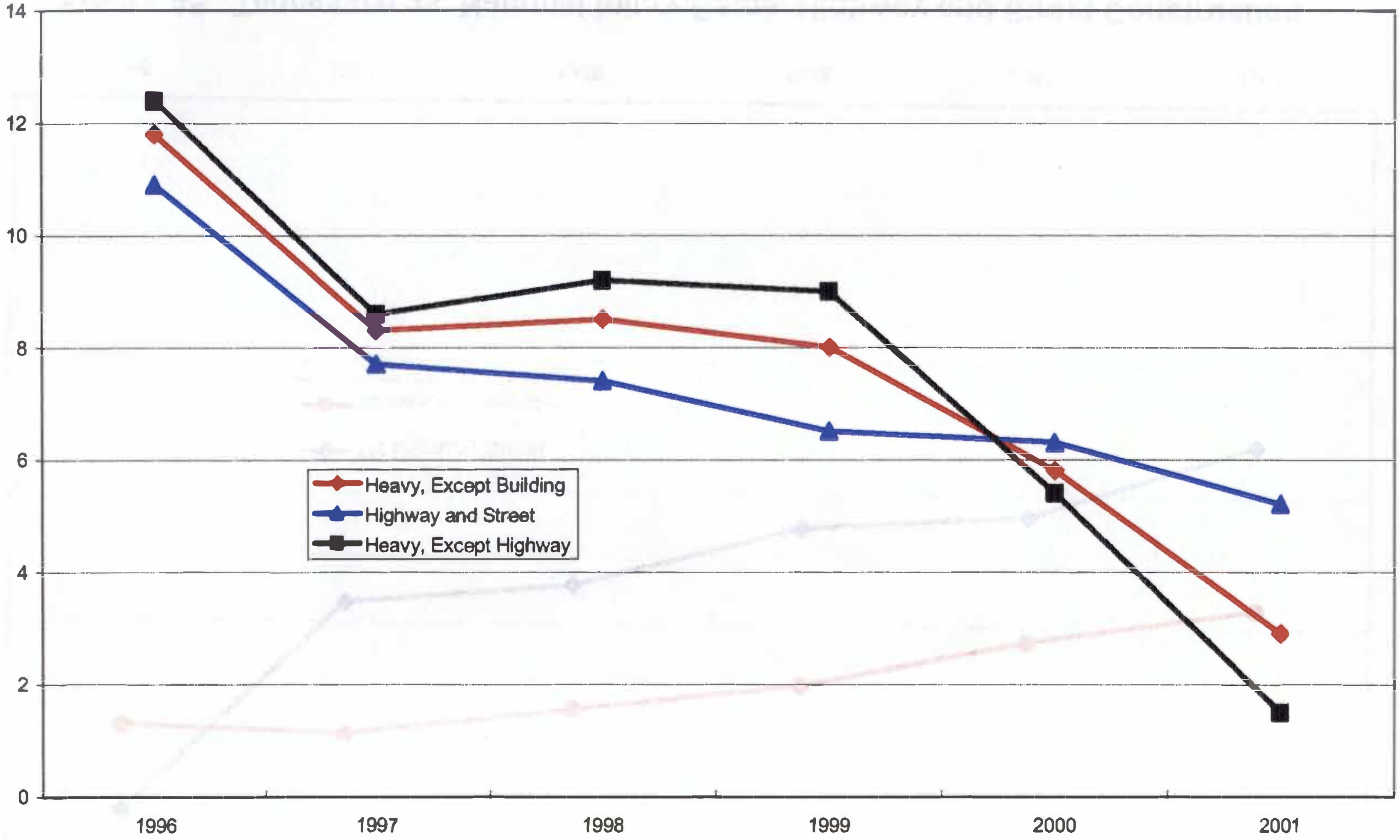


Figure A4. Tennessee Injury Rates, Construction Divisions

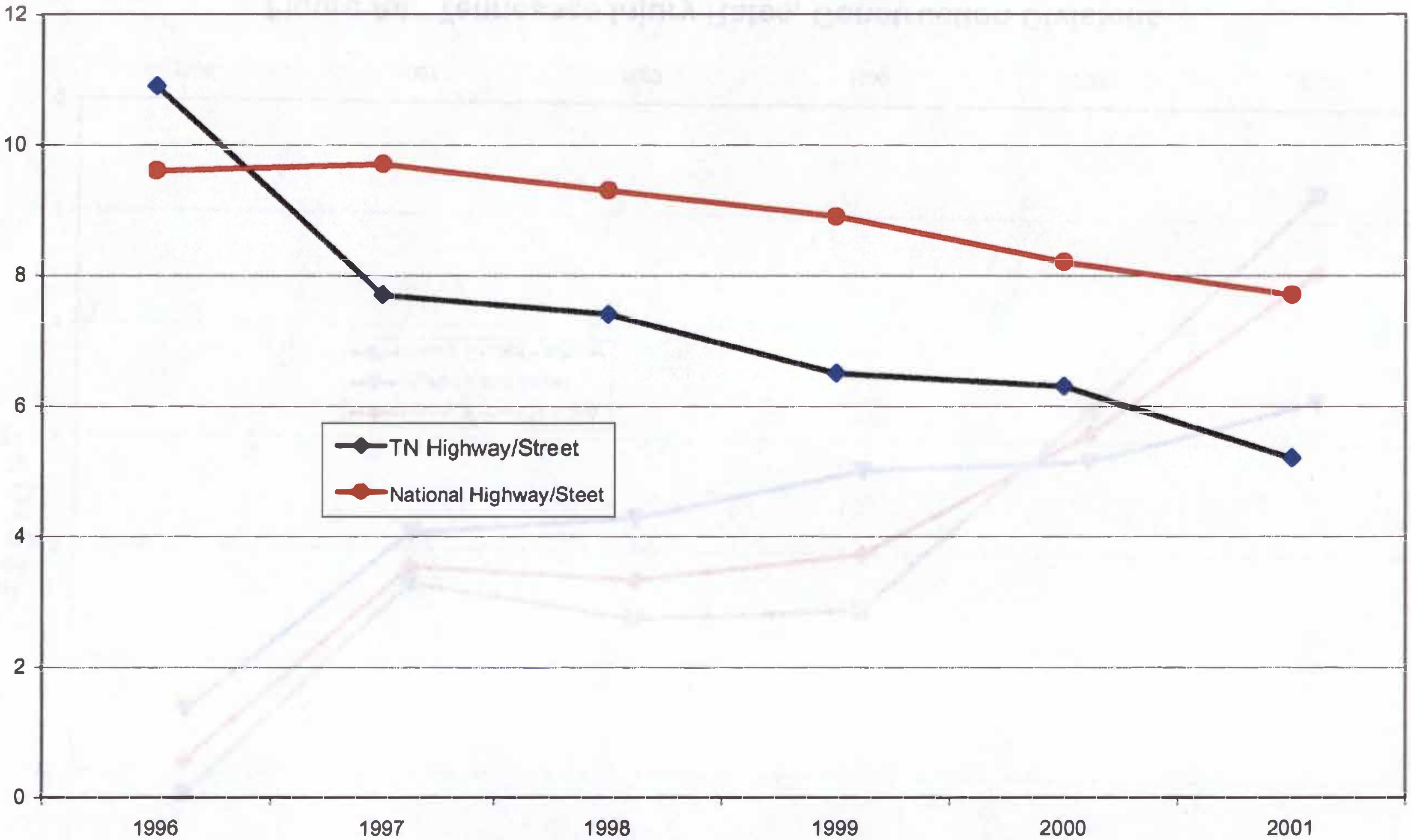


Figure A5. Tennessee vs. National Injury Rates, Highway and Street Construction

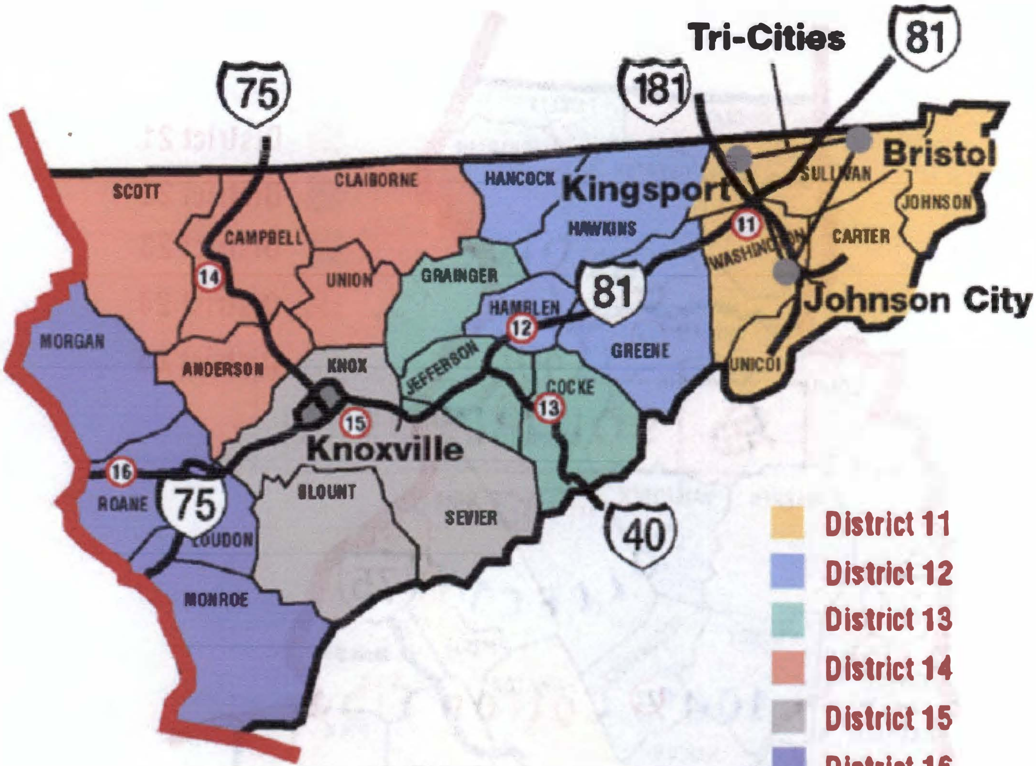


Figure A6. TDOT Region I

Source: http://www.tdot.state.tn.us/

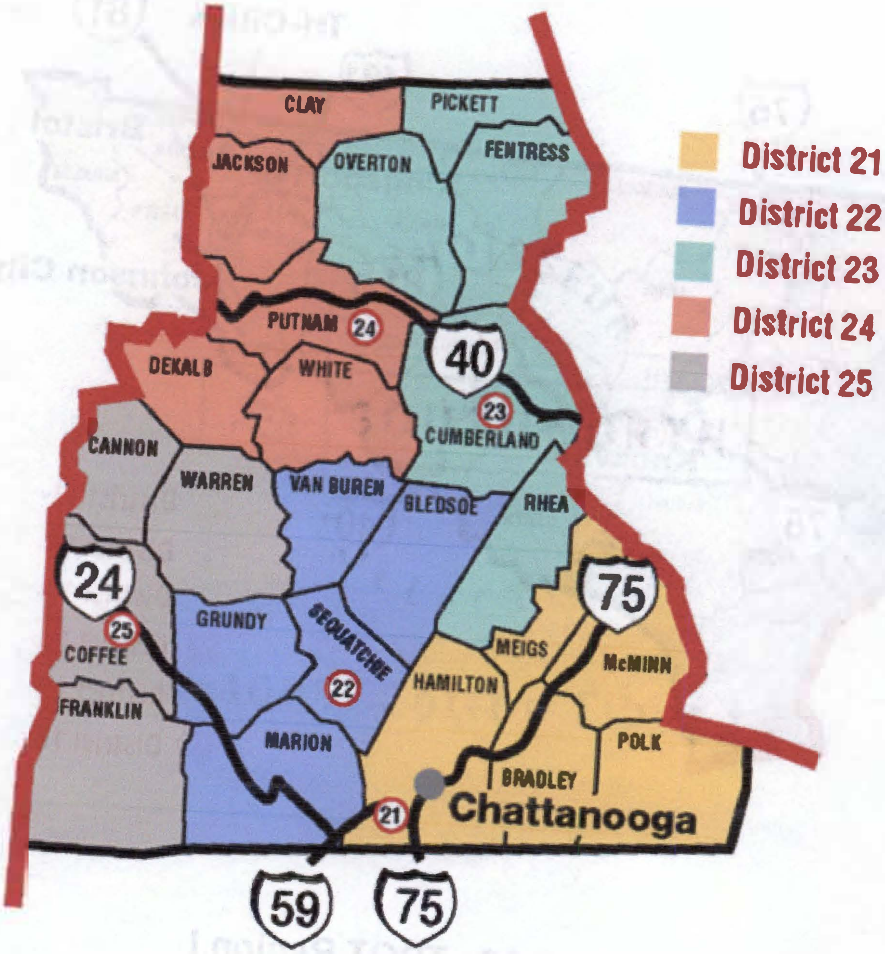


Figure A7. TDOT Region II

Source: http://www.tdot.state.tn.us/

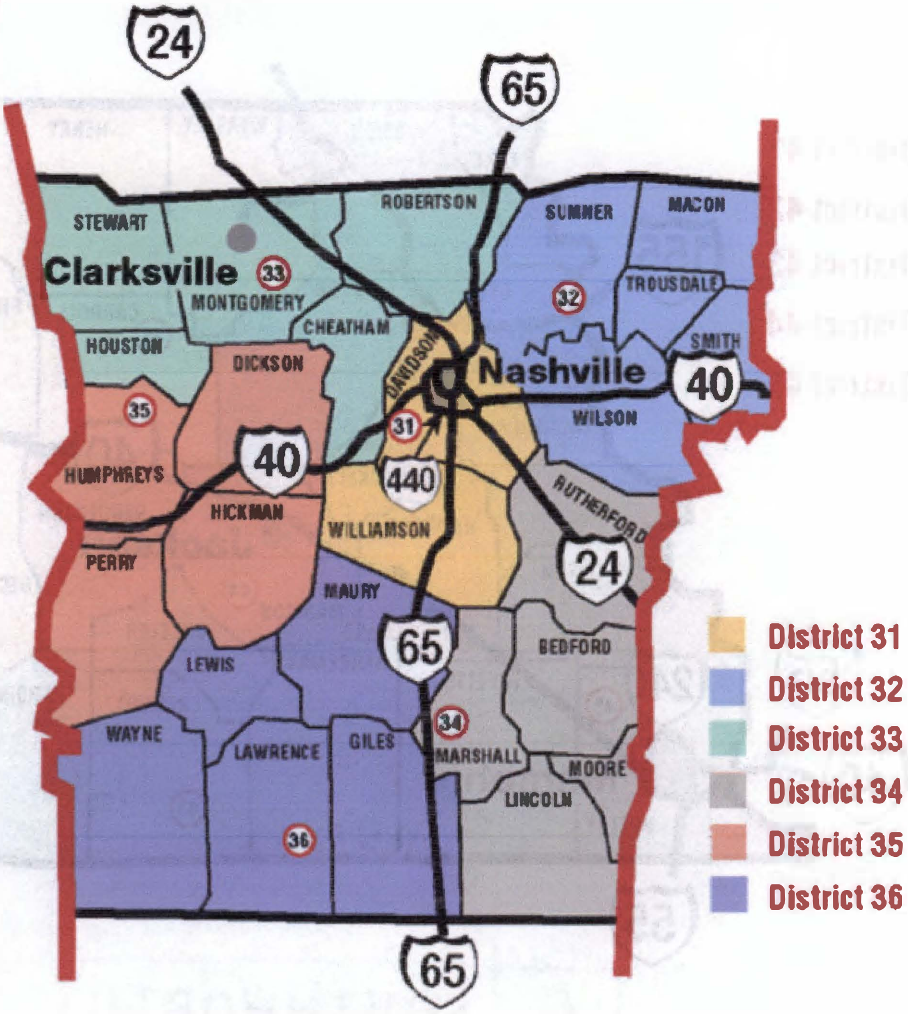


Figure A8. TDOT Region III

Source: http://www.tdot.state.tn.us/

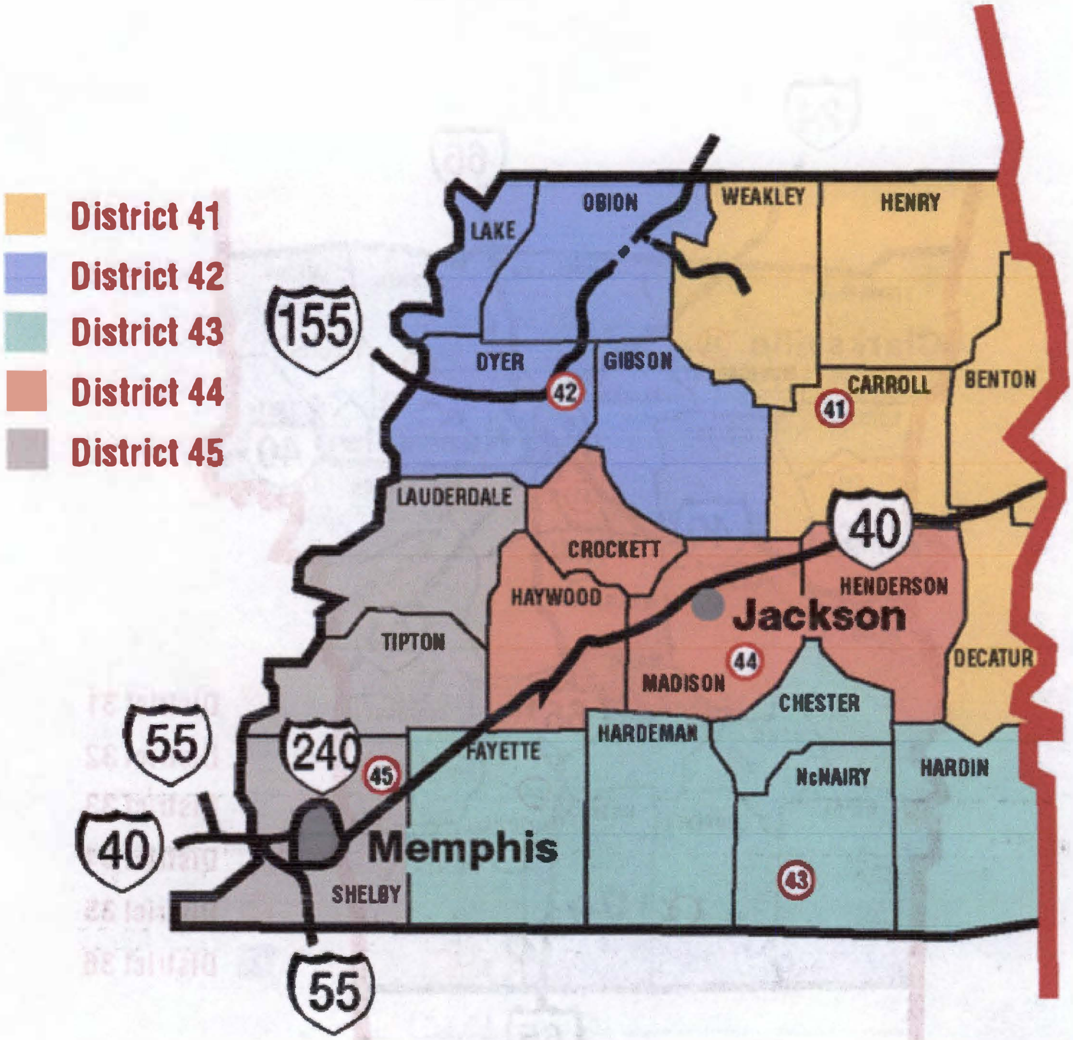


Figure A9. TDOT Region IV

Source: http://www.tdot.state.tn.us/

Table A2: Hours Worked

Day/Type of Hrs.	Project # 1	2	3	4	5	6
Sunday						
Regular Time	208.5	24.5	10.0	0.0	0.0	9.0
Paid Overtime	133.5	0.0	0.0	0.0	0.0	0.0
Straight Time	288.5	18.0	10.0	0.0	0.0	9.0
Daily Overtime	53.5	6.5	0.0	0.0	0.0	0.0
Total Hours Worked	342.0	24.5	10.0	0.0	0.0	9.0
Monday						
Regular Time	50.0	3562.5	8347.0	2768.5	6985.5	7395.0
Paid Overtime	0.0	0.0	35.0	0.0	0.5	0.0
Straight Time	40.0	3179.0	7551.5	2510.5	5850.0	6118.0
Daily Overtime	10.0	383.5	830.5	258.0	1136.0	1277.0
Total Hours Worked	50.0	3562.5	8382.0	2768.5	6986.0	7395.0
Tuesday						
Regular Time	6461.0	3874.5	8568.0	2732.0	7593.6	7907.0
Paid Overtime	6.0	0.0	35.0	0.0	42.0	0.0
Straight Time	5230.5	3379.0	7747.5	2493.0	6420.5	6488.5
Daily Overtime	1236.5	495.5	855.5	239.0	1215.1	1418.5
Total Hours Worked	6467.0	3874.5	8603.0	2732.0	7635.6	7907.0
Wednesday						
Regular Time	5522.5	3964.5	8381.5	2632.0	6845.5	8447.0
Paid Overtime	6.0	0.0	35.0	0.0	63.0	3.0
Straight Time	4488.5	3476.5	7526.5	2406.0	5800.5	6965.0
Daily Overtime	1040.0	488.0	890.0	226.0	1108.0	1485.0
Total Hours Worked	5528.5	3964.5	8416.5	2632.0	6908.5	8450.0
Thursday						
Regular Time	4924.5	3887.0	8160.5	2644.0	7029.5	7720.5
Paid Overtime	9.0	16.0	48.0	0.0	349.0	605.0
Straight Time	4084.0	3427.0	7350.5	2440.0	6208.5	6844.0
Daily Overtime	849.5	476.0	858.0	204.0	1170.0	1481.5
Total Hours Worked	4933.5	3903.0	8208.5	2644.0	7378.5	8325.5
Friday						
Regular Time	4452.5	2439.0	5123.0	1749.0	4253.5	3576.8
Paid Overtime	105.5	1137.0	2851.0	515.0	2208.0	3608.2
Straight Time	3812.5	3366.5	7255.0	2088.0	5629.5	6236.5
Daily Overtime	745.5	209.5	719.0	176.0	832.0	948.5
Total Hours Worked	4558.0	3576.0	7974.0	2264.0	6461.5	7185.0
Saturday						
Regular Time	2105.5	1.0	68.0	0.0	944.5	168.9
Paid Overtime	1269.0	4.0	0.0	6.0	1523.5	247.6
Straight Time	2855.5	5.0	61.0	6.0	2435.0	398.0
Daily Overtime	519.0	0.0	7.0	0.0	33.0	18.5
Total Hours Worked	3374.5	5.0	68.0	6.0	2468.0	416.5

Table A2: Continued

Day/Type of Hrs.	Project # 7	8	9	10	11	12
Sunday						
Regular Time	18.0	166.0	423.5	80.0	0.0	22.0
Paid Overtime	0.0	14.0	617.0	0.0	0.0	12.0
Straight Time	16.0	171.0	655.0	60.0	0.0	24.0
Daily Overtime	2.0	9.0	170.5	20.0	0.0	10.0
Total Hours Worked	18.0	180.0	825.5	80.0	0.0	34.0
Monday						
Regular Time	13955.9	6927.3	24448.6	5529.0	1958.2	7350.6
Paid Overtime	0.0	153.0	0.0	0.0	0.0	0.0
Straight Time	11505.0	5653.3	19608.8	4592.0	1611.0	6107.0
Daily Overtime	2450.9	1427.0	4847.8	937.0	347.2	1243.6
Total Hours Worked	13955.9	7080.3	24456.6	5529.0	1958.2	7350.6
Tuesday						
Regular Time	14999.7	7484.0	27380.6	6142.5	2080.0	7996.5
Paid Overtime	8.0	158.0	11.0	0.0	0.0	0.0
Straight Time	12402.5	6054.5	21818.0	5054.5	1700.5	6603.5
Daily Overtime	2605.2	1587.5	5573.6	1088.0	379.5	1393.0
Total Hours Worked	15007.7	7642.0	27391.6	6142.5	2080.0	7996.5
Wednesday						
Regular Time	14952.6	7502.0	27439.9	6238.0	2120.5	8085.5
Paid Overtime	7.0	100.5	172.5	0.5	5.0	7.0
Straight Time	12428.0	6034.5	21987.9	5178.5	1743.0	6743.0
Daily Overtime	2531.6	1568.0	5614.4	1060.0	382.5	1349.5
Total Hours Worked	14959.6	7602.5	27602.4	6238.5	2125.5	8092.5
Thursday						
Regular Time	13525.7	6105.0	23752.3	5212.0	1976.1	7548.0
Paid Overtime	1130.3	1147.8	2825.4	237.0	151.8	617.5
Straight Time	12081.7	5776.8	21310.0	4577.0	1749.5	6686.5
Daily Overtime	2582.8	1478.5	5177.7	872.0	378.4	1479.0
Total Hours Worked	14664.5	7255.3	26487.7	5449.0	2127.9	8165.5
Friday						
Regular Time	6518.7	2595.1	11106.6	2645.5	1086.2	3500.0
Paid Overtime	6706.7	3581.5	14873.9	2298.0	737.1	3844.0
Straight Time	11474.0	5612.1	21532.5	4261.5	1675.0	6710.5
Daily Overtime	1751.4	564.5	4171.0	682.0	148.4	633.5
Total Hours Worked	13225.4	6176.6	25703.5	4943.5	1823.4	7344.0
Saturday						
Regular Time	220.5	540.5	921.5	241.5	9.0	115.0
Paid Overtime	602.0	827.5	2742.5	424.0	43.0	419.0
Straight Time	767.5	1282.0	3036.0	639.0	52.0	533.0
Daily Overtime	55.0	108.0	507.0	26.5	0.0	1.0
Total Hours Worked	822.5	1390.0	3543.0	665.5	52.0	534.0

Table A2: Continued

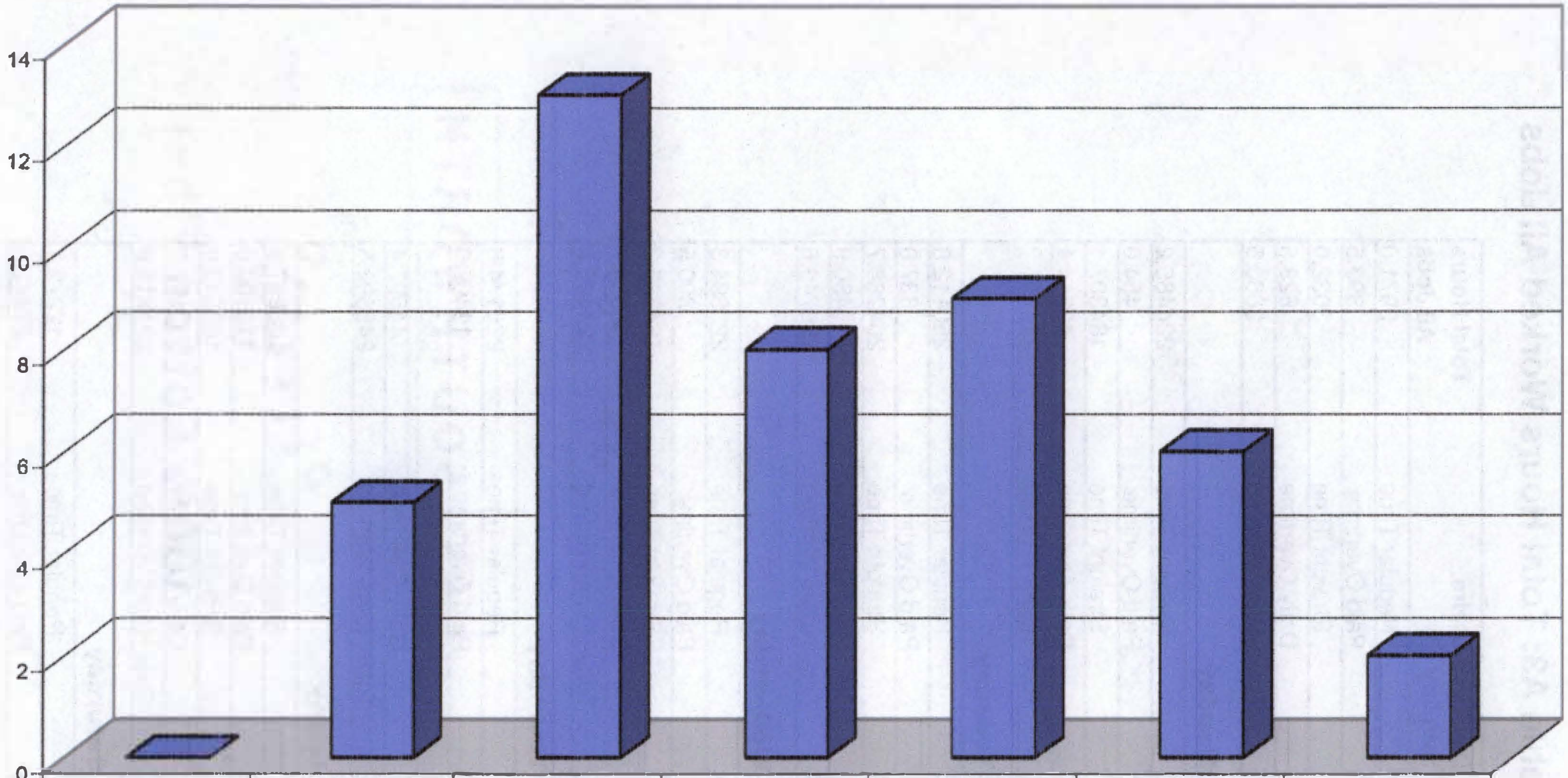
Day/Type of Hrs.	Project # 13	14	15	16	17	18
Sunday						
Regular Time	27.0	39.5	677.5	73.0	84.0	28.0
Paid Overtime	0.0	54.5	18.5	5.0	10.0	0.0
Straight Time	20.0	53.0	612.5	69.0	80.0	24.0
Daily Overtime	7.0	41.0	94.5	9.0	14.0	4.0
Total Hours Worked	27.0	94.0	707.0	78.0	94.0	28.0
Monday						
Regular Time	5383.1	76.0	37526.1	16290.5	12248.5	10194.5
Paid Overtime	0.0	0.0	114.0	10.0	0.0	3.0
Straight Time	4468.5	66.0	30222.5	13034.5	9861.0	8012.5
Daily Overtime	914.6	10.0	7417.6	3266.0	2387.5	2189.0
Total Hours Worked	5383.1	76.0	37640.1	16300.5	12248.5	10201.5
Tuesday						
Regular Time	5551.7	3040.5	39282.4	18024.0	12605.0	10595.0
Paid Overtime	0.0	11.0	163.5	0.0	0.0	0.0
Straight Time	4560.0	2518.0	31541.5	14327.5	10185.0	8337.5
Daily Overtime	991.7	533.5	7904.4	3696.5	2420.0	2257.5
Total Hours Worked	5551.7	3051.5	39445.9	18024.0	12605.0	10595.0
Wednesday						
Regular Time	5730.0	3082.3	38848.6	17616.0	12940.5	10588.0
Paid Overtime	5.0	0.0	233.0	25.5	0.0	3.0
Straight Time	4677.5	2505.0	31499.8	14120.5	10485.5	8289.5
Daily Overtime	1057.5	577.3	7581.9	3521.0	2455.0	2301.5
Total Hours Worked	5735.0	3082.3	39081.6	17641.5	12940.5	10591.0
Thursday						
Regular Time	5144.6	5144.6	34224.7	15125.0	11451.5	9564.0
Paid Overtime	237.5	237.5	4927.0	1158.0	689.0	910.0
Straight Time	4387.5	4387.5	31517.0	13107.5	9877.5	8180.0
Daily Overtime	994.6	994.6	7634.7	3175.5	2263.0	2294.0
Total Hours Worked	5382.1	5382.1	39151.7	16283.0	12140.5	10474.0
Friday						
Regular Time	2297.5	2752.3	14802.3	6953.4	5179.5	3065.5
Paid Overtime	2318.5	224.5	22238.9	7719.1	5607.0	6611.5
Straight Time	4106.5	2472.0	30494.3	11965.5	9258.5	7683.0
Daily Overtime	509.5	504.8	6546.9	2707.0	1528.0	1994.0
Total Hours Worked	4616.0	2976.8	37041.2	14672.5	10786.5	9677.0
Saturday						
Regular Time	263.5	1334.3	2366.0	857.0	209.0	20.0
Paid Overtime	189.6	1231.0	5817.3	2340.0	691.5	873.0
Straight Time	429.1	2251.0	7513.0	2991.5	869.0	710.0
Daily Overtime	24.0	320.8	670.3	205.5	31.5	183.0
Total Hours Worked	453.1	2571.8	8183.3	3197.0	900.5	893.0

Table A2: Continued

Day/Type of Hrs.	Project # 19	20	21	22	23
Sunday					
Regular Time	5.0	0.0	385.0	6.0	684.5
Paid Overtime	23.0	0.0	0.0	3.0	3.0
Straight Time	28.0	0.0	355.5	9.0	529.5
Daily Overtime	0.0	0.0	29.5	0.0	158.0
Total Hours Worked	28.0	0.0	385.0	9.0	687.5
Monday					
Regular Time	1910.0	4521.5	19610.5	6477.5	20969.0
Paid Overtime	0.0	0.0	45.5	1.5	91.5
Straight Time	1688.5	3887.0	16245.5	5404.0	17091.0
Daily Overtime	221.5	634.5	3410.5	1075.0	3969.5
Total Hours Worked	1910.0	4521.5	19656.0	6479.0	21060.5
Tuesday					
Regular Time	2210.0	4647.5	21254.9	6244.5	23437.8
Paid Overtime	0.0	0.0	39.5	10.5	152.5
Straight Time	1937.0	3990.5	17536.9	5261.5	18700.8
Daily Overtime	273.0	657.0	3757.5	993.5	4889.5
Total Hours Worked	2210.0	4647.5	21294.4	6255.0	23590.3
Wednesday					
Regular Time	2083.5	4461.0	20350.5	5823.5	39.0
Paid Overtime	0.0	0.0	95.5	39.0	0.0
Straight Time	1837.5	3814.0	17015.5	4901.0	961.5
Daily Overtime	246.0	647.0	3430.5	961.5	5862.5
Total Hours Worked	2083.5	4461.0	20446.0	5862.5	0.0
Thursday					
Regular Time	2087.5	4469.2	20107.9	5954.5	20416.3
Paid Overtime	7.5	19.0	667.0	242.5	3265.3
Straight Time	1833.5	3873.5	17372.4	5189.5	18734.0
Daily Overtime	261.5	614.7	3402.5	1007.5	4947.5
Total Hours Worked	2095.0	4488.2	20774.9	6197.0	23681.5
Friday					
Regular Time	1137.5	2461.5	8337.0	3072.0	7883.5
Paid Overtime	769.0	1013.5	9992.0	2543.5	13597.5
Straight Time	1832.5	3372.5	15789.5	4886.5	18099.5
Daily Overtime	74.0	102.5	2539.5	729.0	3381.5
Total Hours Worked	1906.5	3475.0	18329.0	5615.5	21481.0
Saturday					
Regular Time	0.0	8.5	335.0	442.0	1101.0
Paid Overtime	0.0	16.5	1970.5	989.8	5215.5
Straight Time	0.0	25.0	2164.0	1406.0	5567.0
Daily Overtime	0.0	0.0	141.5	25.8	749.5
Total Hours Worked	0.0	25.0	2305.5	1431.8	6316.5

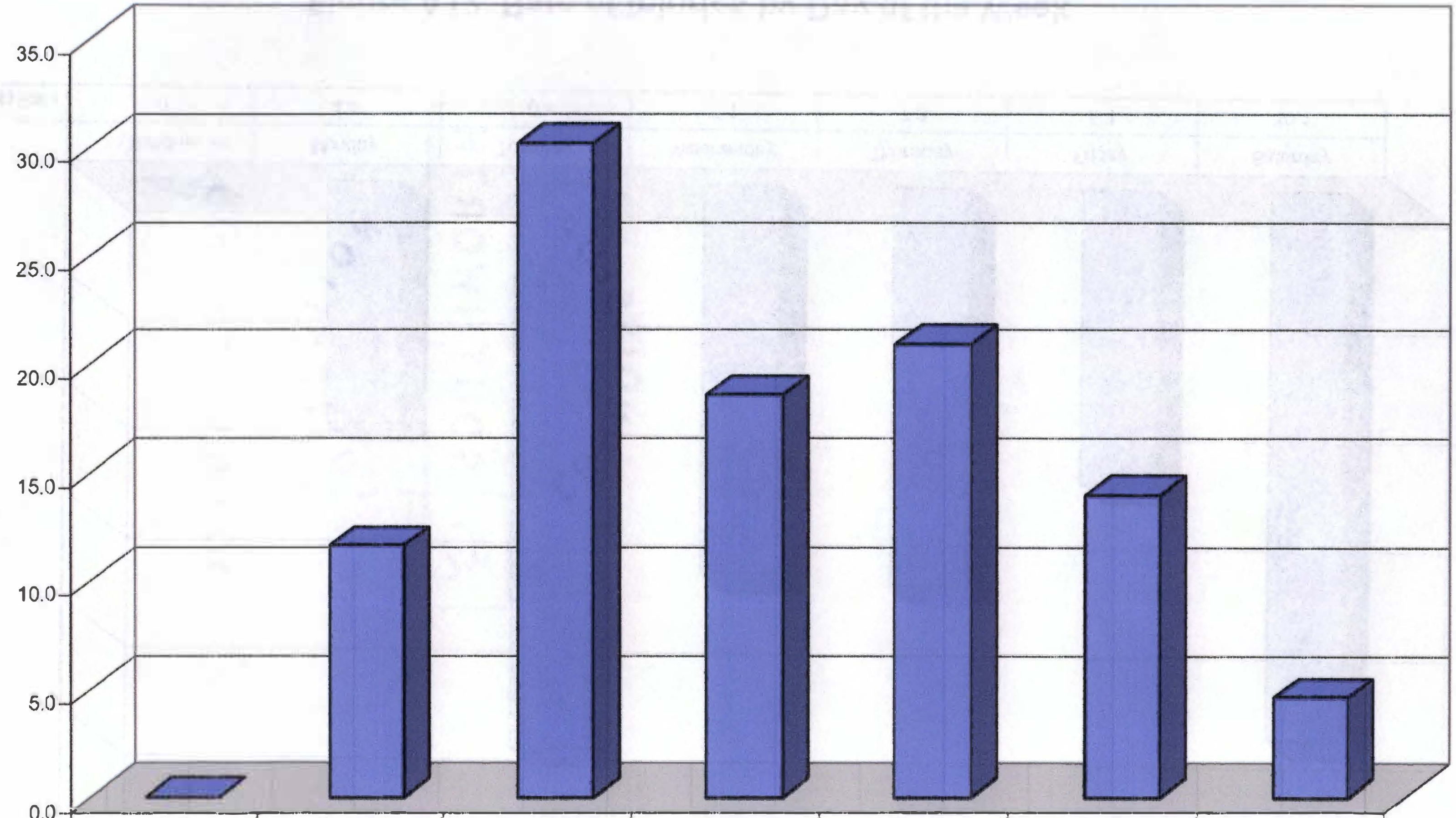
Table A3: Total Hours Worked All Jobs

Day/Type of Hrs.	Total Hours All Jobs
Sunday	
Regular Time	2971.0
Paid Overtime	893.5
Straight Time	3032.0
Daily Overtime	628.5
Total Hours Worked	3660.5
Monday	
Regular Time	224485.2
Paid Overtime	454.0
Straight Time	184307.1
Daily Overtime	40644.1
Total Hours Worked	224951.2
Tuesday	
Regular Time	250112.6
Paid Overtime	637.0
Straight Time	204288.7
Daily Overtime	46460.9
Total Hours Worked	250749.6
Wednesday	
Regular Time	223694.3
Paid Overtime	800.5
Straight Time	184885.2
Daily Overtime	46384.7
Total Hours Worked	224445.8
Thursday	
Regular Time	226174.8
Paid Overtime	19497.0
Straight Time	200995.4
Daily Overtime	44597.4
Total Hours Worked	245592.8
Friday	
Regular Time	106987.9
Paid Overtime	115100.9
Straight Time	189613.8
Daily Overtime	32197.9
Total Hours Worked	221811.8
Saturday	
Regular Time	12272.1
Paid Overtime	27442.8
Straight Time	35995.6
Daily Overtime	3626.8
Total Hours Worked	39622.4



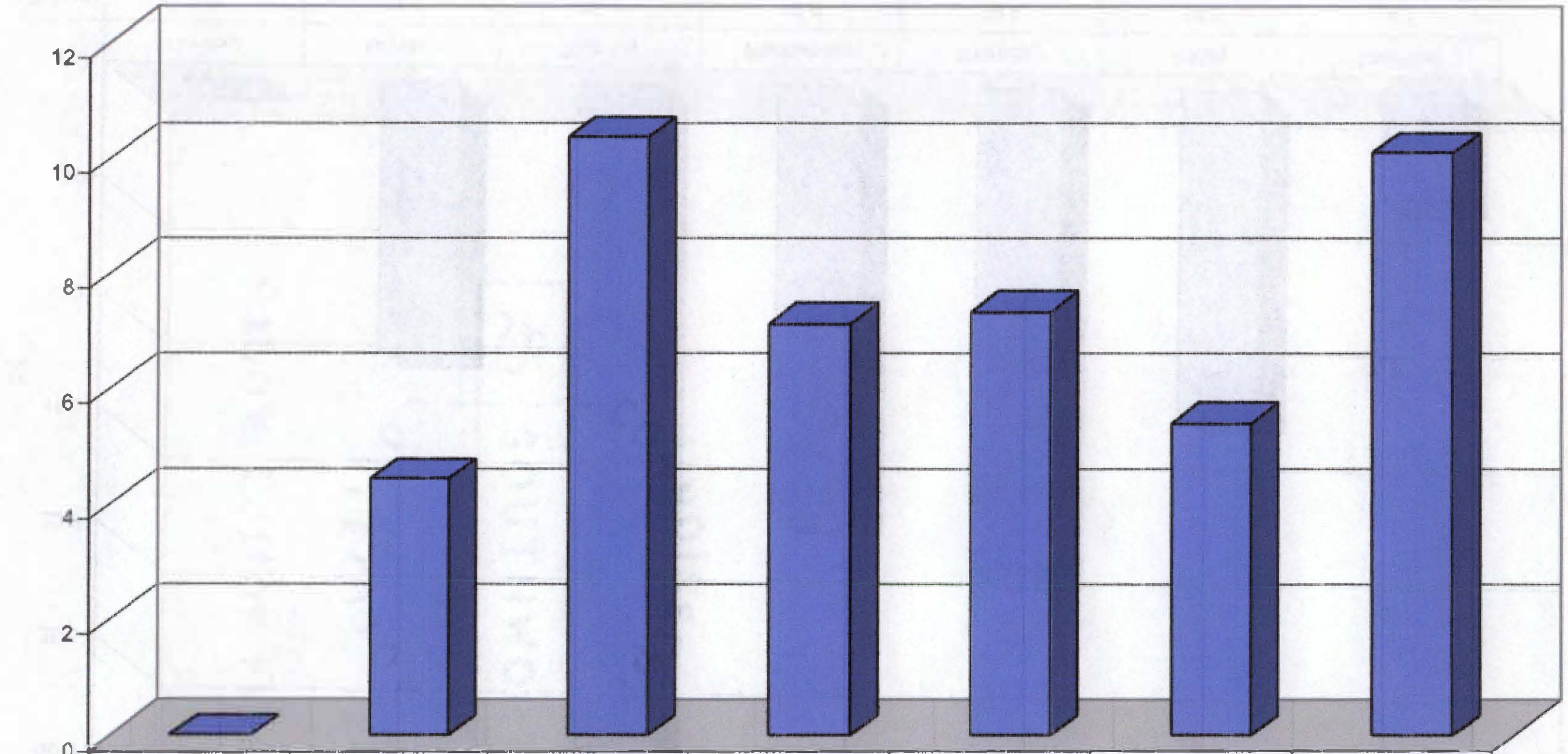
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Number	0	5	13	8	9	6	2

Figure A10. Number of Injuries by Day of the Week



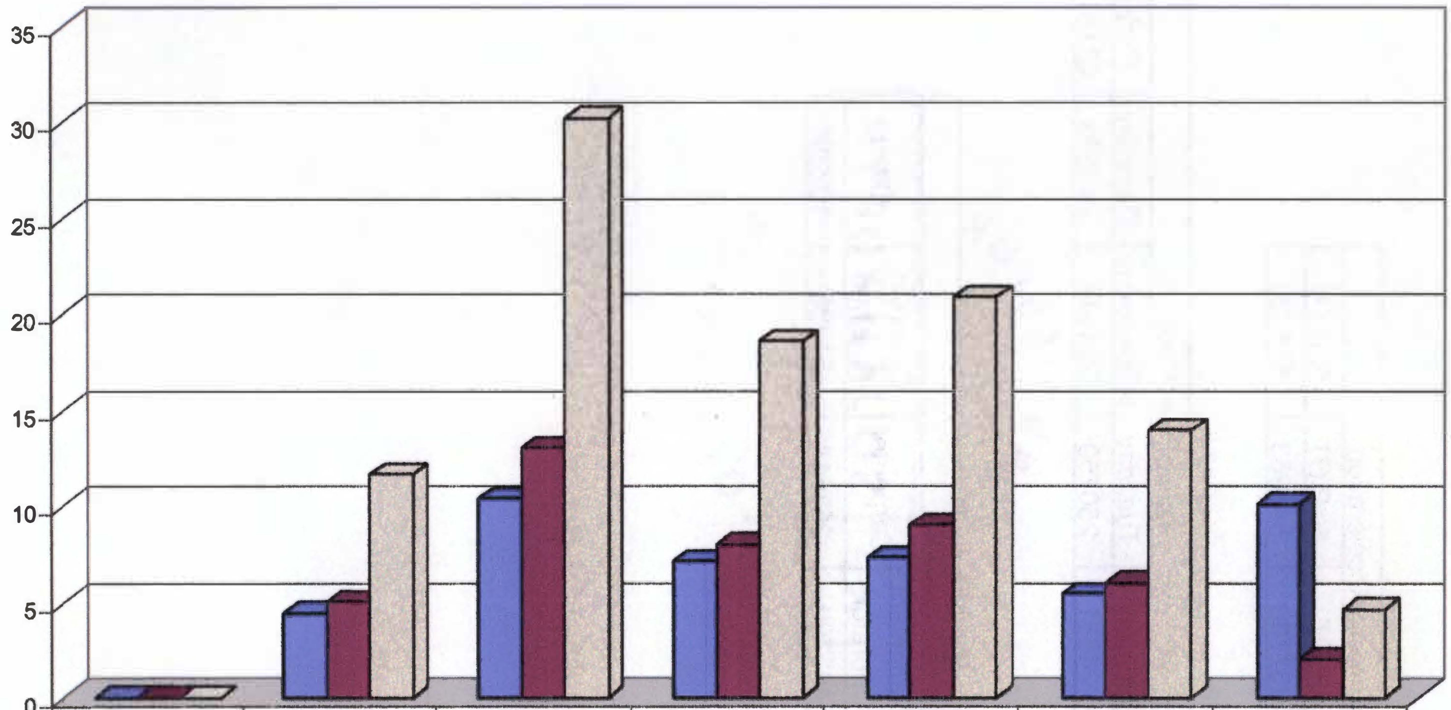
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Percent	0.0	11.6	30.2	18.6	20.9	14.0	4.7

Figure A11. Percent of Injuries by Day of the Week



	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Rate	0	4.4	10.4	7.1	7.3	5.4	10.1

Figure A12. Rate of Injuries by Day of the Week



	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Rate	0	4.4	10.4	7.1	7.3	5.4	10.1
Number	0	5	13	8	9	6	2
Percent	0.0	11.6	30.2	18.6	20.9	14.0	4.7

Figure A13. Injuries by Day of the Week

Table A4: Denominators

Overtime/Project Acceleration				
	D.OT	*P.OT*	*% P.OT*	*% D.OT*
Total Hours	689547	237700	549963	546529

Day of the Week							
	Sunday	*Monday*	*Tuesday*	*Wednesday*	*Thursday*	*Friday*	*Saturday*
Total Hours	3661	224951	250750	224446	245593	221812	39622

Craft					
	Laborer	Equipment Operator	Carpenter	Concrete Finisher	Other
Total Hours	376991	405790	267614	51738	102890

Vita

Travis J. Strong was born and raised in South Carolina. After serving in the United States Air Force, he completed his Bachelors and Masters of Science degrees at the University of Tennessee. At the time of his graduation, he had accepted a job with Valley Engineering Surveying and Planning in Harrisonburg, Virginia.