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An Approach for Measuring Reductions in Construction Worker Illnesses and Injuries: Baseline Measures of Construction Industry Practices for the National Construction Goals

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Abstract

The Construction and Building Subcommittee of the National Science and Technology Council is developing baseline measures of current construction industry practices and measures of progress with respect to each of the seven National Construction Goals. The seven National Construction Goals are concerned with: (1) reductions in the delivery time of constructed facilities; (2) reductions in operations, maintenance, and energy costs; (3) increases in occupant productivity and comfort; (4) reductions in occupant-related illnesses and injuries; (5) reductions in waste and pollution; (6) increases in the durability and flexibility of constructed facilities; and (7) reductions in construction worker illnesses and injuries. Baseline measures and measures of progress are being produced for each of the four key construction industry sectors. The four sectors are: (1) residential; (2) commercial/institutional; (3) industrial; and (4) public works. This report provides a detailed set of baseline measures for National Construction Goal 7 (reductions in construction worker illnesses and injuries). As such, it describes data sources, data classifications, and the metrics used to develop the baseline measures. Extensive use of charts and tables is made throughout this document to illustrate the process by which the baseline measures were developed.

Keywords

benchmarking; building economics; construction; construction safety and health; costs; economic analysis; metrics; occupational illnesses; occupational injuries

Preface

This study was conducted by the Office of Applied Economics in the Building and Fire Research Laboratory (BFRL) at the National Institute of Standards and Technology (NIST). The study was sponsored by the Construction and Building Subcommittee of the National Science and Technology Council. The BFRL project, of which this study is a part, seeks to develop baseline measures and measures of progress with respect to each of the seven National Construction Goals. These measures are to be disseminated both through publications and, ultimately, electronically via the World Wide Web. The intended audience for this report is the Construction and Building Subcommittee member organizations as well as construction industry representatives, the occupational safety and health community, and other interested parties.

Acknowledgments

The author wishes to thank all those who contributed so many excellent ideas and suggestions which he has attempted to incorporate into this report. The author wishes to thank Dr. Jack E. Snell and Mr. John Talbott, Co-Chairs of the Construction and Building Subcommittee, and Dr. Andrew J. Fowell, Secretariat of the Construction and Building Subcommittee, for their guidance, suggestions, and support. The author wishes to thank the Construction Industry Institute (CII) for providing an aggregated, project-level data set covering the commercial/institutional, industrial, and public works sectors. Special thanks are extended to Dr. Kirk Morrow, formerly with CII, and Dr. Stephen Thomas, CII Assistant Director for Benchmarking, for their stimulating discussions on the uses of these data. Special appreciation is extended to Drs. Harold E. Marshall and Sieglinde K. Fuller of the Office of Applied Economics at NIST's Building and Fire Research Laboratory (BFRL) for the thoroughness of their reviews and for their many insights and to Ms. Catherine Linthicum for her assistance in preparing the manuscript for review and publication. Special appreciation is also extended to Mr. Matt Gillen, Senior Scientist, National Institute for Occupational Safety and Health (NIOSH) and to the members of the NIOSH Construction Steering Committee for their many helpful comments. Special appreciation is also extended to Dr. Earl S. Pollack, Senior Statistical Advisor, The Center to Protect Worker's Rights (CPWR) and to the staff at CPWR for their many helpful comments. Special appreciation is also extended to Mr. Daniel Cardy, formerly with BFRL's Office of Applied Economics, who helped immensely with the data collection and analysis effort during his summer internship. Thanks are also due to Ms. Christine Izzo of BFRL's Office of Applied Economics for her comments on the earlier drafts of this report and for her assistance in interpreting the results of the data analysis effort.

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List of Acronyms

Acronym	Definition
AFL-CIO	American Federation of Labor - Congress of Industrial Organizations
BFRL	Building and Fire Research Laboratory
BLS	Bureau of Labor Statistics
C&B	Construction and Building
CCI	Census of the Construction Industry
CCIT	Committee on Civilian Industrial Technology
CII	Construction Industry Institute
CPS	Current Population Survey
CPWR	Center to Protect Workers' Rights
DIA	Denver International Airport
GDP	Gross Domestic Product
IIR	Illness Incidence Rate
LWCIR	Lost Workday Case Incidence Rate
NCG	National Construction Goal
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
OM&E	Operations, Maintenance, and Energy
OSHA	Occupational Safety and Health Administration
RD&D	Research, Development, and Deployment
RIR	Recordable Incidence Rate
SIC	Standard Industrial Classification
VIP	Value of Construction Put in Place

Executive Summary

The National Science and Technology Council, a cabinet-level group chaired by the president, is charged with setting federal technology policy and coordinating R&D strategies across a broad cross-section of public and private interests. It has established nine research and development committees, including the Committee on Civilian Industrial Technology (CCIT), to collaborate with the private sector in developing a comprehensive national technology policy. The purpose of CCIT is to enhance the international competitiveness of US industry through federal technology policies and programs. The Construction and Building Subcommittee of CCIT coordinates and defines priorities for federal research, development, and deployment related to the industries that produce, operate, and maintain constructed facilities, including buildings and infrastructure.[i]

The mission of the Construction and Building Subcommittee is to enhance the competitiveness of US Industry, public safety, and environmental quality through research and development, in cooperation with US industry, labor, and academia, for improvement of the life cycle performance of constructed facilities. To accomplish its mission, the Construction and Building Subcommittee has established seven National Construction Goals in collaboration with a broad cross section of the construction industry.[ii]

Data describing current practices of the US construction industry are needed to establish baselines against which the industry can measure its progress towards achieving the seven National Construction Goals. The Goals are: (1) reductions in the delivery time of constructed facilities; (2) reductions in operations, maintenance, and energy costs; (3) increases in occupant productivity and comfort; (4) reductions in occupant-related illnesses and injuries; (5) reductions in waste and pollution; (6) increases in the durability and flexibility of constructed facilities; and (7) reductions in construction worker illnesses and injuries. Baseline measures and measures of progress will be produced for each National Construction Goal in each of the four key construction industry sectors. The four sectors are: (1) residential; (2) commercial/institutional; (3) industrial; and (4) public works.

This document is the third in a series of studies prepared by NIST's Building and Fire Research Laboratory.[iii] It provides a detailed set of baseline measures for National

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[i] Wright, Richard N. 1995. "Government and Industry Working Together." *Construction Business Review* (January/February): pp. 44-49.

[ii] Wright, Richard N., Arthur H. Rosenfeld, and Andrew J. Fowell. 1995. *Construction and Building: Federal Research and Development in Support of the US Construction Industry*. Washington, DC: National Science and Technology Council.

[iii] Two earlier companion documents focused on National Construction Goals 1 and 2. For information on reductions in delivery time (Goal 1), see Chapman, Robert E., and Roderick Rennison. 1998. *An Approach for Measuring Reductions in Delivery Time: Baseline Measures of Construction Industry Practices for the National Construction Goals*. NISTIR 6189. Gaithersburg, MD: National Institute of Standards and Technology. For information on reductions in operations, maintenance, and energy costs (Goal 2) see Chapman, Robert E., and Roderick Rennison. 1998. *An Approach for Measuring Reductions*

Construction Goal 7, reductions in construction worker illnesses and injuries. The baseline measures characterize current industry performance for Goal 7. Industry performance in 1994 is used as the reference point from which the values of the baseline measures are calculated. Goal 7 was identified as one of the highest priority National Construction Goals by the construction industry.

The intended audience for this document includes both the construction community and the occupational safety and health community as a whole. This includes the Construction and Building Subcommittee member organizations, the four organizations that provided industry input on the National Construction Goals,[iv] construction industry managers from companies large and small, unions and trade associations, academic researchers, construction industry customers from the private and public sectors, insurance carriers providing workers compensation coverage for construction projects, and safety and health specialists working for and with the construction industry. In addition, because this document includes both detailed information on the baseline measures for National Construction Goal 7 and a compilation of statistics on the four sectors and the construction industry as a whole, it is anticipated that this document will serve as a resource reference for readers with a wide variety of interests in the construction industry.

The construction industry is a key component of the US economy. A key indicator of construction activity is the value of new construction put in place. Data published by the US Bureau of the Census establish the composition of construction expenditures by type of construction.

Table ES-1 summarizes both the annual sector totals and the sum total. Since 1992, the value of new construction put in place has risen slightly from $393.8 billion in 1992 to $435.5 billion in 1996 in constant 1992 dollars. The largest component of new construction over this period was in the residential sector (about 34 percent of the total), with the smallest component in the industrial sector (about 7 percent).

This document has five chapters and an appendix. Chapter 1 explains the purpose, scope, and general approach. Chapter 2 introduces the National Construction Goals and describes how a well-defined set of metrics is used to develop the baseline measures and measures of progress. Chapter 3 presents the baseline measures. Chapter 4 analyzes the impact of safety practice use on reducing construction worker illnesses and injuries. Chapter 5 concludes the document with a summary and suggestions for further research. The appendix provides an overview of the construction industry.

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in Operations, Maintenance, and Energy Costs: Baseline Measures of Construction Industry Practice for the National Construction Goals. NISTIR 6185. Gaithersburg, MD: National Institute of Standards and Technology.

[iv] The four organizations that provided industry input are: (1) National Association of Home Builders Research Center (residential); (2) National Institute of Building Sciences (commercial/institutional); (3) Construction Industry Institute (industrial); and (4) American Public Works Association (public works).

Table ES-1. Value of New Construction Put in Place in Millions of 1992 Dollars: Sector Totals and Sum Total

Sector	Value of Construction Put in Place ($ Millions)				
	1992	**1993**	**1994**	**1995**	**1996**
Residential	133,658	141,076	156,576	146,167	157,846
Commercial/Institutional	122,960	125,770	128,116	137,006	149,445
Industrial	30,902	27,212	28,161	30,391	29,219
Public Works	106,311	103,762	103,360	101,593	98,973
Total – All Sectors	393,831	397,820	416,213	415,157	435,483

Source: US Bureau of the Census, *Current Construction Reports: Value of Construction Put in Place*, C30.

Chapter 2 provides perspective on the overall effort to develop baseline measures and measures of progress for each of the seven National Construction Goals. First, each National Construction Goal is introduced and described. Next, the process for developing baseline measures for each Goal is described. This process involves: (1) specifying data relationships; (2) collecting and compiling the key data and supporting information for the base year, 1994; (3) defining metrics for each goal/sector combination; and (4) producing the metrics in a summary form (i.e., figures and tables to depict the metrics). The methods for measuring progress use the baselines as their reference point. Because the National Construction Goals may be specified as targets measured against baseline values, "gap analysis" is the preferred method for defining the measures of progress. The advantage of this measure of performance is that it employs the same values for each measure as used in computing the baselines. The gap analysis method measures how much of the initial gap (i.e., between the baseline value and the goal value) has been closed by some future date. Criteria are then presented which ensure that the data selected for analysis are well-defined, consistent, and replicable.

Chapter 3 presents the baseline measures. These measures are based on data published by the Bureau of Labor Statistics (BLS). Section 3.1 describes the BLS data. The baseline measures are reported and described in Section 3.2. Time-series data are presented in Section 3.3 to highlight trends in construction worker health and safety.

The BLS data cover both non-fatal construction worker illnesses and injuries and construction-related fatalities. Non-fatal illnesses and injuries are classified into three case types: (1) recordable; (2) lost workday; and (3) illness.[v] BLS produces incidence rates for each case type. These rates[vi] are: (1) the recordable incidence rate (referred to

[v] A recordable incident is a work-related death or illness and any injury which results in: loss of consciousness, restriction of work or motion, transfer to another job, or medical treatment beyond first aid. An incident is defined as a lost workday case if it results in days away from work or restricted work activity.

[vi] The incidence rates for recordable and lost workday cases represent the number of injuries and illnesses per 100 full-time workers and are calculated as: (N/EH) x 200,000, where N = the number of injuries and illnesses, EH = the total hours worked by all employees during the calendar year, and 200,000 = the base for 100 equivalent full-time workers (working 40 hours per week, 50 weeks per year). The incidence rates (i.e., the denominator) for illnesses represent the number of illnesses per 10,000 full-time workers.

hereafter as the RIR); and (2) the lost workday case incidence rate (referred to hereafter as the LWCIR); and (3) the illness incidence rate (referred to hereafter as the IIR). BLS also produces incidence rates for fatalities.[vii]

Table ES-2 shows general information on the construction industry as a whole along with sector-specific information compiled from the BLS data. Note that the BLS data are for the year 1994. Thus, the BLS data report safety-related results for the base year (i.e., 1994).

Table ES-2 records the baseline values for each of the four key incidence rates. These rates are: (1) the RIR; (2) the LWCIR; (3) the IIR; and (4) the fatality incidence rate. The first row of the table records the value of each incidence rate for the construction industry as a whole. The next four rows record the value of each incidence rate for each sector (i.e., residential, commercial/institutional, industrial, and public works). The last row records the value of each incidence rate for special trade contractors (i.e., Standard Industrial Classification (SIC) Code 17). Special trade contractors are reported separately because they serve all four sectors of the construction industry. Unfortunately, it is not possible to "redistribute" incidents from SIC Code 17 to any of the other construction industry sectors. Therefore, SIC Code 17 is treated as if it were a "sector." The information on each of the four types of incidents (i.e., recordable, lost workday, illness, and fatality) for SIC Code 17 is incorporated into the incidence rates for the construction industry as a whole.

Table ES-2 includes a series of explanatory notes to help understand both what is included and what is not included in the sector-specific baseline values of the key incidence rates. Note "a" indicates that the baseline values of the RIR and the LWCIR for the residential sector are estimated. Estimates for the RIR and the LWCIR for the residential sector are produced by combining information from two, three-digit SIC Codes (152 and 153). Specifically, information on the incidence rate and the number of incidents is used to estimate craft workhours for each three-digit SIC Code. The number of incidents are then added together (e.g., the number of recordables in SIC Code 152 and the number of recordables in SIC Code 153) to get the numerator and the number of craft workhours are added together to get the denominator in the formula used to calculate the RIR and the LWCIR, respectively (see the definitions of the terms "N" and "EH" in footnote v). Each resultant (i.e., the value returned by dividing N by EH) is then multiplied by 200,000 to get the estimated value for the RIR and for the LWCIR in the residential sector (see footnote vi). Note "b" indicates that sector-specific values for the commercial/institutional and industrial sectors require information on two, four-digit SIC Codes (1541 and 1542). In the absence of such information, the value for the three-digit SIC Code 154 is used. Thus, the commercial/institutional sector and the industrial sector have the same value for the RIR as SIC Code 154 and the same value for the LWCIR as SIC Code 154. Note "c" indicates that additional information on SIC Code 15 is needed

[vii] The incidence rates for fatalities represent the number of fatal occupational injuries per 100,000 employed workers. Note that the denominator used in calculating the incidence rates for fatalities is the number of workers rather than full-time workers. Since many of these workers have worked only a small fraction of a year, the rates will be lower than they would be if they were based on full-time workers.

in order to develop sector-specific values for the IIR for the residential, commercial/ institutional, and industrial sectors. Because in 1994 information on the IIR was only published at the two-digit SIC Code level, three of the four sectors (i.e., residential, commercial/institutional, and industrial) have the same baseline values for the IIR. Note "d" indicates that sector-specific fatality incidence rates can not be generated because information on the number of self-employed construction workers is only reported for the construction industry as a whole.

Table ES-2. Summary of the Baseline Measures for the Construction Industry Overall and for Each Sector

Sector	Incidence Rate			
	per 100	per 100	per 10,000	per 100,000
	Recordable	Lost Workday	Illness	Fatality
All	11.8	5.5	21.8	14.8
Residential	10.3[a]	5.0[a]	22.6[c]	14.8[d]
Commercial/Institutional	11.5[b]	5.1[b]	22.6[c]	14.8[d]
Industrial	11.5[b]	5.1[b]	22.6[c]	14.8[d]
Public Works	10.2	5.0	23.4	14.8[d]
Special Trade Contractors	12.5	5.8	21.2	14.8[d]

Source: US Bureau of Labor and Statistics, *Occupational Injuries and Illnesses: Counts, Rates, and Characteristics, 1994*, Bulletin 2485, and *Fatal Workplace Injuries in 1994: A Collection of Data and Analysis*, Report 908.

[a] Estimated.
[b] Requires information on the number of incidents and the number of craft work hours in SIC Codes 1541 and 1542.
[c] Requires information on the number of incidents and the number of craft work hours in SIC Codes 152, 153, 1541, and 1542.
[d] Requires information on the number of construction workers in SIC Codes 152, 153, 1541, 1542, 16, and 17.

Chapter 4 presents an analysis of the impact of safety practice use on reducing construction worker illnesses and injuries.[viii] Chapter 4 contains three sections. The first section introduces the concept of a safety practice and gives several examples of safety practices currently in use within the construction industry. A discussion of safety practices is included because safety practices are a vehicle for reducing construction-related illnesses and injuries. A full discussion of safety practices is beyond the scope of this report. However, sufficient descriptive material is presented to make the case that safety practices capable of serving the needs of different types of construction firms exist and that these practices will promote progress towards achieving the National Construction Goal of reducing construction-related illnesses and injuries by 50 %.

[viii] The term practice as used in this document refers to a formal process for implementing and documenting performance improvements.

The second section of the chapter presents project-based empirical evidence on how safety practice use translates into reductions in the RIR and the LWCIR. The empirical evidence presented in this chapter and its analysis uses data provided to NIST by the Construction Industry Institute (CII).[ix] The CII data are noteworthy because they are recorded on a project basis and therefore include information on both the prime contractor and all subcontractors. Although the prime contractor is usually a member of CII, and hence a fairly large construction establishment, the subcontractors are often smaller construction establishments. CII classifies each project in its database into a unique category under each of four major headings. One of these headings, industry group, has four categories: buildings, heavy industrial, light industrial, and infrastructure. These industry group categories are easily mapped into the three non-residential sectors—commercial/institutional, industrial, and public works—used by the Construction and Building Subcommittee. In addition, the CII data may be classified according to each of the three remaining major headings and evaluated further to determine the impact of this new classification dimension on the calculated values of the RIR and of the LWCIR. The three remaining major headings are: project cost, project nature (i.e., new construction or additions and alterations), and craft workhours.

The results of analyzing the impact of using CII's Zero Accidents safety practice on reducing the values of the RIR and of the LWCIR are very encouraging. In all cases (i.e., for all the data classification categories examined), the mean values of the RIR and of the LWCIR were reduced significantly—often by as much as 75 percent—as the degree of safety practice use moved from the lowest level to the highest level. It is also very encouraging to note that even modest increases in the degree of safety practice use can translate into significant reductions (e.g., 30 to 50 percent) in the mean values of the RIR and of the LWCIR.

The third section discusses how the more intensive use of safety practices can be expected to translate into significant reductions in construction-related illnesses and injuries. Several key practice implementation and intervention effectiveness issues are then discussed (e.g., why the CII Zero Accidents safety practice might not be particularly well-suited for small construction firms). The section concludes with a discussion of why the aggressive use of safety practices is a key instrument in achieving the 50 percent reduction in construction worker illnesses and injuries set forth in National Construction Goal 7.

Chapter 5 discusses additional areas of research that might be of value to government agencies and private sector organizations who are concerned about reducing construction worker illnesses and injuries. These areas of research are concerned with: (1) the dissemination of more detailed illness and injury data by the BLS that would facilitate the construction of sector-specific measures as opposed to general measures; (2) the development of an action plan for disseminating information on safety practices and for establishing guidelines on how to adapt safety practices for use by small and mid-sized construction firms; (3) the collection of additional project-level data to analyze the

[ix] All data provided to NIST by CII have been aggregated in a manner that precludes identification of an individual company's or project's performance.

relationships between practice use and reductions in construction worker illnesses and injuries; (4) the role of the Construction and Building Subcommittee member organizations in promoting the achievement of National Construction Goal 7; and (5) the measurement and evaluation of progress toward achievement of National Construction Goal 7.

The appendix provides a snapshot of the US construction industry and the context within which the baseline measures are developed. An extensive set of statistics has been compiled on each sector; many of these statistics are included in the appendix. These statistics are useful not only as a tool for defining the baseline measures but also as a resource reference for readers with a wide variety of interests in the construction industry.

The appendix contains three sections. Each section deals with a particular topic. First, information on the value of construction put in place is provided to show the size of the construction industry and each of its four sectors—residential, commercial/institutional, industrial, and public works. Second, information on the nature of construction activity for each sector of the industry is presented. The Standard Industrial Classification (SIC) Codes for the construction industry are introduced and described as a means for organizing construction activity. Information on the nature of construction activity includes breakouts between new construction activities, maintenance and repair activities, and additions and alterations. Third, information on employment in the construction industry is summarized and a series of employment-related statistics are presented. The SIC Codes for the construction industry are used as a means for organizing key employment-related information.

1. Introduction

1.1 Background

The National Science and Technology Council, a cabinet-level group chaired by the president, is charged with setting federal technology policy and coordinating R&D strategies across a broad cross-section of public and private interests. It has established nine research and development committees, including the Committee on Civilian Industrial Technology (CCIT), to collaborate with the private sector in developing a comprehensive national technology policy. The purpose of CCIT is to enhance the international competitiveness of US industry through federal technology policies and programs. The Construction and Building Subcommittee of CCIT coordinates and defines priorities for federal research, development, and deployment related to the industries that produce, operate, and maintain constructed facilities, including buildings and infrastructure.[1]

The mission of the Construction and Building Subcommittee is to enhance the competitiveness of US Industry, public safety, and environmental quality through research and development, in cooperation with US industry, labor, and academia, for improvement of the life cycle performance of constructed facilities. To accomplish its mission, the Construction and Building Subcommittee has established seven National Construction Goals in collaboration with a broad cross section of the construction industry.[2]

Data describing current practices of the US construction industry are needed to establish baselines against which industry can measure its progress towards achieving the seven National Construction Goals. The seven National Construction Goals are concerned with: (1) reductions in the delivery time of constructed facilities; (2) reductions in operations, maintenance, and energy costs; (3) increases in occupant productivity and comfort; (4) reductions in occupant-related illnesses and injuries; (5) reductions in waste and pollution; (6) increases in the durability and flexibility of constructed facilities; and (7) reductions in construction worker illnesses and injuries.

Although information having relevance to the seven goals is available, for the most part, this information has such a narrow focus that a consistent set of baseline measures and associated measures of progress cannot be produced without first conducting a significant research effort. Specifically, information from a wide variety of data sets needs to be collected, reviewed, analyzed, and critiqued to ensure that the resulting baseline measures and measures of progress are:

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[1] Wright, Richard N. 1995. "Government and Industry Working Together." *Construction Business Review* (January/February): pp. 44-49.
[2] Wright, Richard N., Arthur H. Rosenfeld, and Andrew J. Fowell. 1995. *Construction and Building: Federal Research and Development in Support of the US Construction Industry*. Washington, DC: National Science and Technology Council.

(1) adequate (i.e., they not only capture the complexities of the US construction industry but also represent a consensus among experts in the field); and

(2) suitable for dissemination to the public.

It is essential to have baseline data and associated measures of progress to determine the success of actions taken to improve the competitiveness of the US construction industry. In addition, baselines and measures of progress will make it possible to demonstrate the benefits of advanced technologies and practices, and to guide decision makers in prioritizing potential programs.

The goal of this project is to develop a suite of products that support the measurement and attainment of the National Construction Goals by the four key construction industry sectors. The four industry sectors are: (1) residential; (2) commercial/institutional; (3) industrial; and (4) public works. Three basic sets of products are envisioned:

(1) *Baseline Measures*: Develop baseline measures that characterize current industry performance with respect to each of the seven goals. The averages of current practice (defined in this document as industry performance in 1994) will become the baselines for measuring progress towards achieving each of the goals.

(2) *Measures of Progress*: Develop methods for measuring progress. These "results" measures are envisioned as a composite of performance measures offering a means not only for monitoring actual performance but also for marshaling support for improving results.

(3) *Periodic Reports*: Provide information on each of the seven goals. This information will be made available to interested parties both through publications and, ultimately, electronically via the World Wide Web. Potential outlets for the baselines and measures of progress include the Construction and Building Subcommittee member organizations[3] and the four organizations that provided industry input on the National Construction Goals.[4]

1.2 Purpose

The purpose of this document is twofold. First and foremost, this document provides a detailed set of baseline measures for National Construction Goal 7 (reductions in construction worker illnesses and injuries). As such, it describes data sources, data

[3] The following Federal Agencies are members of The Construction and Building Subcommittee: Department of Agriculture, Department of Commerce, Department of Education, Department of Energy, Department of Health and Human Services, Department of Housing and Urban Development, Department of Interior, Department of Labor, Department of Transportation, Department of Veterans Affairs, Environmental Protection Agency, General Services Administration, National Aeronautics and Space Administration, National Science Foundation.

[4] The four organizations that provided industry input are: (1) National Association of Home Builders Research Center (Residential); (2) National Institute of Building Sciences (Commercial/Institutional); (3) Construction Industry Institute (Industrial); and (4) American Public Works Association (Public Works).

classifications, and the metrics used to develop the baseline measures. Extensive use of charts and tables is made throughout this document to illustrate the process by which the baseline measures were developed. This document is the third in a series of studies prepared by NIST's Building and Fire Research Laboratory (BFRL). The earlier companion documents focus on National Construction Goal 1, reductions in delivery time,[5] and National Construction Goal 2, reductions in operations, maintenance, and energy costs.[6]

The second purpose of this document is to analyze the impact of safety practice use on reducing construction worker illnesses and injuries. This analysis is based on data provided to NIST by the Construction Industry Institute (CII).

1.3 Scope and Approach

This document has four chapters and an appendix in addition to the Introduction. Chapter 2 introduces the National Construction Goals and describes how a well-defined set of metrics is used to develop the baseline measures and measures of progress. Chapter 3 presents the baseline measures. All of the baseline measures are based on data published by the Bureau of Labor Statistics (BLS) of the US Department of Labor. Chapter 4 introduces the concept of a safety practice and gives several examples of safety practices currently in use within the construction industry. How the use of the CII Zero Accidents safety practice affects safety performance is then analyzed. Chapter 5 concludes the document with a summary and suggestions for further research. The appendix provides an overview of the construction industry.

Because this document is part of a series and each document is designed to stand alone within the series, there is some repetition of material provided in the earlier companion documents. These materials are located in Chapter 2 and the appendix. Chapter 2 has been condensed considerably whereas the material presented in the appendix has been edited and revised slightly.[7] Thus, readers familiar with the material contained in the earlier companion documents may skip directly to the baseline measures contained in Chapter 3.

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[5] Chapman, Robert E., and Roderick Rennison. 1998. *An Approach for Measuring Reductions in Delivery Time: Baseline Measures of Construction Industry Practice for the National Construction Goals.* NISTIR 6189. Gaithersburg, MD: National Institute of Standards and Technology.

[6] Chapman, Robert E., and Roderick Rennison. 1998. *An Approach for Measuring Reductions in Operations, Maintenance, and Energy Costs: Baseline Measures of Construction Industry Practice for the National Construction Goals.* NISTIR 6185. Gaithersburg, MD: National Institute of Standards and Technology.

[7] The material contained in the appendix was originally published as Sections 3.1 through 3.3 of Chapter 3 in NISTIRs 6189 (see Chapman and Rennison, *An Approach for Measuring Reductions in Delivery Time*.) and 6185 (see Chapman and Rennison, *An Approach for Measuring Reductions in Operations, Maintenance, and Energy Cost*.).

2. The National Construction Goals: A Tool for Promoting Competitiveness Within the Construction Industry

2.1 Description of the National Construction Goals

The Construction and Building (C&B) Subcommittee has studied research priorities expressed by the construction industry. These priorities translate into the following seven National Construction Goals:

1. 50 % Reduction in Delivery Time
2. 50 % Reduction in Operation, Maintenance, and Energy Costs
3. 30 % Increase in Productivity and Comfort
4. 50 % Fewer Occupant-Related Illnesses and Injuries
5. 50 % Less Waste and Pollution
6. 50 % More Durability and Flexibility
7. 50 % Reduction in Construction Worker Illnesses and Injuries

To make the National Construction Goals operational, their values are based on the values of a well-defined set of baseline measures. As noted in the Introduction, the values of the baseline measures for each goal are averages of industry performance in 1994. The year 1994 was established as the basis for computing the values of the baseline measures because it was the year when the National Construction Goals were first formulated.[8]

Two priority thrusts, better constructed facilities and health and safety of the construction work force, were defined as the focus of C&B-related research, development, and deployment (RD&D) activities. The objective of the C&B-related RD&D activities is to make technologies and practices capable of achieving the goals under the two priority thrusts available for general use in the construction industry by 2003.

Achievement of the National Construction Goals will: (1) reduce the first costs and life-cycle costs of constructed facilities in the four key construction industry sectors (i.e., residential, commercial/institutional, industrial, and public works); (2) result in better constructed facilities; and (3) result in improved health and safety for both construction workers and occupants of constructed facilities. Achievement of the goals will convey benefits to each of the four construction industry sectors (e.g., housing will become more affordable through reductions in first costs and life-cycle costs). However, depending on the goal and the construction industry sector, the beneficial impacts are expected to vary. To gain a better appreciation of the importance of the National Construction Goals, both individually, and taken together, and of their relationship to the four key construction

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[8] Wright, Richard N., Arthur H. Rosenfeld, and Andrew J. Fowell. 1994. *Rationale and Preliminary Plan for Federal Research for Construction and Building*. NISTIR 5536. Washington, DC: National Science and Technology Council.

industry sectors, a brief description of each goal follows. The descriptions are patterned after those given in the report by Wright, Rosenfeld, and Fowell.[9]

Goal 1: 50 % Reduction in Delivery Time

Delivery time is defined as the elapsed time from the decision to construct a new facility until its readiness for service. Delivery time issues affect both industrial competitiveness and project costs. During the initial planning, design, procurement, construction, and start-up process, the needs of the client are not being met. Furthermore, the client's needs evolve over time, so a facility long in delivery may be uncompetitive or unsuitable when it is finished. Delays almost always translate into increased project costs due to inflationary effects, higher financial holding costs, and reduced productivity. Furthermore, the investments in producing the facility cannot be recouped until the facility is operational. Owners, users, designers, and constructors are among the groups calling for technologies and practices to reduce delivery time.

Goal 2: 50 % Reduction in Operation, Maintenance, and Energy Costs

Operations, maintenance, and energy (OM&E) costs are a major factor in the life-cycle costs of a constructed facility. In some cases, OM&E costs over the life of a facility exceed its first cost. However, because reductions in OM&E costs are often associated with increased first costs, facility owners and managers may underinvest in cost saving technologies. Furthermore, undue attention on minimizing first costs may result in a facility which is expensive to operate and maintain, wastes energy resources, is inflexible, and rapidly becomes obsolete. Finally, because OM&E costs tend to increase more rapidly than the general rate of inflation, facility owners and operators are often forced to reallocate funds to cover OM&E costs. Reductions in OM&E costs will produce two types of benefits. First, constructed facilities will become more affordable because facility owners and operators are making more cost-effective choices among investments (e.g., design configurations) which affect life-cycle costs. Second, these same facilities will better conserve scarce energy resources.

Goal 3: 30 % Increase in Productivity and Comfort

Industry and government studies have shown that the annual salary costs of the occupants of a commercial or institutional building are of the same order of magnitude as the capital cost of the building.[10] Occupant comfort depends largely on the nature of buildings, building furnishings, and indoor environments. The quality of indoor environments also has a large impact on occupant health and productivity. Improvement of the productivity of the occupants (or for an industrial facility, improvement of the productivity of the

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[9] Wright, Richard N., Arthur H. Rosenfeld, and Andrew J. Fowell. 1995. *Construction and Building: Federal Research and Development in Support of the US Construction Industry*. Washington, DC: National Science and Technology Council.

[10] Building Owners and Managers Association. 1994. *Experience Exchange Report, National Cross-Tabulations, 1994*. Washington, DC: Building Owners and Managers Association.

process housed by the facility) is an important performance characteristic for most constructed facilities.

Goal 4: 50 % Fewer Occupant-Related Illnesses and Injuries

Buildings are intended to shelter and support human activities, yet the environment and performance of buildings can contribute to illnesses and injuries for building users. Examples are avoidable injuries caused by fire or natural hazards, slips and falls, disease from airborne microbes, often associated with a workplace environment, and building damage or collapse from fire, earthquakes, or extreme winds. Reductions in illnesses and injuries will increase building users' productivity as well as reduce the costs of medical care and litigation.

Goal 5: 50 % Less Waste and Pollution

Improvement of the performance of constructed facilities provides major opportunities to reduce waste and pollution at every step of the delivery process, from raw material extraction to final demolition and recycling of the facility and its contents. Additional reductions come from reduced energy use, reduced water consumption, and reductions in waste water production, which are considered in part by Goal 2.

Goal 6: 50 % More Durability and Flexibility

Durability denotes the capability of the constructed facility to continue (given appropriate maintenance) its initial performance over the intended service life. Flexibility denotes the capability to adapt the constructed facility to changes in use or users' needs. Increased durability and flexibility of constructed facilities reduces life-cycle costs and prolongs the economic life of the facility (i.e., the period of time over which an investment in the original facility is considered to be the least-cost alternative for meeting a particular objective).

Goal 7: 50 % Reduction in Construction Worker Illnesses and Injuries

Health and safety issues exert a major effect on the competitiveness of the US construction industry. Construction workers die as a result of work-related trauma at a rate which is higher than all other industries except mining and agriculture. Construction workers also experience a higher incidence of nonfatal injuries resulting in days away from work than workers in other industries do. Although the construction workforce represents less than 6 percent of the nation's workforce, it is estimated that the construction industry pays about 15 percent of the nation's workers' compensation.[11]

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[11] The Center to Protect Workers' Rights. 1997. *The Construction Chart Book: The US Construction Industry and Its Workers*. Report D1-97. Washington, DC: The Center to Protect Workers' Rights.

2.2 Baseline Measures

As noted earlier, the baseline measures for each goal are averages of industry performance in 1994. Thus, with regard to the baseline measures, 1994 is the "base year." Consequently, data from 1994 drive the data collection effort culminating with the development of the baseline measures for each National Construction Goal.

The process for developing baseline measures used in this project involves: (1) specifying data relationships; (2) collecting and compiling the key data and supporting information for the base year, 1994;[12] (3) defining metrics for each goal/sector combination; and (4) producing the metrics in a tabular summary form and, where appropriate, producing charts and graphs to depict the metrics. If the goal/sector combination has components and subcomponents, then metrics are defined for each. This process is employed because the metrics represent not only a statement of current construction industry performance, but tools for measuring an individual organization's performance as well. By providing a small set of well-defined metrics, individual organizations can construct their own performance baselines. For example, individual organizations can see how a collection of their projects performs vis-à-vis the "national" data. To summarize, the basic philosophy behind the baseline measures is that they are not a static tool whose sole purpose is quantifying the value of the goal but a means for driving performance improvement within individual organizations.

2.3 Measures of Progress

The methods for measuring progress use the baselines as their reference point. The measures of progress employ a method that makes use of both key outputs (i.e., summary measures) and interlinking metrics (i.e., a composite of performance measures including constituent parts and functional relationships). Because the National Construction Goals may be specified as targets measured against baseline values, "gap analysis" is an appropriate method for defining the measures of progress.

To gain a better understanding of how gap analysis may be applied, consider the following case illustration. One component of Goal 7, Construction Worker Illnesses and Injuries, is the recordable incidence rate.[13] If Goal 7 targets a 50 % reduction in construction worker illnesses and injuries, we may adopt an across-the-board reduction of 50 % for all components of that goal. Therefore, for this component, the goal is to reduce the recordable incidence rate by 50 %. Denote the industry average in 1994 by BR_{94} (i.e., the <u>*B*</u>aseline value for the <u>*R*</u>ecordable incidence rate). Denote the goal for the recordable incidence rate for 2003 by GR_{03}; it is equal to $0.5*BR_{94}$. Denote the difference between

[12] If data are available for years in addition to 1994 (e.g., 1989 through 1997), then these data are collected at the same time as the base year data and used to illustrate trends; these data are also used to compute the associated measures of performance.

[13] A recordable incident is a work-related death or illness or any injury, which results in: loss of consciousness, restriction of work or motion, transfer to another job, or requires medical treatment beyond first aid. The incidence rate represents the number of recordable incidents per 100 full-time workers.

the baseline and the goal (i.e., BR_{94} - GR_{03}) by dR_{94}. This difference may be thought of as a gap (i.e., the difference between the actual level and the desired level). Similarly, for some given year, say 1997, whose actual value is R_{97}, the gap becomes dR_{97} (i.e., R_{97} - GR_{03}).

This method also enables us to measure how much of the initial gap has been closed. One measure of performance is the percent of the initial gap which has been closed by some given date, say 1997. Denote this amount as $P(dR_{97})$, where:

$$P(dR_{97}) \quad = \quad (1 - (dR_{97} / dR_{94})) * 100$$

The advantage of this measure of performance is that it employs the same values for each measure used in computing the baselines. Although the gap analysis method is simple and straightforward, it offers considerable flexibility. Consequently, it is the recommended method for generating measures of progress.[14]

2.4 Interactions Between the National Construction Goals, the Baseline Measures, and the Measures of Progress

As noted earlier, the objective of the C&B-related RD&D activities is to have *technologies and practices* capable of meeting the goals available in 2003. This objective raises an important issue, namely, the relationships between the baseline measures, the measures of progress, and the goals. Several relationships that warrant consideration are the following. First, it is important to recognize that the goal can always be represented as a function of the baseline measure. Thus, given a baseline "value," a target or goal "value" can be specified. Second, for baseline measures to be most beneficial, they need to be tied to specific "metrics" that are well-defined and able to be used by interested parties (e.g., a specific government agency could substitute its own data into the metric and use it to establish its own "baseline" values). Finally, the measures of progress need to make explicit the relationship between the baseline, the goal, and the current level of improvement.

[14]The gap analysis method has another advantage in that priorities can be easily incorporated. For example, recordable incidents can be separated into two, mutually exclusive categories: (1) lost workday cases; and (2) cases without lost workdays. Consequently, progress towards closing the gap on one component (e.g., lost workday cases) could be viewed as more important than progress on another component (e.g., cases without lost workdays) for that Goal. Multiattribute decision analysis (MADA) provides a well-established tool for assigning priorities to components. (See, American Society for Testing and Materials. 1998. *Standard Practice for Applying Analytical Hierarchy Process (AHP) to Multiattribute Decision Analysis of Investments Related to Buildings and Building Systems*. E 1765. West Conshohocken, PA: American Society for Testing and Materials.) MADA may also be used to develop a hierarchical relationship among components (i.e., a composite of performance measures including constituent parts and functional relationships). Such an approach would help to analyze how changes in individual metrics (i.e., components at a lower level within the hierarchical relationship) affect the level and rate of change of key outputs (i.e., the highest level metric in the hierarchical relationship).

The previous discussion implies that the form of the baseline measure is important as a "facilitator" of performance (i.e., a linkage to performance-improving technologies and practices). Two forms of baseline measures that may serve as facilitators are point estimates (i.e., an average value) and a distribution of values. Although an *average value* is a good baseline measure, it collapses a great deal of information into a single reference point. An alternative way to think about a baseline measure is as *the distribution of values* of industry performance in 1994. This approach, while more data intensive, is a great deal more flexible. Over the long term, the key stakeholders (e.g., researchers, innovators, owners, and contractors) can focus on pushing the entire distribution towards a more competitive position (e.g., faster delivery time) rather than just focusing on improving the average value of some "unknown" distribution. It is important to recognize that *the distribution of values* contains not only the mean or average value of the metric that defines the baseline measure, but the highest and lowest values as well. For example, if the percentiles of the distribution are available, an individual organization (e.g., government agency, construction firm, etc.) could calculate a representative set of values and, hence, determine their location within the distribution. This information could then be used for goal setting and for developing measures of progress within a particular organization.

2.5 Criteria for Data Selection

Criteria are needed to ensure that the data selected for analysis are well defined, consistent, and replicable. Because data are so important to the baseline measures for each goal, BFRL reviewed many potential sources (e.g., journals, technical publications, electronic media) of baseline-related data/information. This review suggested three criteria that must be met by any data in order to be accepted for analysis. These criteria are:

(1) Published by a reliable, nationally recognized organization and available to the public;

(2) Updated on a regular basis; and

(3) Able to be normalized to account for changes in the building stock and the level of construction activity.

Clearly, the data used to produce the baseline measures must be reliable, accessible to the public, and updated on a regular, preferably an annual, basis. Thus, the requirement for the first two criteria items is self evident. The requirement for the third criteria item is more complex and stems from the fact that the construction industry tends to be cyclical in nature. The cyclical nature of the construction industry is discussed in some detail in the appendix to this report. To better understand the need for the third criteria item, consider the case of a recordable incident. If the number of recordable incidents is declining, does this imply that the rate at which such incidents are occurring in the construction industry is also declining? The answer to this rhetorical question is "no," because in the construction industry both the level of employment and the total number of craft work hours varies considerably over the business cycle (see Section A.3). Thus, the relevant metric for computing the baseline measure for recordable incidents is not the number of recordable incidents but the recordable incidence rate, or RIR. The calculation of the RIR is normalized because it is based on 100 full-time workers, each working 40 hours per week, 50 weeks per year. Although reducing the number of recordable incidents is a desirable outcome, improved health and safety for construction workers will only result when the recordable incidence rate is reduced.

The previous discussion demonstrates why each of the three criteria items are appropriate for establishing the baseline measures for each goal. These criteria are also appropriate for any data associated with measures of progress for each goal.

2.6 Special Requirements Due to Data Classification Issues

Construction projects are carried out by a prime contractor usually with the assistance of one or more subcontractors (e.g., an excavation contractor). Construction projects by their nature (e.g., single-family residence, high-rise office building, manufacturing facility, and highway bridge) can be assigned to one of the four sectors used by the Construction and Building Subcommittee (i.e., residential, commercial/institutional, industrial, and public works).

The data used to establish the baseline measures are published by the Bureau of Labor Statistics (BLS). These data are classified in three different ways: (1) for the entire construction industry; (2) by two-digit SIC Code; and (3) by three-digit SIC Code. The data for the entire construction industry are the most complete. However, these data can not be broken down by sector. The two-and three-digit SIC Code data are too aggregated to match exactly the four sectors defined by the Construction and Building Subcommittee. Thus, the baseline measures for each sector presented in the next chapter have associated with them a number of caveats. An additional problem is posed by the way BLS collects information on special trade contractors.

Special trade contractors are often subcontractors on a construction project. Thus, for the same construction project, the prime contractor maintains information on their safety performance and each subcontractor maintains information on their safety performance. When BLS surveys construction establishments (see Section 3.1), the prime contractor and the subcontractors are surveyed separately. Consequently, there is no linkage back to the construction project, say a single-family residence, where the prime contractor was a home builder that managed the job and performed most of the construction tasks and the subcontractors carried out excavation, plumbing, and electrical work. In this case, any construction-related illnesses and injuries associated with the prime contractor would fall under the residential sector and any construction-related illnesses and injuries associated with the subcontractors would fall under the heading of special trades. For this reason, a fifth sector, special trades, is used in reporting the baseline measures.

Although the North American Industrial Classification System introduced in 1997, will result in a better match to the Construction and Building Subcommittee sectors, BLS is not yet reporting construction-related illnesses and injuries data using the new classification system. In addition, the problem of how to assign special trade contractors will remain. Only at the industry level will BLS report data on all construction establishments.

2.7 How This Document Helps

This document is part of a series. As such, it provides perspective on the overall effort to develop baseline measures and measures of progress for each of the seven National Construction Goals. It also serves to highlight how these measures and their associated metrics can be used to drive performance improvement.

On a deeper level, this document provides step-by-step descriptions of how to construct a well-defined set of baseline measures, their components, and associated metrics for a specific goal for each of the four construction industry sectors. Information on data relationships, data sources, and data collection and analysis provide the underpinnings for the results presented in this document. It is anticipated that once users of this document have understood the vital role of metrics as a process improvement tool, they will see how the National Construction Goals will benefit both their organization and the US construction industry.

3. Baseline Measures of Construction Worker Illnesses and Injuries Data

This chapter traces the development of the baseline measures for construction worker illnesses and injuries. Data sources are described and matched to the key types of safety and health-related information. The safety and health-related baseline measures are then derived from the source data. Time-series data are then presented to highlight trends in construction worker health and safety. The chapter concludes with a summary of the key safety and health-related baseline measures.

3.1 Data Considerations: Sources, Availability, and Constraints

Preliminary data searches for safety and health-related information identified the US Department of Labor (USDL), Bureau of Labor Statistics (BLS) as the primary source for the baseline measures. The BLS data are primary in that BLS collects data via survey, analyzes the data, and publishes the results of their analyses annually. BLS data are the most comprehensive national data available to the public.

The Center to Protect Workers' Rights (CPWR) was identified as an additional, secondary data source. CPWR focuses on safety and health in construction and related economics issues. CPWR is the research and development arm of the Building and Trades Department of the AFL-CIO. CPWR publishes *The Construction Chart Book*.[15] The *Chart Book* is designed to summarize statistics on construction industry and employment trends. The intent of the *Chart Book* is to define key characteristics of the industry, while providing information about sources of data. The *Chart Book* was helpful in identifying ways to summarize and present health-related information.

This report provides a sampling of the type of data available from the BLS on fatal and nonfatal injuries and illnesses. The BLS disseminates data in a continuous series of annual releases from the BLS safety and health statistical series. These releases cover

- Workplace Injuries and Illnesses and Characteristics of Injuries and Illnesses Resulting in Absences from Work, from the *Survey of Occupational Injuries and Illnesses*.

- Fatal Occupational Injuries, from the *National Census of Fatal Occupational Injuries.*

The *Survey of Occupational Injuries and Illnesses* provides data on injuries and illnesses that are derived from a two-stage sample selection process. The first stage involves selecting establishments. The second stage involves selecting the sample of cases involving days away from work which is derived from the sample establishments. The

[15] The Center to Protect Workers' Rights. 1997. *The Construction Chart Book: The US Construction Industry and Its Workers*. Report D1-97. Washington, DC: The Center to Protect Workers' Rights.

National Census of Fatal Occupational Injuries provides actual, verifiable data on fatalities.

Survey of Occupational Injuries and Illnesses

The sample data on nonfatal occupational injuries and illnesses used in this report came from the 1994 *Survey of Occupational Injuries and Illnesses* of the BLS.[16] In cooperation with State agencies, BLS collects information from employers[17] on the number and incidence[18,19] of nonfatal work-related injuries and illnesses. The survey sample selected by BLS consists of approximately 250,000 establishments in private industry. Survey data are solicited from employers having 11 employees or more in agricultural production, and from all employers in agricultural services, forestry, and fishing; oil and gas extraction; construction; manufacturing; transportation and public utilities; wholesale trade; retail trade; finance, insurance and real estate; and services (except private households). Data for employees covered by other Federal safety and health legislation are provided by the Mine Safety and Health Administration of the U.S. Department of Labor.

Each year the *Survey* provides estimates by industry and by State of the number of workplace injuries and illnesses, and also by the number of injuries and illnesses that involve lost work time. The average number of days away from work and the percent distribution of days away from work by industry are also given.

By recording the days away from work, the *Survey* provides a measure of the "seriousness" of injuries and illnesses. The majority of recorded illness cases are new illness cases that are recognized, diagnosed, and reported during the year. Long-term latent illnesses are believed to be understated in the *Survey's* illness measures because they are difficult to relate directly to workplace activity.

For workers with injuries and illnesses involving time away from work, the *Survey* estimates the number and percent distribution of injuries and illnesses by occupation, sex, age, race, and length of service. Numbers, percent distributions, and incidence rates are also calculated by detailed nature of injury and illness, part of body affected, source of the injury or illness, and type of event or exposure leading to the incident. Cross tabulations of the worker characteristics and injury/illness circumstances are also

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[16] US Department of Labor. 1997. *Occupational Injuries and Illnesses: Counts, Rates, and Characteristics, 1994.* Bulletin 2485. Washington, DC: Bureau of Labor Statistics.

[17] Construction establishments with no employees (i.e., self-employed construction workers) are not covered by the *Survey*.

[18] Three broad categories—the recordable incidence rate (RIR), the lost workday case incidence rate (LWCIR), and the illness incidence rate (IIR)—are used to specify the incident rate.

[19] The incidence rates for the RIR and the LWCIR represent the number of injuries and illnesses per 100 full-time equivalent workers and were calculated as: (N/EH) x 200,000, where N = the number of injuries and illnesses, EH = the total hours worked by all employees during the calendar year, and 200,000 = the base for 100 equivalent full-time workers (working 40 hours per week, 50 weeks per year). The incidence rate for the IIR represents the number of illnesses per 10,000 full-time equivalent workers.

available. The median and percent distribution of days away from work are estimated for each worker and case characteristic.

National Census of Fatal Occupational Injuries

The *National Census of Fatal Occupational Injuries* collects a systematic, verifiable count of all fatal work injuries as well as detailed information on how these events occurred. Multiple data sources are used to identify, verify, and profile fatal work injuries. These records include death certificates, State and Federal workers' compensation reports, OSHA fatality reports, news media, coroner/medical examiner reports, and autopsy reports. The method of cross-referencing source documents assures that the counts are as complete and accurate as possible.

In addition to providing frequency counts and incidence rates,[20] the *Census* provides information on the type of incident and machinery or equipment involved; nature of injury and part of body affected; occupation, age, race, and sex of the worker; and industry of the employer. Profiles of fatalities occurring to specific groups of workers, for specific types of events, and for cases involving certain types of equipment or machinery are also possible. Summary tables of the *Census* are released approximately eight months after the end of the reference year. This report uses data from the 1994 *Census*.[21]

3.2 Baseline Measures: Key Incidence Rates for Construction Worker Illnesses and Injuries

The baseline measures presented in this section are based on data published by BLS. The BLS data cover both nonfatal construction worker illnesses and injuries and construction-related fatalities. Nonfatal illnesses and injuries are classified into three case types: (1) recordable; (2) lost workday; and (3) illness. BLS produces incidence rates for each case type. These rates are: (1) the recordable incidence rate (RIR); (2) the lost workday case incidence rate (LWCIR); and (3) the illness incidence rate (IIR). BLS also produces incidence rates for fatalities.

A total of 6.8 million injuries and illnesses were estimated in private industry workplaces during 1994, resulting in a rate of 8.4 cases for every 100 full-time workers. The rate varied widely by industry, ranging from slightly more than 12 injuries and illnesses for every 100 full-time manufacturing workers to slightly less than 3 in finance, insurance, and real estate. Table 3-1 records the incidence rates for the nine major industry

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[20] The fatality incidence rate represents the number of fatal occupational injuries per 100,000 employed workers and was calculated as follows: (N/W) x 100,000, where N = the number of fatal work injuries, and W = the number of employed workers. Note that the denominator, W, used in calculating the fatality incidence rate is the number of workers rather than full-time workers. Since many of these workers have worked only a small fraction of a year, the fatality incidence rate will be lower than it would be if it was based on full-time workers.

[21] US Department of Labor. 1996. *Fatal Workplace Injuries in 1994: A Collection of Data and Analysis.* Report 908. Washington, DC: Bureau of Labor Statistics.

divisions. The table includes four types of information: (1) total cases, referred to as the RIR; (2) total lost workday cases (i.e., those resulting in days away from work or restricted work activity), referred to as the LWCIR; (3) cases with days away from work; and (4) cases without lost workdays. Total cases (i.e., the RIR) is equal to the sum of total lost workday cases (i.e., the LWCIR) and cases without lost workdays. The 1994 average incidence rates (i.e., RIR and LWCIR) for each major industry division are recorded in a bar chart format in Figure 3-1. The RIR for each industry division is shown as a lightly shaded bar; the LWCIR for each industry division is shown as a darkly shaded bar.

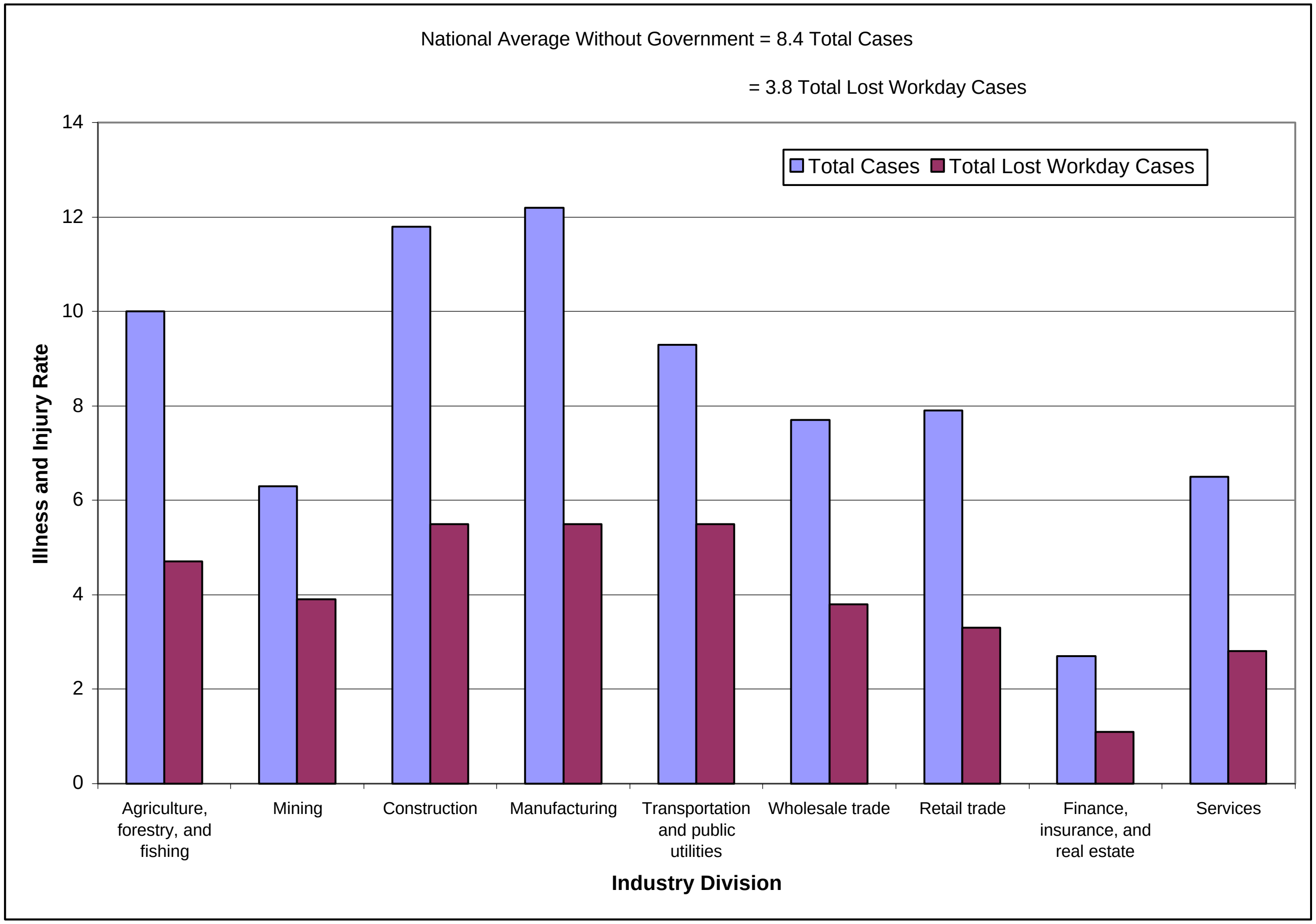
Table 3-1. Nonfatal Occupational Injury and Illness Incidence Rates per 100 Full-Time Workers by Industry, 1994

Industry	Total Cases[1]	Lost Workday Cases		Cases Without Lost Workdays
		Total[2]	With Days Away from Work[3]	
Agriculture, forestry, and fishing[4]	10.0	4.7	3.9	5.2
Mining[5]	6.3	3.9	3.3	2.4
Construction	11.8	5.5	4.9	6.3
Manufacturing	12.2	5.5	3.2	6.8
Transportation and public utilities[5]	9.3	5.5	4.2	3.9
Wholesale trade	7.7	3.8	2.8	3.9
Retail trade	7.9	3.3	2.6	4.6
Finance, insurance, and real estate	2.7	1.1	0.9	1.6
Services	6.5	2.8	2.2	3.7

Source: US Bureau of Labor Statistics, *Occupational Injuries and Illnesses: Counts, Rates, and Characteristics, 1994*, Bulletin 2485, pp. 11-24.

[1] The incidence rates represent the number of injuries and illnesses per 100 full-time workers and are calculated as: (N/EH) x 200,000, where N = the number of injuries and illnesses, EH = the total hours worked by all employees during the calendar year, and 200,000 = the base for 100 equivalent full-time workers (working 40 hours per week, 50 weeks per year).
[2] Total lost workday cases equals cases involving restricted work activity only plus Days-Away-from-Work cases with or without restricted work activity.
[3] Days-Away-from-Work cases include those which result in days away from work with or without restricted work activity.
[4] Excludes farms with fewer than 11 employees.
[5] Data conforming to OSHA definitions for mining operators in coal, metal, and nonmetal mining and for employers in railroad transportation and provided to BLS by the Mine Safety and Health Administration, U.S. Department of Labor; and the Federal Railroad Administration, U.S. Department of Transportation. Independent mining contractors are excluded from the coal, metal, and nonmetal mining industries.

Figure 3-1. Nonfatal Occupational Injury and Illness Incidence Rates per 100 Full-Time Workers by Industry, 1994



Source: US Bureau of Labor Statistics, *Occupational Injuries and Illnesses: Counts, Rates, and Characteristics, 1994,* Bulletin 2485, pp. 11-24

The national average incidence rate for private industry (i.e., without government) fell from 8.9 cases per 100 full-time workers in 1992 to 8.5 cases in 1993 and 8.4 cases in 1994. The number of injuries and illnesses estimated in any given year can be influenced by changes in the level of economic activity, working conditions and work practices, worker experience and training, and the number of hours worked. More serious injuries (i.e., the LWCIR) had an incidence rate of 3.8 in 1994.

In the construction industry, there were about 529 thousand injuries and illnesses estimated in 1994, resulting in an RIR of 11.8 cases for every 100 full-time workers. The RIR has decreased from 13.1 in 1992 and 12.2 in 1993 to 11.8 cases in 1994. During a recent 10 year period, the RIR has steadily decreased from a rate of 15.5 in 1984 to 11.8 cases per 100 full-time workers in 1994. By 1997, the RIR had declined to 9.5 (see Section 3.3).

The steady decline in the RIR for the construction industry broke new ground in 1994. For the first time in the more than 20-year history of the *Survey*, the injury and illness rate in construction fell below the rate in manufacturing. The overall rates for these two industry divisions continued to be higher than the rates in other industry divisions.

Although the steady decline in the estimated value of the RIR in the construction industry is encouraging, a number of independent studies[22, 23] indicate that the RIR values based on the *Survey* underestimate injury rates in the construction industry. The primary source of the discrepancy is under-reporting by construction establishments. Persuasive evidence exists that firms with fewer than 50 employees under report occupational injuries to BLS.[24] Glazner *et al*[25] advance three reasons why under-reporting is a significant factor in the construction industry: (1) the construction industry includes many small firms relative to other industries, and most evidence points to small firms as those most likely to under report; (2) the construction industry, made up almost entirely of firms that must compete with others to work on projects, has a strong incentive to under report because of the use of experience modification ratings (i.e., ratings based on workers' compensation claims data) by construction project managers and prime contractors in the bidding process; and (3) construction is one of the riskiest industries, with concomitly high workers' compensation premiums and, therefore, an economic disincentive to make claims.[26] Finally, for the construction industry in particular, BLS

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[22] Glazner, Judith F., Joleen Borgerding, Jan T. Lowery, Jessica Bondy, Kathryn L. Mueller, and Kathleen Kreiss. 1998. "Construction Injury Rates May Exceed National Estimates: Evidence from the Construction of the Denver International Airport." *American Journal of Industrial Medicine* (Vol. 24): pp. 105-112.

[23] Oleinick, Arthur, Jeremy V. Gluck, and Kenneth E. Guire. 1995. "Establishment Size and Risk of Occupational Injury." *American Journal of Industrial Medicine* (Vol. 28): pp. 1-21.

[24] *Ibid*. pp. 19-20.

[25] Glazner *et al.*, p.111.

[26] Workers' compensation premiums are usually calculated individually for each firm, while health insurance premiums, for all but the largest firms, are calculated by pooling the experience of many like-sized firms. Thus, if costs were shifted from workers' compensation to health insurance, a firm's workers' compensation premium could be kept artificially low without an offsetting rise in health insurance premiums, because those premiums would be subsidized by companies sharing the firm's health insurance pool.

rates likely underestimate risk for workers on construction sites by including off-site workers, such as office staff.[27]

The previous paragraph served to highlight an important factor, namely, the size of construction establishments. Issues related to construction establishment size reappear throughout this chapter. Construction establishment size is important because the construction industry is very fragmented. This complicates efforts to disseminate information on ways to improve safety performance (see Section 5.2). To better understand the importance of construction establishment size, Table 3-2 has been compiled from Census data. Table 3-2 presents information on construction establishments with employees classified by establishment size. Reference to the table shows that more than 80 % of all construction establishments have less than 10 employees. Approximately 98 % of all construction establishments have less than 50 employees. Construction establishments with less than 50 employees employ approximately two-thirds of wage and salary construction workers. On the other hand, construction establishments with 50 or more employees account for approximately 2 % of all construction establishments. These, larger establishments, employ approximately one-third of wage and salary construction workers.

Table 3-2. Percentage of Construction Establishments and Employees by Establishment Size, 1994

Establishment Size	Percent of All	
	Establishments	Employees
1 to 9	82.70	28.39
10 to 49	15.23	38.34
50 to 249	1.93	22.92
250 to 999	0.13	7.06
1000 or more	0.01	3.29

Source: US Bureau of the Census, *County Business Patterns, 1994*.
See also http://fisher.lib.virginia.edu/cbp/national.html

Tables 3-3, 3-4, and 3-5 summarize the *Survey* data for 1994 on nonfatal occupational injury and illness incidence rates for the construction industry as a whole, by two-digit SIC Code, and by three-digit SIC Code. In each table, the rows are arranged by industry (i.e., the construction industry as a whole, by two-digit SIC Code, and by three-digit SIC Code). Table 3-3 provides two types of information: (1) on injuries and illnesses combined; and (2) on injuries only. Table 3-3 provides a frame of reference from which to view more detailed information on the RIR, on the LWCIR, and on construction-related illnesses. Tables 3.4 and 3.5 are constructed to promote a better understanding of how construction establishment size, as measured by the number of employees, affects the key incidence rates. Table 3-4 focuses on one column of data from Table 3-3; it provides information on how the value of the RIR varies as a function of construction establishment size, classified by employment size group. Table 3-5 focuses on another

[27] Glazner *et al*, p. 106.

column of data from Table 3-3; it provides information on how the value of the LWCIR varies by employment size group.

Table 3-3 builds on the same format employed in Table 3-1. The first row of data recorded in Table 3-3—**Construction**—provides a direct link back to Table 3-1, where the construction industry was but one of the major industry divisions for which data were reported. Note that Table 3-3 provides an additional breakout of data, since it records information not only for injuries and illnesses but also for injuries only. Because the same column headings are included both under the major headings of **Injuries and Illnesses** and **Injuries**, any differences can be attributed to construction-related illnesses. The key incidence rates—RIR and LWCIR—are found under the first two column subheadings **Injuries and Illnesses/Total Cases** and **Lost Workday Cases Total**, respectively. These values are 11.8 for the RIR and 5.5 for the LWCIR. Additional information is recorded under the next two column subheadings under the major heading of **Injuries and Illnesses**. These four values are identical to the four values recorded in Table 3-1 for the construction industry as a whole.

Table 3-3 serves to highlight both the wealth of information published by BLS on nonfatal occupational illnesses and injuries in the construction industry and the challenge in using this information to produce sector-specific baseline measures. The BLS data recorded in Table 3-3 and in other tables and figures in this section provide many insights into construction worker health and safety issues. In addition, BLS formulates and publishes their information in a way that enables researchers to "drill down" on a particular data element. This approach is employed with the RIR, linking Tables 3-3 and 3-4, and with the LWCIR, linking Tables 3-3 and 3-5. When the full range of health and safety information published by BLS is considered, the ways in which researchers can "slice" and analyze that information multiplies greatly.

However, when attempting to produce sector-specific baseline measures, one is confronted with two significant challenges. First, BLS neither collects nor publishes data on the construction industry at the four-digit SIC Code level. BLS does publish information on nonfatal occupational illnesses and injuries for manufacturing at the four-digit SIC Code level. Information at the four-digit SIC Code level is necessary in order to produce sector-specific baseline measures for the industrial sector and the commercial/ institutional sector. This is because the three-digit SIC Code 154 combines information on all non-residential buildings (see Section A.2). At the four-digit SIC Code level, industrial buildings and warehouses are classified under SIC Code 1541 and non-residential buildings other than industrial buildings and warehouses are classified under SIC Code 1542. Thus, the four-digit SIC Code 1541 maps into the industrial sector and the four-digit SIC Code 1542 maps into the commercial/institutional sector. In the absence of information on SIC Codes 1541 and 1542, no distinction can be made between the rate of construction worker illnesses and injuries in either the industrial sector or the commercial/institutional sector. Therefore, the baseline values for the commercial/institutional sector and the industrial sector have the same value for the RIR as SIC Code 154 and the same value for the LWCIR as SIC Code 154. Second, although the information associated with SIC Codes 15 and 16 can be mapped into individual sectors, special trade contractors, SIC Code 17, serve all four sectors of the construction industry. Unfortunately, it is not possible to "redistribute" recordable or lost workday cases from SIC Code 17 to any of the other construction industry SIC Codes. As a result, the synthesis of sector-specific baseline measures (see Section 3.4) has to treat SIC Code 17 as if it were a "sector" and assign information from the other SIC Codes to the four construction industry sectors.

Examination of the *Survey* data for the three two-digit SIC Codes recorded in Table 3-3 shows that special trade contractors have higher values of both the RIR and the LWCIR than do general building contractors or contractors engaged in heavy construction, except building. Going down one more level to the three-digit SIC Codes, shows that the value of the RIR ranges from a low of 7.6 for painting and paper hanging to 17.5 for roofing, siding, and sheet-metal work. Furthermore, five of the nine three-digit SIC Codes for special trade contractors—171, 174, 175, 176, and 179—exceed the mean value of the RIR (i.e., 11.8) for the construction industry as a whole, whereas none of the three-digit SIC Codes associated with the other types of construction exceed the mean value. Turning to the LWCIR, Table 3-3 reveals that severe injuries have higher incidence rates for special trade contractors than for other types of construction. For example, six of the nine three-digit SIC Codes for special trade contractors—174, 175, 176, 177, 178, and 179—exceed the mean value of the LWCIR (i.e., 5.5) for the construction industry as a whole. Further examination of Table 3-3 demonstrates that the same patterns occur when injuries only are considered.

Table 3-4 takes a closer look at the RIR data recorded in Table 3-3. Two characteristics are of particular importance in interpreting the RIR data. First, a direct link back to Table 3-2 is included under the **Employment Size Groups** subheading of **All**. Specifically, for each grouping of the construction industry (i.e., the construction industry as a whole, by two-digit SIC Code, or by three-digit SIC Code) the overall mean value of the RIR for that grouping is recorded under the subheading **All**. Second, each construction establishment's data is classified under one of the five **Employment Size Groups** headings. These headings are: (1) 1 – 10; (2) 11 – 49; (3) 50 – 249; (4) 250 – 999; and (5) 1,000 or more. Examination of the values for the RIR recorded under each **Employment Size Group** heading reveals two interesting patterns. First, if a particular three-digit SIC Code has a relatively high value for the RIR under the **All** subheading, then it remains relatively higher across all **Employment Size Groups**. Second, the Employment Size Group that tends to have the highest mean values for the RIR corresponds to establishments with 50 to 249 employees.

Table 3-3. Nonfatal Occupational Injury and Illness Incidence Rates per 100 Full-Time Workers in the Construction Industry, 1994

Industry	SIC Code	1994 Annual Average Employment (1000's)	Injuries and Illnesses				Injuries			
			Total Cases	Lost Workday Cases: Total	Lost Workday Cases: With Days Away from Work	Cases Without Lost Workdays	Total Cases	Lost Workday Cases: Total	Lost Workday Cases: With Days Away from Work	Cases Without Lost Workdays
Construction		**5,010.0**	**11.8**	**5.5**	**4.9**	**6.3**	**11.5**	**5.4**	**4.8**	**6.2**
General building contractors	**15**	**1,200.5**	**10.9**	**5.1**	**4.5**	**5.8**	**10.7**	**5.0**	**4.4**	**5.7**
Residential building construction	152	608.9	10.3	5.1	4.7	5.3	10.2	5.0	4.6	5.1
Operative builders	153	28.2	9.5	3.3	3.0	6.3	9.4	3.2	2.9	6.1
Nonresidential building construction	154	563.4	11.5	5.1	4.3	6.4	11.2	5.0	4.2	6.2
Heavy construction, except building	**16**	**736.4**	**10.2**	**5.0**	**4.2**	**5.3**	**10.0**	**4.9**	**4.2**	**5.1**
Highway and street construction	161	225.8	10.7	5.0	4.1	5.7	10.5	4.9	4.0	5.5
Heavy construction, except highway	162	510.6	10.0	5.0	4.3	5.1	9.8	4.9	4.2	4.9
Special trade contractors	**17**	**3,072.8**	**12.5**	**5.8**	**5.2**	**6.7**	**12.3**	**5.6**	**5.1**	**6.6**
Plumbing, heating, air conditioning	171	687.4	13.2	5.3	4.6	7.9	13.0	5.2	4.6	7.8
Painting and paper hanging	172	173.3	7.6	4.3	4.0	3.3	7.3	4.1	3.8	3.2
Electrical work	173	566.3	10.8	4.3	3.8	6.5	10.6	4.2	3.8	6.4
Masonry, stonework, and plastering	174	429.5	14.0	7.1	6.6	6.9	13.8	7.0	6.5	6.8
Carpentry and floor work	175	210.0	13.5	6.8	6.2	6.7	13.4	6.7	6.2	6.6
Roofing, siding, and sheet metal work	176	206.2	17.5	9.1	8.4	8.4	17.2	8.9	8.2	8.3
Concrete work	177	—	11.3	6.0	5.4	5.3	11.0	5.8	5.3	5.2
Water well drilling	178	—	9.7	5.7	5.2	3.9	9.5	5.7	5.1	3.8
Miscellaneous specialty contractors	179	—	12.2	5.7	5.0	6.5	11.9	5.6	4.9	6.3

Source: US Bureau of Labor Statistics, *Occupational Injuries and Illnesses: Counts, Rates, and Characteristics, 1994*, Bulletin 2485, pp. 11-12.

Table 3-4. Recordable Incidence Rates per 100 Full-Time Workers in the Construction Industry by Employment Size Group, 1994

Industry	SIC Code	Employment Size Groups					
		ALL	1 - 10	11 - 49	50 - 249	250 - 999	1,000+
Construction		**11.8**	**7.7**	**13.0**	**14.6**	**10.2**	**4.6**
General building contractors	**15**	**10.9**	**8.6**	**11.9**	**13.7**	**—**	**—**
Residential building construction	152	10.3	8.5	10.9	15.4	13.5	—
Operative builders	153	9.5	—	12.1	8.7	—	—
Nonresidential building construction	154	11.5	—	12.7	13.3	6.6	—
Heavy construction, except building	**16**	**10.2**	**5.4**	**11.7**	**11.5**	**8.6**	**4.7**
Highway and street construction	161	10.7	5.2	9.9	11.4	—	—
Heavy construction, except highway	162	10.0	5.4	12.4	11.5	—	—
Special trade contractors	**17**	**12.5**	**7.5**	**13.6**	**16.3**	**—**	**—**
Plumbing, heating, air conditioning	171	13.2	7.2	14.6	17.3	13.2	—
Painting and paper hanging	172	7.6	6.2	7.4	11.7	—	—
Electrical work	173	10.8	6.7	11.8	12.8	10.4	10.5
Masonry, stonework, and plastering	174	14.0	6.0	16.0	18.1	9.9	—
Carpentry and floor work	175	13.5	7.8	13.7	22.1	36.0	—
Roofing, siding, and sheet metal work	176	17.5	13.7	16.8	22.2	25.6	—
Concrete work	177	11.3	5.8	12.3	16.7	15.8	—
Water well drilling	178	9.7	7.2	14.7	9.6	—	—
Miscellaneous specialty contractors	179	12.2	9.0	13.4	14.3	—	—

Source: US Bureau of Labor Statistics, http://www.bls.gov/special.requests/ocwc/oshwc/osh/os/ostb0252.txt

Table 3-5. Lost Workday Case Incidence Rates per 100 Full-Time Workers in the Construction Industry by Employment Size Group, 1994

Industry	SIC Code	Employment Size Groups					
		ALL	1 - 10	11 - 49	50 - 249	250 - 999	1,000+
Construction		**5.5**	**4.0**	**6.1**	**6.4**	**4.5**	**2.3**
General building contractors	**15**	**5.1**	**4.5**	**5.6**	**5.8**	**—**	**—**
Residential building construction	152	5.1	4.5	5.3	6.9	5.1	—
Operative builders	153	3.3	—	4.6	2.6	—	—
Nonresidential building construction	154	5.1	—	5.8	5.6	3.0	—
Heavy construction, except building	**16**	**5.0**	**2.6**	**6.0**	**5.5**	**3.7**	**2.5**
Highway and street construction	161	5.0	2.5	4.8	5.3	—	
Heavy construction, except highway	162	5.0	2.6	6.5	5.6	—	—
Special trade contractors	**17**	**5.8**	**3.9**	**6.3**	**7.0**	**—**	**—**
Plumbing, heating, air conditioning	171	5.3	3.5	5.8	6.4	5.7	—
Painting and paper hanging	172	4.3	3.8	4.3	5.7	—	—
Electrical work	173	4.3	3.0	4.5	4.8	4.8	6.1
Masonry, stonework, and plastering	174	7.1	3.6	7.8	9.1	5.8	—
Carpentry and floor work	175	6.8	4.5	6.9	10.4	14.9	—
Roofing, siding, and sheet metal work	176	9.1	6.4	9.6	11.0	12.9	—
Concrete work	177	6.0	3.5	6.7	8.3	6.6	—
Water well drilling	178	5.7	5.1	7.3	4.7	—	—
Miscellaneous specialty contractors	179	5.7	4.6	6.4	6.2	—	—

Source: US Bureau of Labor Statistics, http://www.bls.gov/special.requests/ocwc/oshwc/osh/os/ostb0254.txt

Although the first pattern is to be expected, the second pattern bears a closer examination. What the data are telling us is that medium sized construction establishments tend to have higher recordable incidence rates. Very small establishments (i.e., 1 to 10 employees) and very large establishments (i.e., 1,000 or more employees) exhibit the best safety performance, as measured by the mean value of the RIR for that Employment Size Group. Relatively better safety performance should be expected for very large establishments, since they are more likely to have formal construction worker safety programs in place, to conduct safety-related training activities, and to use the superior safety performance of their workforce as a marketing tool. To interpret the rates for smaller construction establishments requires recognition of the potential for under-reporting by those establishments. Studies of the Denver International Airport (DIA) construction project by Glazner *et al*[28] and by Lowery *et al*,[29] revealed significant differences in the RIR both between the annual industry averages published by BLS and the annual averages for the DIA project and between the BLS rates for each employment size group and the rate for the DIA project for the same size group. Differences in the LWCIR were more modest, and generally fell in line with the incidence rates published by BLS.

The DIA project's overall total injury rates were over twice those published by BLS for the construction industry for each year of DIA construction. Total injury rates for the DIA project were consistently higher than the BLS rates across all employment size groups. However, the injury rate pattern by company size at DIA differed from BLS's in that small firms had injury rates that were higher or comparable to most other size categories. Lowery *et al* assert that the reporting procedures established under DIA's Owner Controlled Insurance Program coupled with its on-site medical clinic facilitated the complete reporting of injuries, thereby virtually eliminating the potential for reporting bias by company size. The results of the Lowery *et al* study indicate that employees of smaller companies are at higher risk of injury than those of large companies when controlling for job risk and other predictors of injury. These findings are in conflict with the BLS estimates. Lowery *et al* conclude that the lower RIR estimates published by BLS are probably due to under reporting.[30]

Table 3-5 takes a closer look at the LWCIR data recorded in Table 3-3. As before, two characteristics are of particular importance in interpreting the LWCIR data. First, a direct link back to Table 3-3 is included under the **Employment Size Groups** subheading of **All**. Thus, for each grouping of the construction industry the overall mean value of the LWCIR for that grouping is recorded under the subheading **All**. Second, each construction establishment’s data is classified under one of the five **Employment Size Groups** headings. Examination of the values for the LWCIR recorded under each **Employment Size Group** heading reveals the same two patterns that were associated with the RIR. First, if a particular three-digit SIC Code has a relatively high value for the

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[28] Glazner *et al*., 1998, o*p.cit*.
[29] Lowery, Jan T., Joleen A. Borgerding, Boguaug Zhen, Judith E. Glazner, Jessica Bondy, Kathleen Kreiss. 1998. "Risk Factors for Injury Among Construction Workers at Denver International Airport." *American Journal of Industrial Medicine* (Vol. 34): pp. 113-120.
[30] *Ibid*., p. 118.

LWCIR under the **All** subheading, then it remains relatively higher across all **Employment Size Groups**. Second, the Employment Size Group that tends to have the highest mean values for the LWCIR corresponds to establishments with 50 to 249 employees. As was the case for the RIR, the data are telling us that medium sized construction establishments tend to have higher LWCIRs. Once again, very small establishments (i.e., 1 to 10 employees) and very large establishments (i.e., 1,000 or more employees) exhibit the best safety performance, as measured by the mean value of the LWCIR for that Employment Size Group. As noted earlier, relatively better safety performance should be expected for very large establishments, since they are more likely to have formal construction worker safety programs in place, to conduct safety-related training activities, and to use the superior safety performance of their workforce as a marketing tool. Why very small establishments have lower LWCIRs is likely due to under-reporting.

Of the 529 thousand nonfatal injuries and illnesses estimated in the construction industry in 1994, over 519 thousand were *injuries* that resulted in either lost work time, medical treatment other than first aid, loss of consciousness, restrictions of work or motion, or transfer to another job. The remainder of the construction industry cases (about 10 thousand) were *illnesses*.

The BLS classifies nonfatal occupational illnesses into seven categories. These categories are: (1) skin diseases or disorders; (2) dust diseases of the lungs; (3) respiratory conditions due to toxic agents; (4) poisoning; (5) disorders due to toxic agents; (6) disorders associated with repeated trauma; and (7) all other occupational illnesses. Tables 3-6 through 3-8 summarize *Survey* data by category of illness.

A total of 514.7 thousand nonfatal occupational illnesses were estimated in private industry workplaces during 1994. Table 3-6 records information on the rate of nonfatal occupational illnesses in total and by category of illness and industry division for 1994. Reference to the first column of Table 3-6 **Total Illness Cases**, shows that the IIR varies considerably across the nine industry divisions. For example, the IIR in manufacturing is 178.6, more than three times the next highest rate of 54.0 in agriculture, forestry, and fishing. The IIR for construction is 21.8, a rate that is significantly below the national average rate of 63.7. The 1994 average illness incidence rate (IIR) for each major industry division is recorded in a bar chart format in Figure 3-2.

Table 3-6 shows clearly the effects of disorders associated with repeated trauma. Disorders associated with repeated trauma account for nearly two thirds of all nonfatal occupational illnesses (332.1 thousand of 514.7 thousand). These disorders include, but are not limited to, carpal tunnel syndrome and tendonitis. In recent years, increased emphasis has been placed on preventing carpal tunnel syndrome and tendonitis cases because their effects, in terms of lost workdays, are disproportionately large. The second leading cause of nonfatal occupational illnesses is skin diseases and disorders (65.7 thousand of 514.7 thousand). The category of skin diseases and disorders includes eczema, chemical burns and inflammations, and rashes caused by primary irritants and sensitizers or poisonous plants (e.g., poison ivy). The BLS list of skin diseases and disorders does not include frostbite or sunburn, for which construction workers are at risk.

Before turning our attention to construction-related illnesses, it is worth noting that the estimated values for the IIR recorded in Table 3-6 are subject to under-reporting.[31] Researchers at the National Institute for Occupational Safety and Health (NIOSH) and elsewhere recognize the potential for under-reporting occupational illnesses. To remedy this problem, NIOSH is aggressively pursuing a research program aimed at helping health care providers to recognize occupational illnesses and to obtain adequate information on a patient's work and exposure history.[32]

Tables 3-7 and 3-8 record information on nonfatal construction-related illnesses by category of illness. Information is provided for the construction industry as a whole and by two-digit SIC Code. Table 3-7 records values for the IIR. Table 3-8 records the number of illnesses in thousands. Reference to Tables 3-7 and 3-8 demonstrates that disorders associated with repeated trauma and skin diseases or disorders are the leading causes of construction-related illnesses. Although illnesses caused by disorders associated with repeated trauma are not as significant for the construction industry as they are for private industry workplaces in general, they are the leading cause of illnesses for the construction industry as a whole and for two of the three, two-digit SIC Codes. Skin diseases or disorders are the leading cause of illnesses in SIC Code 16 (Heavy construction, except building).

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[31] Chronic occupational illnesses of long latency are almost entirely unreported (e.g., work-related cases of cardiovascular disease, chronic obstructive lung disease, cancers). In addition, there is also severe under-reporting of most non-latent and acute illnesses as well (e.g., work-related musculoskeletal disorders, asthma, irritant and allergic dermatitis, reproductive disorders). Readers interested in obtaining additional information on the subject of under-reported, work-related illnesses are referred to Leigh *et al* (see, Leigh, J. Paul, Steven B. Markowitz, Marianne Fahs, Chonggak Shin, and Philip J. Landrigan. 1997. "Occupational Injury and Illnesses in the United States." *Arch Intern Med* (Vol. 157): pp. 1557-1568.) and to Herbert and Landrigan (see, Herbert, Robin, and Philip J. Landrigan. 2000. "Work-Related Death: A Continuing Epidemic." *American Journal of Public Health* (Vol. 90): pp. 541-545.).

[32] Research on exposure assessment methods is one component of NIOSH's National Occupational Research Agenda (see US Department of Health and Human Services. 1999. *National Occupational Research Agenda: 21 Priorities for the 21st Century*. Publication No. 99-124. Washington, DC: National Institute for Occupational Safety and Health.).

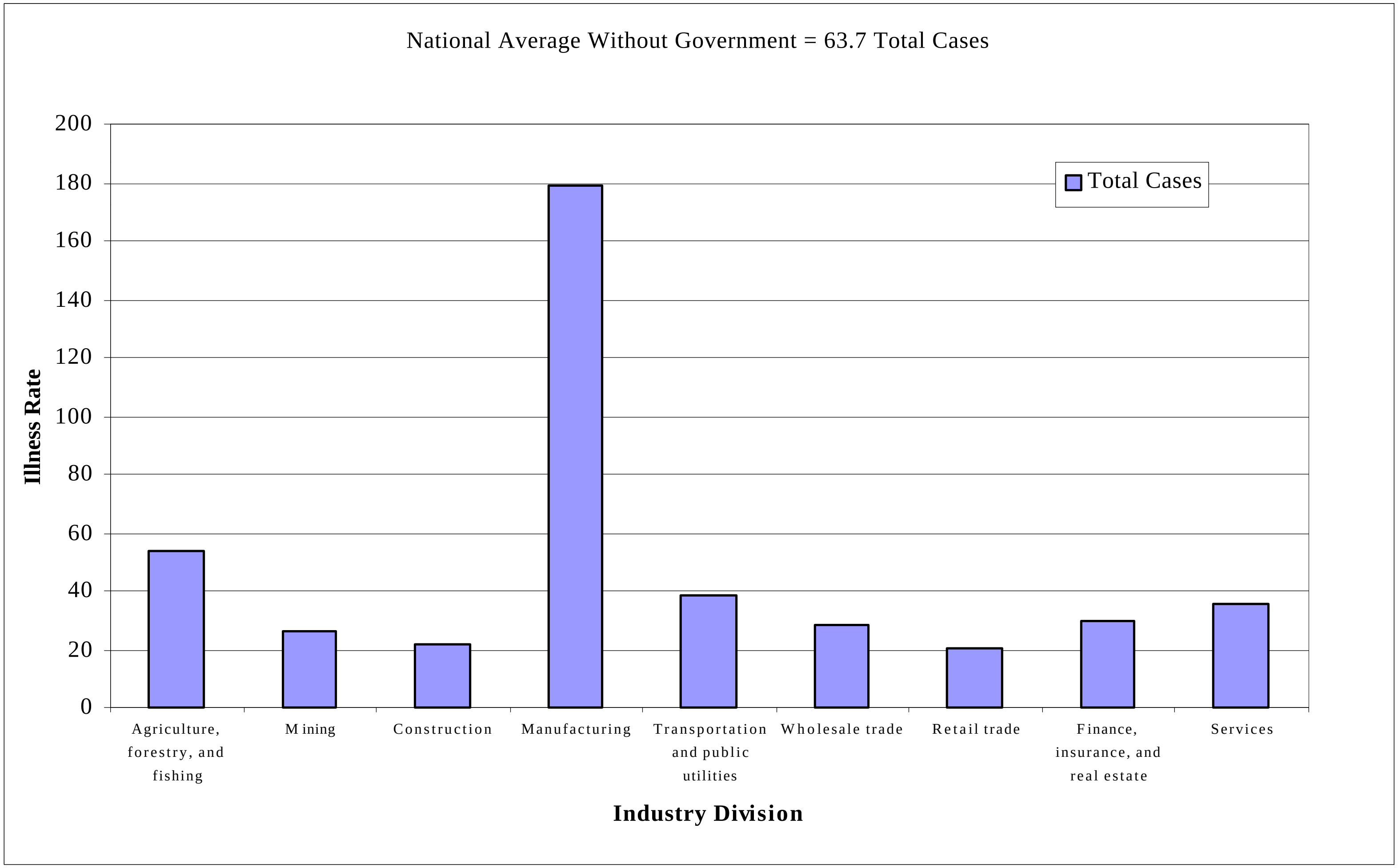
Table 3-6. Nonfatal Occupational Illness Incidence Rates per 10,000 Full-Time Workers by Industry and Illness Category, 1994

Industry	Total Cases[1]	Skin Diseases or Disorders	Dust Diseases of the Lungs	Respiratory Conditions Due to Toxic Agents	Poisoning	Disorders Due to Physical Agents	Disorders Associated With Repeated Trauma	All Other Occupational Illnesses
Agriculture, forestry, and fishing	54.0	25.0	.3	1.8	1.5	5.7	12.1	7.4
Mining	26.1	3.0	6.6	1.2	-	1.8	11.8	1.4
Construction	21.8	5.8	.5	1.9	.5	2.6	6.2	4.3
Manufacturing	178.6	18.3	.5	6.0	1.9	6.4	136.2	9.3
Transportation and public utilities	38.7	5.1	.5	3.0	1.6	2.1	21.1	5.3
Wholesale trade	28.1	4.5	.2	1.5	-	1.1	15.6	4.6
Retail trade	20.1	2.5	.1	1.4	.4	.8	11.2	3.7
Finance, insurance, and real estate	29.8	1.5	.1	1.2	.3	1.3	21.0	4.5
Services	35.7	7.1	.2	3.3	.5	1.8	11.7	11.1

Source: US Bureau of Labor Statistics, *Occupational Injuries and Illnesses: Counts, Rates, and Characteristics, 1994*, Bulletin 2485, pp. 44-46.

[1] The incidence rates represent the number of illnesses per 10,000 full-time workers and are calculated as: (N/EH) x 20,000,000, where N = the number of illnesses, EH = the total hours worked by all employees during the calendar year, and 20,000,000 = the base for 10,000 equivalent full-time workers (working 40 hours per week, 50 weeks per year).

Figure 3-2. Nonfatal Occupational Illness Incidence Rates per 10,000 Full-Time Workers by Industry, 1994



Source: US Bureau of Labor Statistics, *Occupational Injuries and Illnesses: Counts, Rates, and Characteristics, 1994*, Bulletin 2485, pp. 44-46.

Table 3-7. Rate of Nonfatal Construction-Related Illnesses by Illness Category, 1994

Industry	SIC Code	Incidence Rates per 10,000 Full-time Workers							
		Total Illness Cases	Skin Diseases or Disorders	Dust Diseases of the Lungs	Respira-tory Conditions Due to Toxic Agents	Poisoning	Disorders Due to Physical Agents	Disorders Associated With Repeated Trauma	All Other Occupa-tional Illnesses
Construction		**21.8**	**5.8**	**.5**	**1.9**	**.5**	**2.6**	**6.2**	**4.3**
General building contractors	15	22.6	5.0	-	1.2	-	4.4	6.6	4.7
Heavy construction, except building	16	23.4	9.3	-	-	.8	3.2	5.4	3.7
Special trade contractors	17	21.2	5.3	.7	2.5	.4	1.8	6.2	4.3

Source: US Bureau of Labor Statistics: *Occupational Injuries and Illnesses: Counts, Rates, and Characteristics, 1994,* Bulletin 2485, p. 44.

Table 3-8. Number of Nonfatal Construction-Related Illnesses by Illness Category, 1994

Industry	SIC Code	Number of Illnesses in Thousands							
		Total Illness Cases	Skin Diseases or Disorders	Dust Diseases of the Lungs	Respira-tory Conditions Due to Toxic Agents	Poisoning	Disorders Due to Physical Agents	Disorders Associated With Repeated Trauma	All Other Occupa-tional Illnesses
Construction		**9.8**	**2.6**	**.2**	**.9**	**.2**	**1.2**	**2.8**	**1.9**
General building contractors	15	2.4	.5	-	.1	-	.5	.7	.5
Heavy construction, except building	16	1.7	.7	-	-	.1	.2	.4	.3
Special trade contractors	17	5.8	1.4	.2	.7	.1	.5	1.7	1.2

Source: US Bureau of Labor and Statistics, *Occupational Injuries, Illnesses: Counts, Rates, and Characteristics, 1994*, Bulletin 2485, p. 44.

Of the 6,588 fatal work injuries reported in 1994, 1,027 occurred in the construction industry. This represents 15.6 percent of the fatality total, which is nearly three times greater than the share of construction employment (6 percent) of total employment. Table 3-7 records information on the number, percent, and rate of fatal occupational injuries by industry. The fatality incidence rate is calculated based on 100,000 employed workers. Table 3-9 includes the nine major industry divisions plus government. The national average fatality incidence rate for the nine major industry divisions combined is 6 fatalities per 100,000 employees. If government data are included, then the fatality incidence rate falls to 5 fatalities per 100,000 employees. Note that the fatality incidence rate varies considerably. The rate for construction is the third highest (15 fatalities per 100,000 employees); it is exceeded only by mining (27 fatalities per 100,000 employees) and agriculture, forestry, and fishing (24 fatalities per 100,000 employees). The 1994 average fatality incidence rates for each major industry division plus government are recorded in bar chart format in Figure 3-3.

Table 3-9. Number, Percent, and Rate of Fatal Occupational Injuries by Industry, 1994

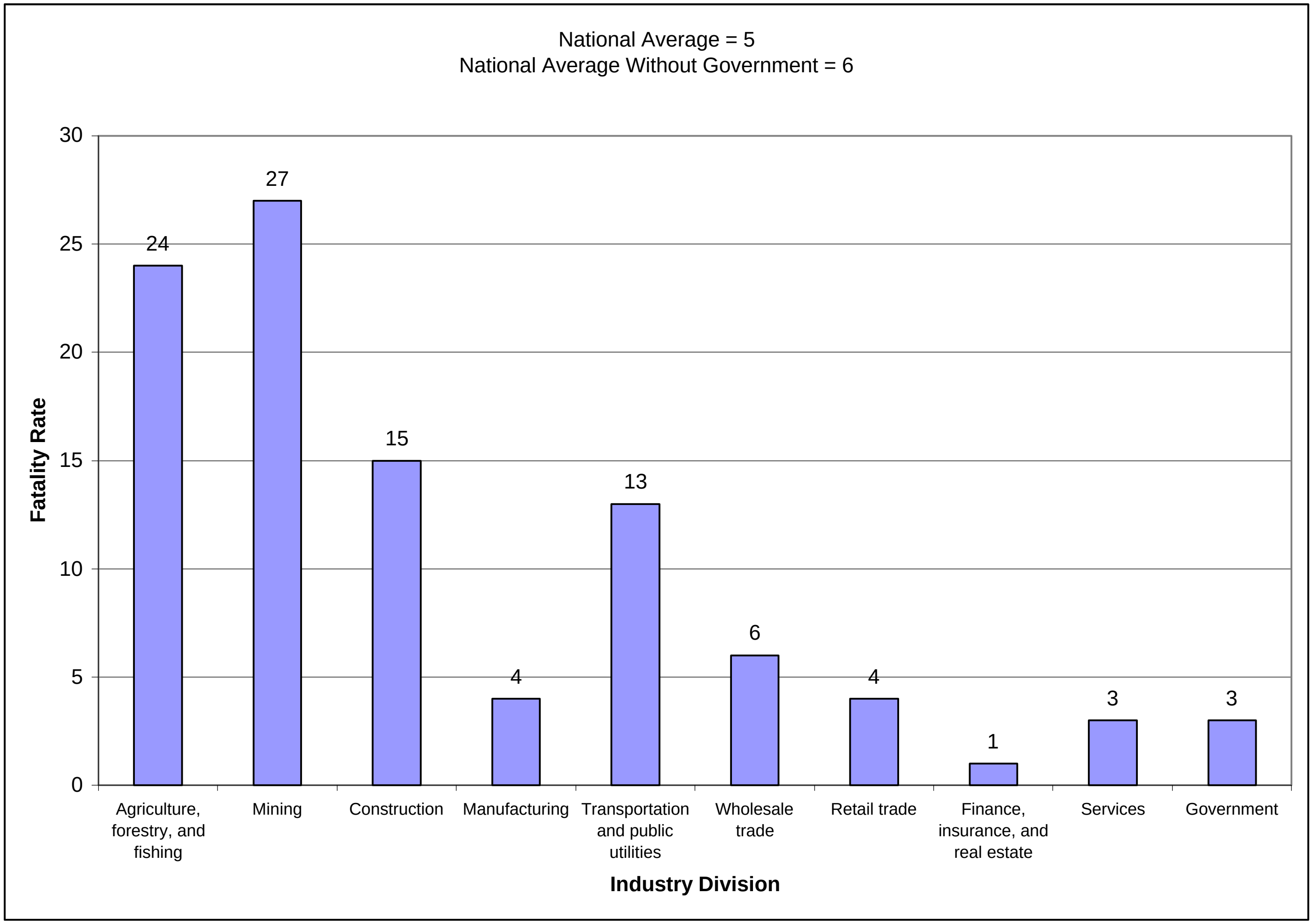
Industry	Fatalities		Employed[1] (in thousands)	Fatalities per 100,000 employed[2]
	Number	Percent		
Agriculture, forestry, and fishing	847	12.9	3,496	24
Mining	180	2.7	668	27
Construction	1,027	15.6	6,948	15
Manufacturing	787	11.9	20,050	4
Transportation and public utilities	944	14.3	7,069	13
Wholesale trade	269	4.1	4,702	6
Retail trade	797	12.1	20,909	4
Finance, insurance, and real estate	112	1.7	7,900	1
Services	844	12.8	33,012	3
Government	665	10.1	19,715	3

Source: US Bureau of Labor Statistics, *Fatal Workplace Injuries in 1994: A Collection of Data and Analysis*, Report 908, p. 121.

[1] The employment figures are annual average estimates of employed civilians 16 years of age and older, from the Bureau of Labor Statistics Current Population Survey (CPS), 1994. A resident military figure, derived from resident and civilian population data from the Bureau of the Census, was added to the CPS employment total and figures for government. CPS data for 1994 are not directly comparable with data for 1993 and earlier years because of the introduction of a major redesign of the survey questionnaire and collection methodology, and the introduction of 1990 census based population controls adjusted for the estimated undercount. For additional information see “Revision in the Current Population Survey Effective January 1994,” in the February 1994 issue of *Employment and Earnings*.

[2] The rate represents the number of fatal occupational injuries per 100,000 employed workers and was calculated as follows: (N/W) x 100,000, where N = the number of fatal work injuries, and W = the number of employed workers, as described in the previous footnote. There were 25 fatally injured workers under the age of 16 years that were not included in the rate calculations to maintain consistency with the CPS employment.

Figure 3-3. Rate of Fatal Occupational Injuries per 100,000 Employed Workers by Industry, 1994

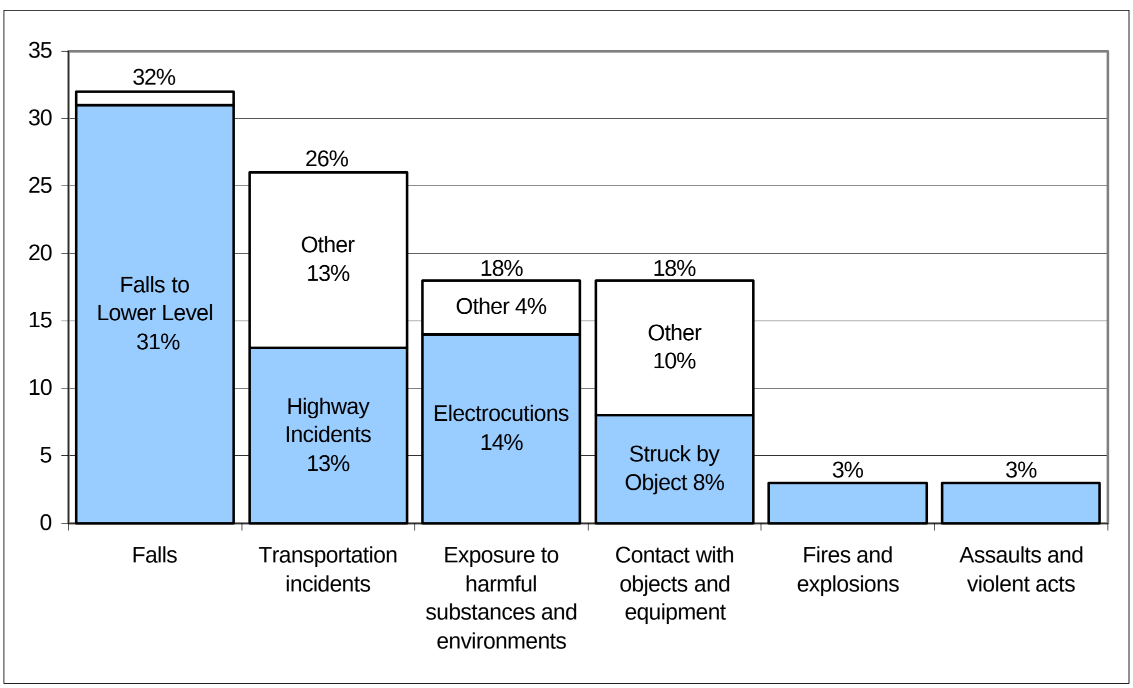


Source: US Bureau of Labor Statistics, *Fatal Workplace Injuries in 1994: A Collection of Data and Analysis*, Report 908, p. 121.

Table 3-10 provides a detailed picture of construction-related fatalities. The table includes both the number of fatalities and the percentage of construction-related fatalities to the national total of 6,588 fatalities. The table includes information on private sector wage and salary workers, government workers, and self-employed workers. As a result of including construction-related fatalities affecting government workers, the total for construction-related fatalities is increased by 47 from 1,027 (see the Construction row entry in Table 3-9) to 1074. Note that more than half of all construction-related fatalities (592 out of 1,074) are associated with special trade contractors. Self-employed workers accounted for 146 of all construction-related fatalities.

Figure 3-4 records fatal occupational injuries in the construction industry by type of incident. Six types of incidents are shown in the figure: (1) falls; (2) transportation incidents; (3) exposure to harmful substances or environments; (4) contact with objects and equipment; (5) fires and explosions: and (6) assaults and violent acts. Figure 3-4 shows that in the construction industry falls to a lower level (316 fatalities) led all other ways in which construction workers were fatally injured in 1994. Falls accounted for nearly one third of all construction-related fatalities. Transportation incidents were responsible for 265 fatalities; 129 of these fatalities were highway incidents. Electrocutions were responsible for 140 construction-related fatalities. 86 construction-related fatalities resulted from being struck by an object (e.g., falling object, flying object, or swinging object). Fires and explosions and assaults and violent acts each accounted for three percent of the total.

Figure 3-4. Percent of Construction Worker Fatalities by Type of Incident, 1994



Source: US Bureau of Labor Statistics, *Fatal Workplace Injuries in 1994: A Collection of Data and Analysis*, Report 908, p. 38.

Table 3-10. Construction-Related Fatalities for Private Sector Wage and Salary Workers, Government Workers, and Self-Employed Workers, 1994

Industry	Fatalities		Private Sector Wage and Salary Workers		Government Workers		Self-Employed Workers	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Construction	**1,074**	**16.3**	**881**	**18.9**	**47**	**7.1**	**146**	**11.7**
General building contractors	**191**	**2.9**	**159**	**3.4**	**—**	**—**	**30**	**2.4**
Residential building construction	83	1.3	63	1.3	—	—	19	1.5
Nonresidential building construction	97	1.5	88	1.9	—	—	8	0.6
Heavy construction, except building	**291**	**4.4**	**236**	**5.1**	**44**	**6.6**	**11**	**0.9**
Highway and street construction	115	1.7	75	1.6	39	5.9	—	—
Heavy construction, except highway	171	2.6	156	3.3	5	0.8	10	0.8
Special trade contractors	**592**	**9.0**	**486**	**10.4**	**—**	**—**	**105**	**8.4**
Plumbing, heating, air conditioning	71	1.1	57	1.2	—	—	14	1.1
Painting and paper hanging	40	0.6	31	0.7	—	—	9	0.7
Electrical work	79	1.2	63	1.3	—	—	15	1.2
Masonry, stonework, tile setting, and plastering	53	0.8	42	0.9	—	—	11	0.9
Carpentry and floor work	31	0.5	20	0.4	—	—	11	0.9
Roofing, siding, and sheet metal work	89	1.4	77	1.6	—	—	12	1.0
Concrete work	34	0.5	30	0.6	—	—	4	0.3
Water well drilling	8	0.1	4	0.1	—	—	4	0.3
Miscellaneous specialty contractors	182	2.8	158	3.4	—	—	24	1.9
Structural steel erection	52	0.8	51	1.1	—	—	—	—
Excavation work	47	0.7	39	0.8	—	—	8	0.6
Special trade contractors, n.e.c.	46	0.7	36	0.8	—	—	10	0.8

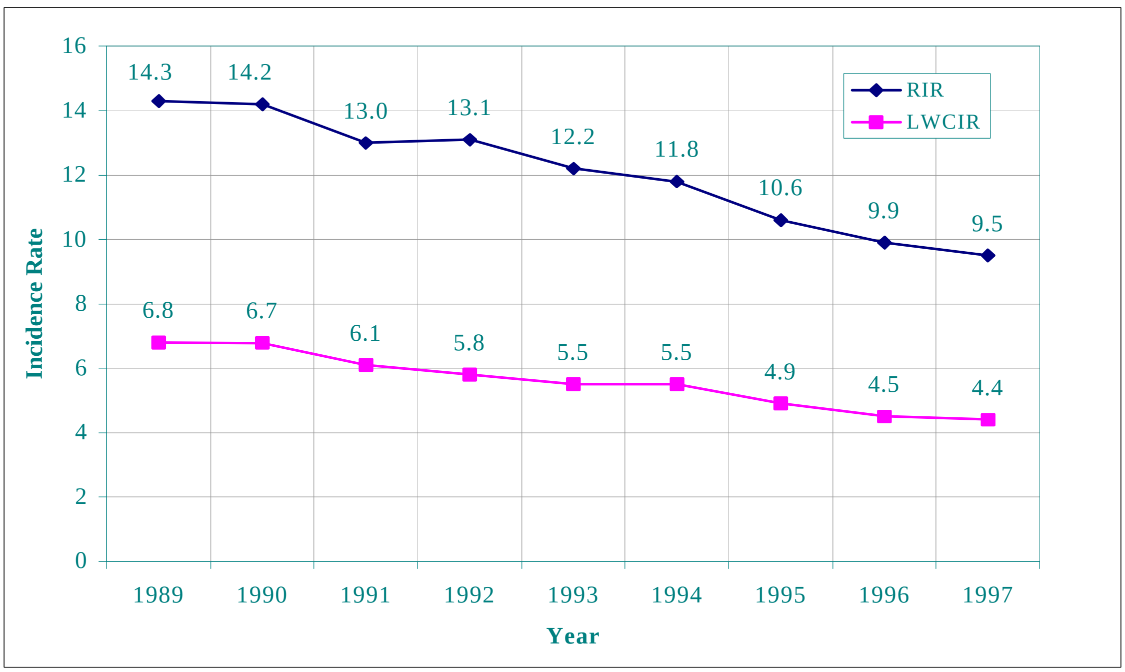
Source: US Bureau of Labor Statistics, *Fatal Workplace Injuries in 1994: A Collection of Data and Analysis*, Report 908, p. 67.

Note: The percentages recorded in Table 3.10 are all based on the national total of 6,588 fatalities. Thus, the 1,074 construction-related fatalities account for 16.3 percent of the national total.

3.3 Trends in Key Incidence Rates for Construction Worker Illnesses and Injuries

The purpose of this section is to highlight trends in the key incidence rates for construction worker illnesses and injuries. Specifically, time-series data are presented on the RIR, LWCIR, IIR, and the fatality incidence rate. We begin with a review of the two core incidence rates, the RIR and the LWCIR. The core incidence rates for construction worker illnesses and injuries have been declining in recent years. Figure 3-5 shows that both the RIR and the LWCIR have declined between 1989 and 1997. During this period, the RIR has declined from 14.3 to 9.5, a drop of almost 34 % and a compound rate of improvement of 5.25 % per annum. During the same period, the LWCIR has declined from 6.8 to 4.4, a drop of more than 35 % and a compound rate of improvement of 5.6 %.

Figure 3-5. Recordable Incidence Rate and Lost Workday Case Incidence Rate for Years 1989-1997



Source: http://www.osha.gov/oshstats/work.html

Additional information on the RIR is recorded in Tables 3-11 and 3-12. Table 3-11 expands the information recorded in Figure 3-5 by adding the calculated values for the RIR for the three, two-digit SIC Codes in the construction industry (i.e., SIC Codes 15, 16, and 17). Table 3-12 expands the information recorded in Figure 3-5 by adding the calculated values for the RIR as a function of employment size group. Both tables provide a direct linkage back to Figure 3-5 by recording the value of the RIR in each year under the **All Establishments** column heading.

Reference to Table 3-11 reveals that the RIR for each of the two-digit SIC Codes in the construction industry has also declined significantly between 1989 and 1997. Recall from the previous section that for the base year, 1994, SIC Code 17 had higher values for the RIR than either SIC Codes 15 or 16 (see Table 3-3). Reference to Table 3-11 demonstrates that SIC Code 17 exceeds the average for all establishments in every year between 1989 and 1997. In addition, the rate of improvement for the RIR between 1989 and 1997 for SIC Code 17 is less than for either SIC Code 15 or SIC Code 16. Thus, the gap in safety performance between establishments within SIC Code 17 and establishments within SIC Codes 15 and 16 is not being closed.

Table 3-11. Rate of Nonfatal Occupational Injuries and Illnesses in the Construction Industry by Two-Digit SIC Code for Years 1989-1997

Year	**All Establish-ments**	**SIC Code**		
		15	16	17
1989	14.3	13.9	13.8	14.6
1990	14.2	13.4	13.8	14.7
1991	13.0	12.0	12.8	13.5
1992	13.1	12.2	12.1	13.8
1993	12.2	11.5	11.1	12.8
1994	11.8	10.9	10.2	12.5
1995	10.6	9.8	9.9	11.1
1996	9.9	9.0	9.0	10.4
1997	9.5	8.5	8.7	10.0

Source: http://www.osha.gov/oshstats/work.html

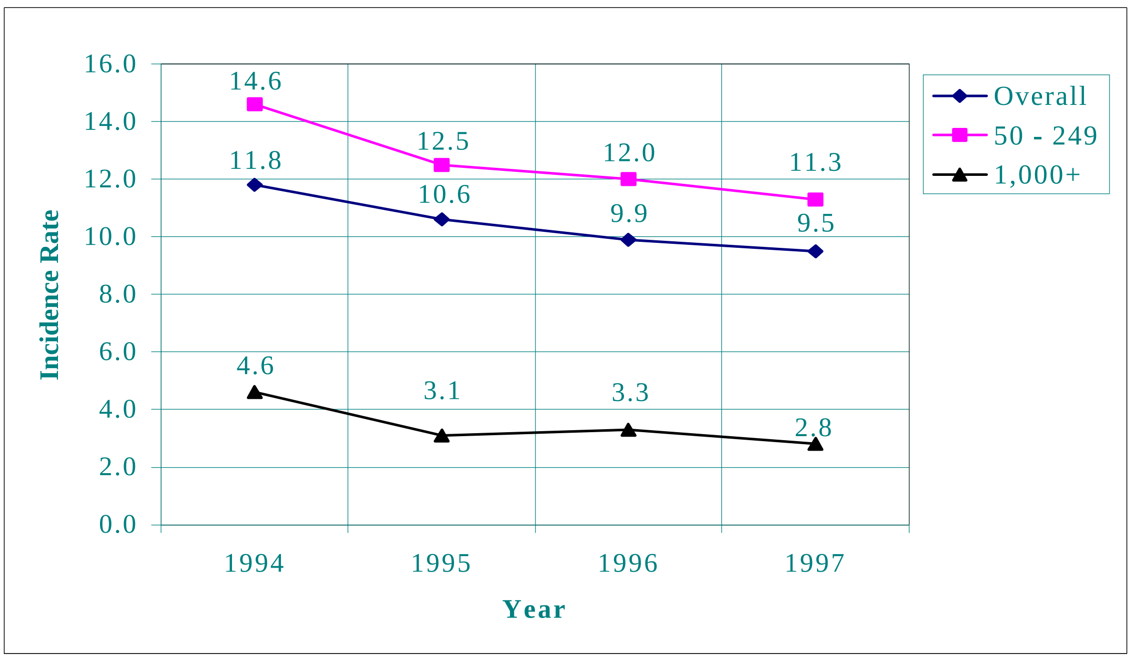
Reference to Table 3-12 reveals that the RIR is improving across all employment size groups. Note that the time series recorded in Table 3-12 is shorter than in Table 3-11, since it begins in the base year 1994. This is because prior to 1994 BLS reported nonfatal illnesses and injuries using a different set of employment size groups (e.g., 1 to 19 employees prior to 1994 versus 1 to 10 employees since 1994). Recall from the previous section that for the base year, 1994, establishments with 50 to 249 employees had the highest values for the RIR and establishments with 1,000 or more employees had the lowest RIR (see Table 3-4). Reference to Table 3-12 demonstrates that establishments with 50 to 249 employees have the highest RIR in each year whereas establishments with 1,000 or more employees have the lowest RIR in each year. In addition, the rate of improvement for the RIR between 1994 and 1997 for establishments with 50 to 249 employees is less than for establishments with 1,000 or more employees. These differences are highlighted in Figure 3-6, where the overall RIR for the construction industry is used as a reference point for the best and worst performing employment size groups.

Table 3-12. Rate of Nonfatal Occupational Injuries and Illnesses in the Construction Industry by Employment Size Group for Years 1994-1997

Year	All Establish-ments	Employment Size Groups				
		1 - 10	11 - 49	50 - 249	250 - 999	1,000+
1994	11.8	7.7	13.0	14.6	10.2	4.6
1995	10.6	6.5	12.3	12.5	9.7	3.1
1996	9.9	6.2	11.4	12.0	8.2	3.3
1997	9.5	6.4	10.3	11.3	8.4	2.8

Source: http://www.bls.gov/oshsumyy.htm, where yy designates the last two digits of the year.

Figure 3-6. Rate of Nonfatal Occupational Injuries and Illnesses in the Construction Industry by Employment Size Group for Years 1994-1997

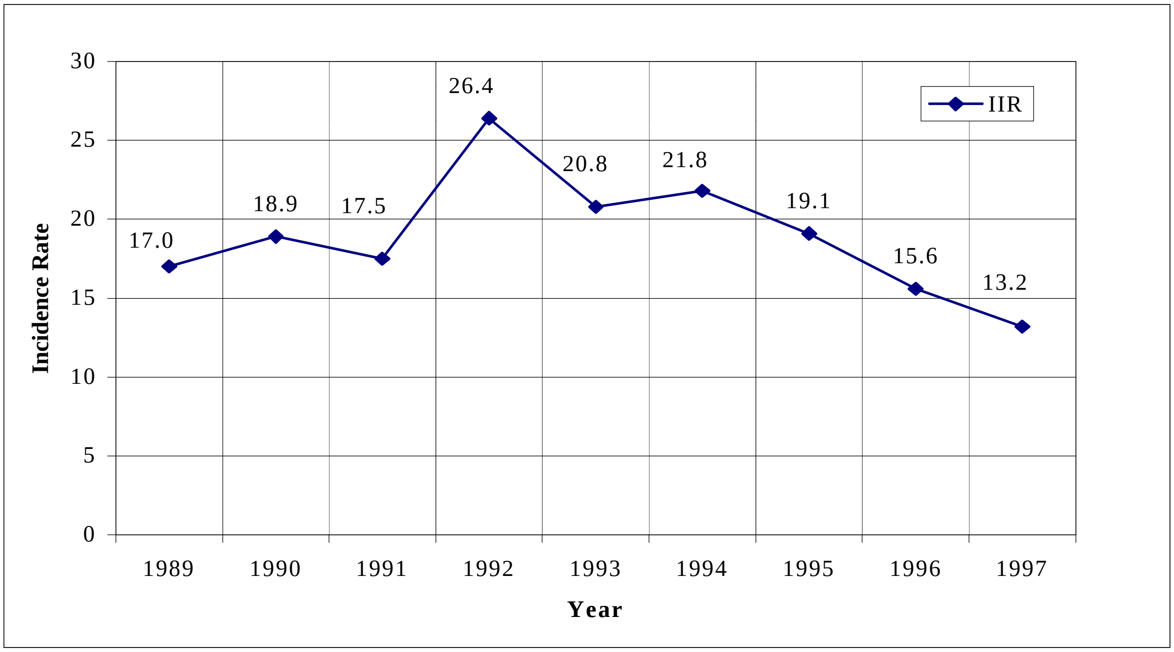


Source: http://www.bls.gov/oshsumyy.htm, where yy designates the last two digits of the year.

Figure 3-7 records information on the IIR. Reference to the figure shows that after reaching a peak in 1992 the IIR has tended to decline. For example, the IIR in 1994 was 21.8. By 1997, the IIR had declined by nearly 40 percent to 13.2.

Table 3-13 records information on the number of construction-related fatalities and the fatality incidence rate for the construction industry as a whole and by class of worker. Table 3-13 includes data from 1992 through 1997. These data record the number of fatalities for all private construction workers, private wage and salary workers, and self-employed workers. Since 1992, the fatality incidence rate in the construction industry has hovered between 14 and 15 per 100,000 workers (see Figure 3-8). Reference to Table 3-13 and Figures 3-8 and 3-9 reveals an underlying pattern. When fatalities are broken down into cases involving wage and salary workers and self-employed workers, the incidence rate for wage and salary workers has declined from 16.2 in 1994 to 14.5 in 1997 whereas the incidence rate for self-employed workers has increased from 9.8 to 12.7 (see Figure 3-9). It is important to note that among the nonagricultural industries, construction has the highest proportion of self-employed workers. Since 1992, the proportion of self-employed workers in the construction industry has ranged between 18.0 % and 21.5 %.[33]

Figure 3-7. Illness Incidence Rate for Years 1989-1997



Source: http://www.bls.gov/oshsumyy.htm, where yy designates the last two digits of the year.

The two traces in Figure 3-9 raise an important safety-related issue. Recall that the *Survey of Nonfatal Occupational Illnesses and Injuries* covers only establishments with employees. Thus, the fatality incidence rate for wage and salary workers is the direct analogue of the incidence rates for the three cases of nonfatal occupational illnesses and injuries (i.e., all four use the same class of workers). The fact that the fatality incidence rate for wage and salary workers is declining, as was the case for the RIR, LWCIR, and IIR, is very encouraging. This downward trend in all four incidence rates suggests that construction establishments with employees are paying increasing attention to safety-related issues, a subject which is covered in some detail in Chapter 4. However, the upward trend in the fatality incidence rate for self-employed workers raises a note of caution. Unless the fatality incidence rate for self-employed workers can be turned around, fatalities in the construction industry may continue at a rate nearly three times the national average. The upward trend in the fatality incidence rate for self-employed

[33] The January issue of *Employment and Earnings* reports tabulations of employed civilians in nonagricultural industries by class of worker (e.g., wage and salary workers and self-employed workers). US Department of Labor. *Employment and Earnings*. Washington, DC: Bureau of Labor and Statistics.

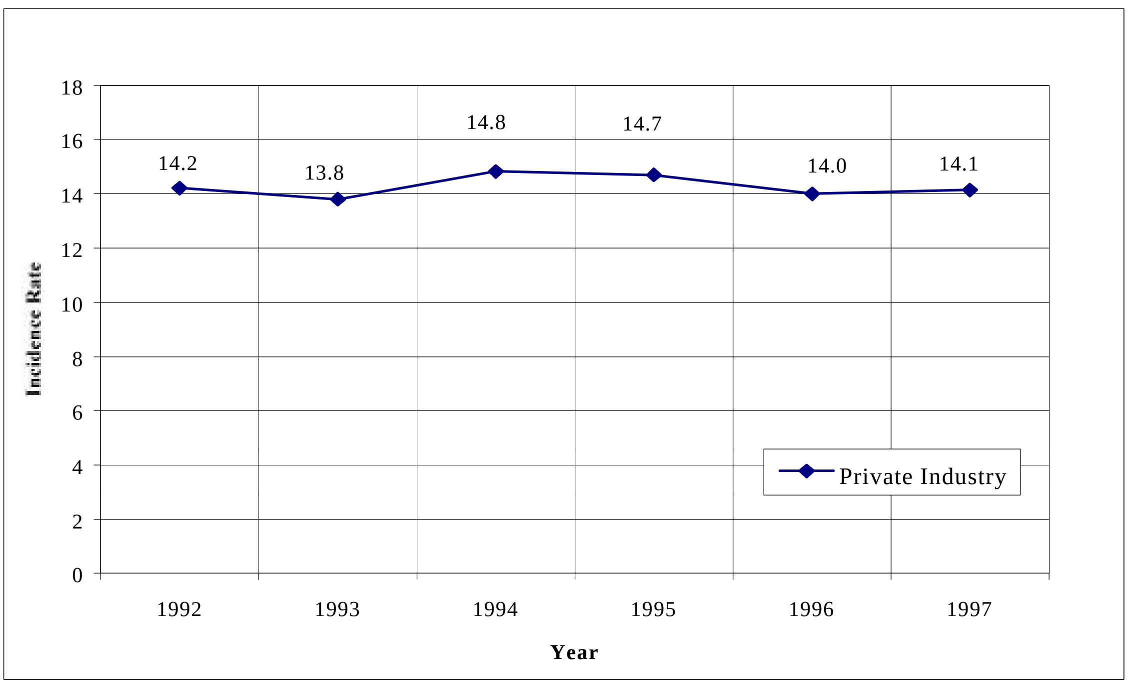
workers also raises a cautionary note on whether the incidence rates for nonfatal occupational illnesses and injuries among self-employed workers are also rising or, at least, not declining.

Table 3-13. Number and Rate of Fatal Occupational Injuries in the Construction Industry by Class of Worker for Years 1992-1997

Year	Class of Worker					
	Total Private Industry		Wage and Salary Workers		Self-employed Workers	
	Number	Rate	Number	Rate	Number	Rate
1992	919	14.2	781	15.6	138	9.4
1993	923	13.8	778	15.1	145	9.3
1994	1,027	14.8	881	16.2	146	9.7
1995	1,048	14.7	888	15.6	160	11.0
1996	1,039	14.0	887	14.9	152	10.2
1997	1,107	14.1	918	14.5	189	12.7

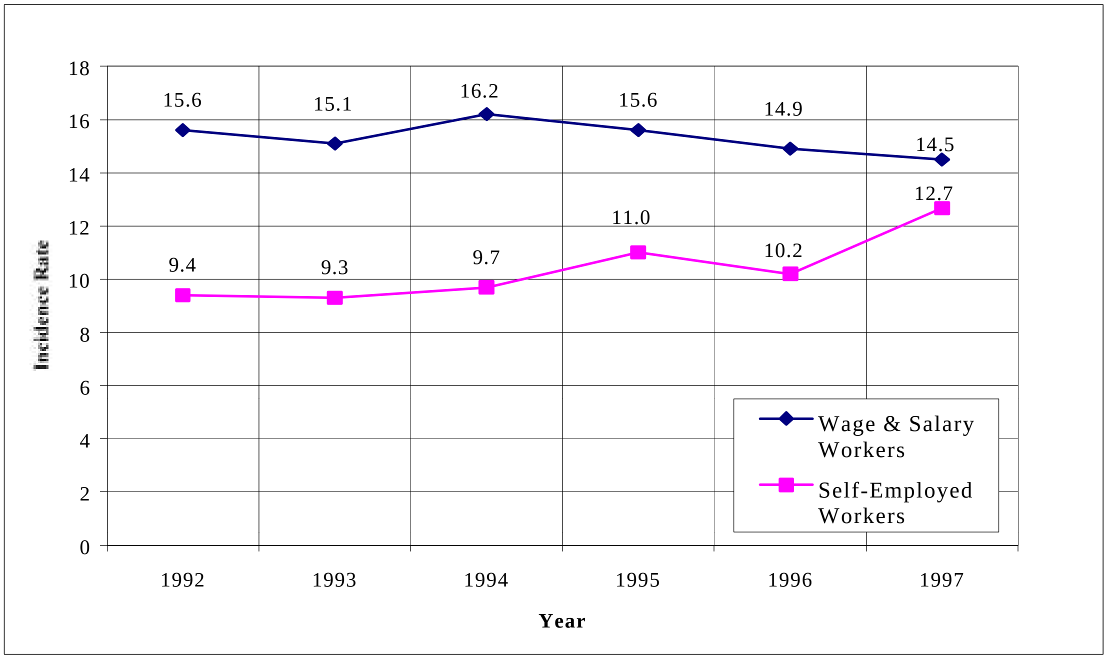
Source: US Bureau of Labor Statistics, *Employment and Earnings*, and http://www.osha.gov/oshstats/work.html

Figure 3-8. Rate of Fatal Occupational Injuries in the Construction Industry for Years 1992-1997



Source: US Bureau of Labor Statistics, *Employment and Earnings*, and http://www.osha.gov/oshstats/work.html.

Figure 3-9. Rate of Fatal Occupational Injuries in the Construction Industry by Class of Worker for Years 1992-1997



Source: US Bureau of Labor Statistics, *Employment and Earnings*, and http://www.osha.gov/oshstat/work.html.

3.4 Synthesis of Industry-Wide and Sector Specific Baseline Measures

Table 3-14 shows general information on the construction industry as a whole and by sector compiled from the Bureau of Labor Statistics (BLS). Note that the BLS data are for the year 1994. Thus, the BLS data report safety-related results for the base year (i.e., 1994).

Table 3-14 records the baseline values for each of the four key incidence rates. These rates are: (1) the RIR; (2) the LWCIR; (3) the IIR; and (4) the fatality incidence rate. The first row of the table records the value of each incidence rate for the construction industry as a whole. The next four rows record the value of each incidence rate for each sector (i.e., residential, commercial/institutional, industrial, and public works). The last row records the value of each incidence rate for special trade contractors (i.e., SIC Code 17). Special trade contractors are reported separately because they serve all four sectors of the construction industry. Unfortunately, it is not possible to "redistribute" incidents from SIC Code 17 to any of the other construction industry sectors. Therefore, SIC Code 17 is treated as if it were a "sector." The information on each of the four types of incidents (i.e., recordable, lost workday, illness, and fatality) for SIC Code 17 is incorporated into the incidence rates for the construction industry as a whole.

Table 3-14. Summary of Baseline Measures

Sector	Incidence Rate			
	per 100	per 100	per 10,000	per 100,000
	Recordable	Lost Workday	Illness	Fatality
All	11.8	5.5	21.8	14.8
Residential	10.3[a]	5.0[a]	22.6[c]	14.8[d]
Commercial/Institutional	11.5[b]	5.1[b]	22.6[c]	14.8[d]
Industrial	11.5[b]	5.1[b]	22.6[c]	14.8[d]
Public Works	10.2	5.0	23.4	14.8[d]
Special Trade Contractors	12.5	5.8	21.2	14.8[d]

Source: US Bureau of Labor Statistics, *Occupational Injuries and Illnesses: Counts, Rates, and Characteristics, 1994*, Bulletin 2485, and *Fatal Workplace Injuries in 1994: A Collection of Data and Analysis*, Report 908.

[a] Estimated.
[b] Requires information on the number of incidents and the number of craft work hours in SIC Codes 1541 and 1542.
[c] Requires information on the number of incidents and the number of craft work hours in SIC Codes 152, 153, 1541, and 1542.
[d] Requires information on the number of construction workers in SIC Codes 152, 153, 1541, 1542, 16, and 17.

Table 3-14 includes a series of explanatory notes to help understand both what is included and what is not included in the sector-specific baseline values of the key incidence rates. Note "a" indicates that the baseline values of the RIR and the LWCIR for the residential sector are estimated. Estimates for the RIR and the LWCIR for the residential sector are produced by combining information from two, three-digit SIC Codes (152 and 153). Specifically, information on the incidence rate and the number of incidents is used to estimate craft workhours for each three-digit SIC Code. The number of incidents are then added together (e.g., the number of recordables in SIC Code 152 and the number of recordables in SIC Code 153) to get the numerator and the number of craft workhours are added together to get the denominator in the formula used to calculate the RIR and the LWCIR, respectively (see the definitions of the terms "N" and "EH" in Note 1 of Table 3-1). Each resultant (i.e., the value returned by dividing N by EH) is then multiplied by 200,000 to get the estimated value for the RIR and for the LWCIR in the residential sector (see Note 1 of Table 3-1). Note "b" indicates that sector-specific values for the commercial/institutional and industrial sectors require information on two, four-digit SIC Codes (1541 and 1542). In the absence of such information, the value for the three-digit SIC Code 154 is used. Thus, the commercial/institutional sector and the industrial sector have the same value for the RIR as SIC Code 154 and the same value for the LWCIR as SIC Code 154. Note "c" indicates that additional information on SIC Code 15 is needed in order to develop sector-specific values for the IIR for the residential, commercial/institutional, and industrial sectors. Because in 1994 information on the IIR was only published at the two-digit SIC Code level, three of the four sectors (i.e., residential, commercial/institutional, and industrial) have the same baseline values for the IIR. Note “d” indicates that sector-specific fatality incidence rates can not be generated because information on the number of self-employed construction workers is only reported for the construction industry as a whole.

4. How Safety Practice Use Affects Performance

Good safety performance requires planning, training, and commitment. The key stakeholders in the construction industry—both the contractors performing the construction tasks and the owners who commission the work—recognize this but are often unclear on how to address the safety performance issue. Because firms in the construction industry are often project centered, ways to address the safety performance issue need to reflect this perspective. Both in the construction industry and elsewhere, firms interested in performance improvement are increasingly turning to formalized procedures and the use of metrics to help them track, analyze, and improve their performance. Safety practices are one type of formalized procedure designed to help construction firms address safety-related issues. Ideally, construction firms will put in place a safety practice and use it to collect safety-related information on individual projects and to document experiences resulting in either particularly good or poor safety performance. By using a safety practice as a means of focusing on facts and data, construction firms can learn from their experiences, improve their safety performance, and reduce the costs associated with poor safety performance.

The goal of this chapter is twofold. First, it introduces the concept of a safety practice and gives several examples of safety practices currently in use within the construction industry. A discussion of safety practices is included because safety practices are a vehicle for reducing construction-related illnesses and injuries. A full discussion of safety practices is beyond the scope of this report. However, sufficient descriptive material is presented to make the case that safety practices capable of serving the needs of different types of construction firms exist and that these practices will promote progress towards achieving the National Construction Goal of reducing construction-related illnesses and injuries by 50 %. Second, this chapter presents project-based empirical evidence on how safety practice use translates into reductions in the recordable incidence rate (RIR) and the lost workday case incidence rate (LWCIR). The empirical evidence presented in this chapter and its analysis uses data collected by the Construction Industry Institute (CII). Information collected by CII as part of an annual survey and compiled in the CII Benchmarking and Metrics Database on the use of the CII Zero Accidents safety practice[34] is used to perform the analysis. The CII Zero Accidents safety practice was developed by a research team composed of a broad cross-section of CII members and outside subject matter experts. The CII Zero Accidents safety practice was designed for use both by CII member firms and by the construction industry at large. Although the construction firms that are members of CII tend to be fairly large, all of the data recorded in the CII Benchmarking and Metrics Database is project based and hence includes craft workhours and injury data for the prime contractor and all subcontractors. The same is true for project data provided by CII members that are building/facility owners. Thus, the results presented in Section 4.2 do not apply solely to the very largest firms in the construction industry but also to the subcontractor tier serving these large firms. However, since in all cases the prime contractor is, relatively speaking, a large

[34] Construction Industry Institute. 1993. *Zero Injury Techniques*. Research Summary 32-1. Austin, TX: Construction Industry Institute.

construction firm, the analysis does not imply that smaller construction firms using the CII Zero Accidents safety practice would achieve similar results or that the CII Zero Accidents safety practice would be particularly well-suited for them.

4.1 Overview of Safety Practices

This section describes briefly three general-purpose safety practices and provides information on two special-purpose safety practices. The three general-purpose safety practices are: (1) the OSHA Safety and Health Program Management Guidelines;[35] (2) ANSI Standard A10.38, Basic Elements of an Employer Program to Provide a Safe and Healthful Work Environment;[36] and (3) the CII Zero Accidents safety practice.[37] The two special-purpose safety practices are: (1) ANSI A10.33, Construction and Demolition Operations—Safety and Health Program Requirements for Multi-Employer Projects;[38] and (2) the Federal Highway Administration's Work Zone Best Practices Program.[39]

OSHA Safety and Health Program Management Guidelines

Effective management of worker safety and health protection is a decisive factor in reducing the extent and severity of work-related injuries and illnesses and related costs. In 1989, OSHA issued recommended guidelines for the effective management and protection of worker safety and health. The OSHA guidelines are summarized in the following paragraphs; they are excerpted from material contained on the OSHA web site.[40]

Employers are advised and encouraged to institute and maintain in their establishments a program that provides adequate systematic policies, procedures, and practices to protect their employees from, and allow them to recognize, job-related safety and health hazards. An effective program includes provisions for the systematic identification, evaluation, and prevention or control of general workplace hazards, specific job hazards, and potential hazards that may arise from foreseeable conditions. Although compliance with the law, including specific OSHA standards, is an important objective, an effective program looks beyond specific requirements of law to address all hazards. It will seek to prevent injuries and illnesses, whether or not compliance is at issue. The extent to which the program is described in writing is less important than how effective it is in practice. As the size of a worksite or the complexity of a hazardous operation increases, however,

[35] *Federal Register* 54(18): pp. 3094-3916, January 26, 1989.
[36] American National Standards Institute, Inc. 1991. *Basic Elements of an Employer Program to Provide a Safe and Healthful Work Environment*. ANSI A10.38-1991. Itasca, IL: National Safety Council.
[37] Construction Industry Institute. 1993. *Zero Injury Techniques*. Research Summary 32-1. Austin, TX: Construction Industry Institute.
[38] American National Standards Institute, Inc. 1992. *Construction and Demolition Operations—Safety and Health Program Requirements for Multi-Employer Projects*. ANSI A10.33-1992. Itasca, IL: National Safety Council.
[39] US Department of Transportation. 1998. *Meeting the Customer's Needs for Mobility and Safety During Construction and Maintenance Operations*. HPQ-98-1. Washington, DC: Federal Highway Administration.
[40] See, http://www.osha-slc.gov/Publications/Const_Res_Man/1926_C_S&H_guide.html

the need for written guidance increases to ensure clear communication of policies and priorities as well as a consistent and fair application of rules.

An effective occupational safety and health program will include the following four main elements: (1) management commitment and employee involvement; (2) worksite analysis; (3) hazard prevention and control; and (4) safety and health training.

1. Management Commitment and Employee Involvement

The elements of management commitment and employee involvement are complementary and form the core of any occupational safety and health program. Management's commitment provides the motivating force and the resources for organizing and controlling activities within an organization. In an effective program, management regards worker safety and health as a fundamental value of the organization and applies its commitment to safety and health protection with as much vigor as to other organizational goals. Employee involvement provides the means by which workers develop and/or express their own commitment to safety and health protection for themselves and for their fellow workers. In implementing a safety and health program, there are various ways to provide commitment and support by management and employees. Some recommended actions are described briefly as follows:

- State clearly a worksite policy on safe and healthful work and working conditions, so that all personnel with responsibility at the site (and personnel at other locations with responsibility for the site) fully understand the priority and importance of safety and health protection in the organization.

- Establish and communicate a clear goal for the safety and health program and define objectives for meeting that goal so that all members of the organization understand the results desired and measures planned for achieving them.

- Provide visible top management involvement in implementing the program so that all employees understand that management's commitment is serious.

- Arrange for and encourage employee involvement in the structure and operation of the program and in decisions that affect their safety and health so that they will commit their insight and energy to achieving the safety and health program's goal and objectives.

- Assign and communicate responsibility for all aspects of the program so that managers, supervisors, and employees in all parts of the organization know what performance is expected of them.

- Provide adequate authority and resources to responsible parties so that assigned responsibilities can be met.

- Hold managers, supervisors, and employees accountable for meeting their responsibilities so that essential tasks will be performed.

- Review program operations at least annually to evaluate their success in meeting the goals and objectives so that deficiencies can be identified and the program and/or the objectives can be revised when they do not meet the goal of effective safety and health protection.

2. Worksite Analysis

A practical analysis of the work environment involves a variety of worksite examinations to identify existing hazards and conditions and operations in which changes might occur to create new hazards. Unawareness of a hazard stemming from failure to examine the worksite is a sign that safety and health policies and/or practices are ineffective. Effective management actively analyzes the work and worksite to anticipate and prevent harmful occurrences. The following measures are recommend to identify all existing and potential hazards:

- Conduct comprehensive baseline worksite survey for safety and health and periodic comprehensive update surveys and involve employees in this effort.

- Analyze planned and new facilities, processes, materials, and equipment.

- Perform routine job hazards analyses.

- Assess risk factors of ergonomics applications to workers' tasks.

- Conduct regular site safety and health inspections so that new or previously missed hazards and failures in hazard controls are identified.

- Provide a reliable system for employees to notify management personnel about conditions that appear hazardous and to receive timely and appropriate responses and encourage employees to use the system without fear of reprisal. This system utilizes employee insight and experience in safety and health protection and allows employee concerns to be addressed.

- Investigate accidents and "near miss" incidents so that their causes and means of prevention can be identified.

- Analyze injury and illness trends over time so that patterns with common causes can be identified and prevented.

3. Hazard Prevention and Control

Where feasible, workplace hazards are prevented by effective design of the job site or job. Where it is not feasible to eliminate such hazards, they must be controlled to prevent unsafe and unhealthful exposure. Elimination or control must be accomplished in a timely manner once a hazard or potential hazard is recognize. Specifically, as part of the program, employers should establish procedures to correct or control present or potential hazards in a timely manner. These procedures should include measures such as the following:

- Use engineering techniques where feasible and appropriate.

- Establish, at the earliest time, safe work practices and procedures that are understood and followed by all affected parties. Understanding and compliance are a result of training, positive reinforcement, correction of unsafe performance, and if necessary, enforcement through a clearly communicated disciplinary system.

- Provide personal protective equipment when engineering controls are infeasible.

- Use administrative controls, such as reducing the duration of exposure.

- Maintain the facility and equipment to prevent equipment breakdowns.

- Plan and prepare for emergencies, and conduct training and emergency drills, as needed, to ensure that proper responses to emergencies will be "second nature" for all persons involved.

- Establish a medical program that includes first aid onsite as well as nearby physician and emergency medical care to reduce the risk of any injury or illness that occurs.

4. Safety and Health Training

Training is an essential component of an effective safety and health program. Training helps identify the safety and health responsibilities of both management and employees at the site. Training is often most effective when incorporated into other education or performance requirements and job practices. The complexity of training depends on the size and complexity of the worksite as well as the characteristics of the hazards and potential hazards at the site.

Employee Training

Employee training programs should be designed to ensure that all employees understand and are aware of the hazards to which they may be exposed and the proper methods for avoiding such hazards.

Supervisory Training

Supervisors should be trained to understand the key role they play in job site safety and to enable them to carry out their safety and health responsibilities effectively. Training programs for supervisors should include the following topics:

- Analyze the work under their supervision to anticipate and identify potential hazards.

- Maintain physical protection in their work areas.

- Reinforce employee training on the nature of potential hazards in their work and on needed protective measures through continual performance feedback and, if necessary, through enforcement of safe work practices.

- Understand their safety and health responsibilities.

ANSI Standard A10.38

ANSI Standard A10.38 is intended to list those minimum elements for a safety and health program for a construction employer. ANSI recommends that each employer adapt the elements to the needs of the construction organization and activity. ANSI Standard A10.38 is one in a series of standards formulated by the Accredited Standards Committee on safety in construction and demolition operations, A10. It is expected that the series of standards will find a major application in industry, serving as a guide to contractors, labor, and equipment manufacturers.

ANSI Standard A10.38 sets forth 12 elements that a construction employer's safety and health program should include. These 12 elements are:

1. A statement of the construction employer's commitment to providing a safe and healthful workplace for all employees.

2. A statement of the construction employer's ultimate responsibility for the implementation of the safety and health program.

3. New hire safety and health orientation training at the time of the initial hire of each new employee.

4. Periodic safety and health training meetings for supervisors and employees.

5. Specific assignment of responsibilities for jobsite safety and health inspections.

6. At least daily inspections for the detection of hazardous conditions or hazardous work performance.

7. Procedures for recording and reporting of incidents in accordance with OSHA requirements.

8. Procedures for the investigation of job-related accidents and illnesses to determine possible cause.

9. Specific designation of management person responsible for review of injuries and illness reports.

10. An emergency response plan that sets forth the procedures to be followed upon the occurrence

11. A policy with procedures for disciplinary action for the enforcement of the construction employer's safety and health program.

12. Reference to all applicable federal, state, and local safety and health laws and regulations.

In addition, ANSI Standard A10.38 recommends that procedures be established to: (1) ensure the correction or abatement of all hazardous conditions; (2) monitor the implementation of the construction employer's safety and health program; (3) monitor to determine that accident, injury, and illness records are accurate and complete; (4) maintain all safety and health records required by OSHA; and (5) provide each employee with a summary of the construction employer's safety and health program.

CII Zero Accidents Safety Practice

As indicated earlier, the CII Zero Accidents safety practice was developed by a research team composed of a broad cross-section of CII members and outside subject matter experts. The CII Zero Accidents safety practice was designed for use both by CII member firms and by the construction industry at large. The CII Zero Accidents safety practice contains 18 elements and 170 techniques. Readers interested in obtaining additional information on the 170 techniques are referred to the CII source document.[41] The 18 elements that comprise the CII Zero Accidents safety practice are:

1. Total Commitment to Zero Accidents

2. Project Safety Manual

3. Pre-Hire and Pre-Assignment Screening and Placement to Match Need

4. Safety Responsibility and Accountability

5. Use of Safety Statistics for Awareness, Accountability, and Process

6. Awareness and Tracking of Direct and Indirect Safety-Related Costs

7. Safety-Related Meetings

8. Hazard Analysis Prior to Project, Work, Task

[41] Construction Industry Institute, *Zero Injury Techniques*, pp. 28-35.

9. Designated Person On-Site to Coordinate Safety

10. Contractor Safety Pre-qualification (Including Subcontractors)

11. Safety Incentive Program

12. New Employee Orientation

13. Formal Classroom Safety Training

14. Accident/Near Miss Investigations

15. Substance and Alcohol Abuse Program

16. Safety Performance Reviews, Inspections, and Audits

17. Empowerment of Employee to Act on Safety

18. Post-Injury Case Management

Additional information on the CII Zero Accidents safety practice is presented in Section 4.2.2, where data linking the use of this practice to reductions in the calculated values of the RIR and the LWCIR are analyzed.

ANSI Standard A10.33

Investigations of major construction failures and individual injuries indicate that in a majority of instances a lack of coordination between the owner, construction manager, general contractor, and/or subcontractors was a primary contributing factor. ANSI Standard A10.33 sets forth the minimum elements that defines the duties and responsibilities of construction employees working on a construction project where a single project manager supervises and controls the project. The standard is a composite of the most effective policy and program elements taken from examples provided by industry. The focus of these elements is on: (1) implementation; (2) responsibilities and authority; (3) combined responsibilities; (4) program assignments; (5) assessment of qualifications; (6) hazard reporting; (7) special safety and health plan; (8) monthly status report; and (9) critical structures and complex processes.

Federal Highway Administration's Work Zone Best Practices Program

The Federal Highway Administration's research on best practices was driven by concerns over fatalities in work zones (i.e., sites where roadway construction and maintenance take place). The Federal Highway Administration (FHWA) in collaboration with the various state departments of transportation and construction industry and safety experts identified 266 best practices. The best practices are designed to minimize delay and/or enhance safety during construction and maintenance operations. Some practice focus on both issues (e.g., portable lighting for critical lane closures) while others affect construction worker safety (e.g., highly visible reflectorized flagger vest) and others affect motorists (e.g., providing real-time traffic information to the public). Readers interested in additional information are encouraged to visit the FHWA work zone best practices web site (http://www.fwha.dot.gov/quality/bestprac.htm).

4.2 Empirical Consideration Based on Construction Industry Institute Data

CII is an internationally recognized research consortium focused on advancing the capital projects industry.[42] CII draws its membership primarily from companies involved in the operation (owners) or construction (contractors) of chemical manufacturing, oil refining, pulp and paper, or similar industrial facilities. Because these facilities also include infrastructure and commercial/office type operations, CII member companies span all three non-residential sectors. In addition, CII contractor members often perform substantial amounts of work in the commercial/institutional and public works sectors as well as in the industrial sector. CII membership is nearly equally split between owner members and contractor members.

CII's role as a catalyst within the capital projects industry promotes a belief that these project-oriented data are likely to become widely recognized throughout the non-residential sectors of the construction industry as benchmarks by which to measure the improvement of the industry. In addition, CII's mission to improve the safety, quality, schedule, and cost effectiveness of the capital investment process—not only through research but also through a systematic implementation process—should ensure the broad dissemination of findings from the annual data collection cycle. Finally, CII's *Goal 2000* initiative closely parallels the aims of National Construction Goals 1 and 7.[43] To achieve *Goal 2000*, CII will perform research that will help reduce total project costs by 20 percent, reduce total project duration by 20 percent, and improve project safety by 25 percent by the year 2000.

4.2.1 Construction Industry Institute Annual Safety Report

Each year since 1990, CII has published a *Safety Report*. Each year's *Safety Report* (e.g., 1999) is based on the immediate prior year's performance data (e.g., 1998). The calculated values for the RIR and the LWCIR provided in the *Safety Report* are based on aggregated totals for owners, contractors, and for both (i.e., total number of recordable incidents, total number of lost workday incidents, and total work hours). Since the issuance of the *Safety Report for 1998*,[44] CII has also collected information on construction-related fatalities. Unfortunately, CII has not collected information on the

[42] The focus of the capital projects industry is on the delivery of new plants and equipment (e.g., buildings, structures, and infrastructure).
[43] Jortberg, Robert F., and Thomas R. Haggard. 1993. *CII: The First Ten Years.* Austin, TX: Construction Industry Institute.
[44] Thomas, Stephen R. 1998. *Safety Report for 1998*. Austin, TX: Construction Industry Institute.

total number of workers. Thus, a fatality incidence rate for the CII member organizations that is consistent with the BLS definition can not be calculated. CII has been informed of this deficiency and is exploring ways to incorporate information on the total number of workers into future *Safety Reports* beginning with the 2001 edition.[45]

The data upon which the annual *Safety Report* is based are provided to CII by its member companies via a survey questionnaire. Although response to the safety questionnaire is voluntary, a significant majority of CII members respond. Over the past several years, a core group of approximately 50 CII members has consistently responded to the safety questionnaire. The safety questionnaire requests information on all projects, regardless of size, that the CII member carried out during the previous calendar year. This information includes total craft workhours, the number of recordable incidents, the number of lost workday cases, and, since 1998, the number of fatalities. The safety questionnaire breaks out information on prime contractors and subcontractors into separate categories. Information is requested on all subcontractors, regardless of size. The safety data provided to CII by member companies are representative of their safety performance because these data cover the entire population of projects carried out during the previous year. In addition, having information on both prime contractors and subcontractors, provides a more complete picture of safety performance at the individual project level. Beginning with the *Safety Report for 1999*,[46] CII also provided respondents with a confidential key report. The key report compares individual company performance to industry rates. For non-respondents and for other interested parties, the *Safety Report for 1999* includes a sample key report based on aggregated rates.

Each new *Safety Report* incorporates information from past *Safety Reports.* Thus, the latest *Safety Report* results in an extended time series of computed values for both the RIR and the LWCIR. The RIR data are plotted in Figure 4-1; the LWCIR data are plotted in Figure 4-2. Each of the time series plotted in Figures 4-1 and 4-2 aggregates data from CII owner and contractor respondents. To provide a frame of reference, national construction industry averages as reported by BLS are also included in each figure. Data for 1989 through 1997 are shown as traces in each figure—one trace for CII respondents and one trace for the national construction industry average. Figures 4-1 and 4-2 demonstrate clearly that the construction industry is improving its safety performance. CII companies, however, continue to set the pace for these improvements. In 1989, CII companies reported an average RIR that was approximately 50 percent of the national average. By 1997, CII companies had improved to only 17 percent of the national average, indicating performance nearly six times as good as the construction industry in general. A similar trend is confirmed by the LWCIR; CII companies improved from 28 percent of the national average in 1989 to only seven percent of the national average in 1997.

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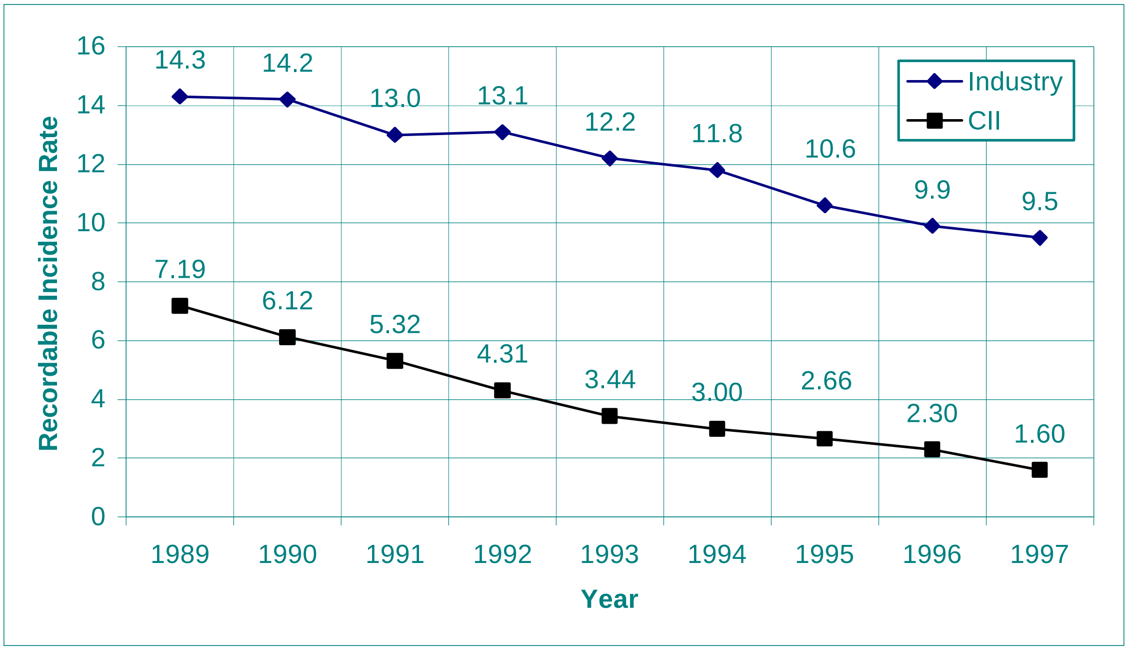
[45] CII does collect information on total craft workhours. This information may be used to estimate the number of full-time workers. Using the number of full-time workers rather than the total number of workers to calculate the fatality incidence rate would result in a higher incidence rate since some construction workers work only a small part of the year.

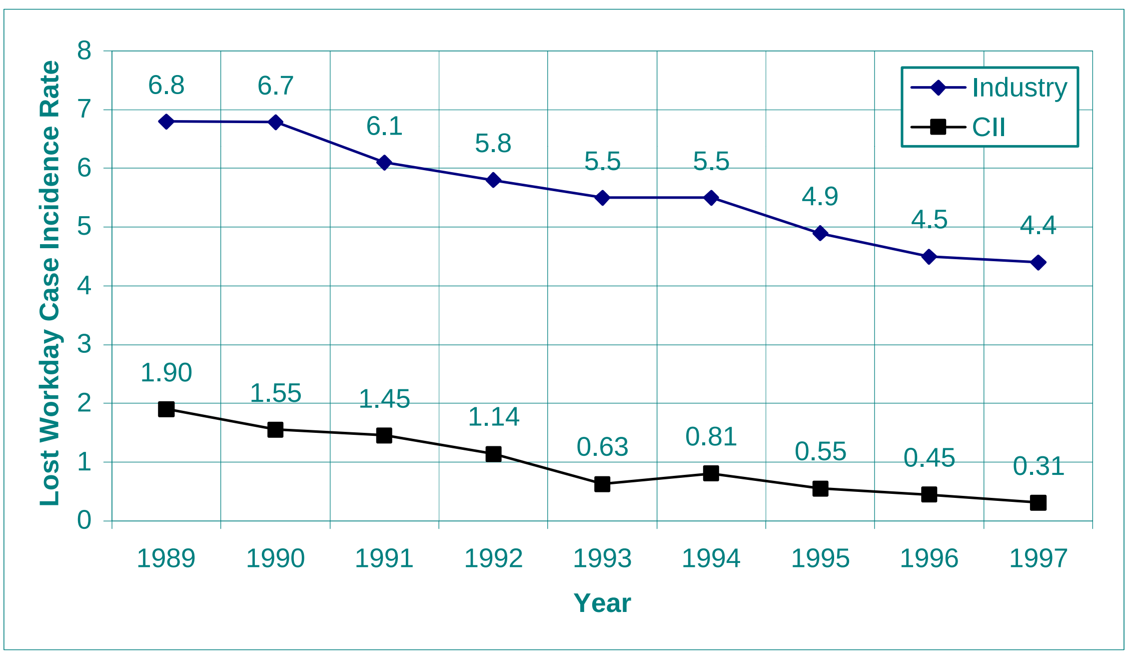
[46] Thomas, Stephen R. 1999. *Safety Report for 1999*. BMM99-4. Austin, TX: Construction Industry Institute.

Figure 4-1. Recordable Incidence Rate for Years 1989-1997



Source: Construction Industry Institute, *Safety Report for 1999*, BMM99-4.

Figure 4-2. Lost Workday Case Incidence Rate for Years 1989-1997



Source: Construction Industry Institute, *Safety Report for 1999*, BMM99-4.

4.2.2 The Construction Industry Institute Benchmarking and Metrics Database

Data from the Construction Industry Institute (CII) Benchmarking and Metrics Database are used as a reference point from which to measure performance improvements due to the use of the CII Zero Accidents safety practice for the three non-residential sectors. These data result in a "specialized" set of baseline measures. The CII data are used in this document because CII has committed itself to an annual cycle of surveying its member companies, collecting data on an individual project basis, analyzing these data, and publishing its findings.

Research by the author indicates that CII is one of the few organizations in the US that is systematically collecting construction project data in a manner conducive to the formulation of performance improvement measures for all three non-residential sectors. CII has agreed to provide NIST with aggregated data from its database, which will enable NIST to develop broad-based, industry-wide performance improvement measures for reductions in construction worker illnesses and injuries.[47] At the same time, NIST's analyses of the CII data will provide CII with valuable insights into the safety performance of its member companies, which will be of direct benefit to its membership.

Several private companies also collect some construction project data for one or more of the three non-residential sectors. However, these data are often specific to a particular segment of the construction industry (e.g., petrochemicals) and thus cannot be used to develop the broad-based, industry-wide measures associated with the National Construction Goals. Furthermore, there may be no fixed reporting intervals or broad-based data collection effort that would provide confidence that these data are representative. In addition, it is likely that such data could only be obtained on a fee-for-service basis.

Therefore, it is considered to be appropriate to make use of data from CII to analyze how safety practice use affects safety performance. The frequency for publishing these data and the methods of data collection meet the criteria established in Chapter 2. However, there are several limitations of the CII data that should be kept in mind. These limitations, when taken together, raise a concern that CII data may not be representative of construction industry "averages" for the three non-residential sectors. This caveat is based on three potential limitations. First, the CII members tend to be large companies. Because the construction industry is dominated by smaller construction firms, the performance of prime contractors on CII projects—both the CII member contractors and any non-member contractors selected by CII owners—should be expected to be better than the construction industry as a whole. However, since the CII Benchmarking and Metrics Database includes information on all subcontractors, the safety performance results presented in this section are not based solely on the performance of large construction establishments. Second, the projects included in the database are self-selected and thus may not be representative of each member firm's safety performance. CII requests their members to submit "typical" projects. However, what is typical to one

[47] All data provided to NIST by CII have been aggregated in a manner that precludes identification of an individual company's or project's performance.

CII member may not be typical to another. Fortunately, the annual *Safety Report* includes information that is representative of each member's projects, since it includes safety performance data on all their projects. Because approximately 60% of the members who provide projects to the Benchmarking and Metrics Database are a subset of those who respond to the annual safety questionnaire, the *Safety Report* serves as a convenient reference point for purposes of comparison. As will be shown later, the similarity between the reported values for the RIR and the LWCIR between the two data sets is very encouraging. Finally, CII member companies *may be more aggressively pursuing* performance improvement measures than companies that are not members of CII. Thus the measures of safety performance derived from these data *may be skewed towards the "best practice" end* of the non-residential construction project spectrum. However, since the objective is to analyze how safety practice use affects safety performance, the CII data are considered to be both appropriate and of value for establishing the performance improvement measures presented in this document.

A key resource in CII's effort to achieve *Goal 2000* is the Benchmarking and Metrics Program. The purposes of the Benchmarking and Metrics Program are: (1) to provide information to member companies on the net impact in overall project performance associated with using CII practices; and (2) to assist member companies in statistical measurements that can improve their own capital project effectiveness. The vehicle through which the purposes of the Benchmarking and Metrics Program are implemented is CII's Benchmarking and Metrics Committee. The Benchmarking and Metrics Committee was chartered by CII's Board of Advisors in November 1993. The Benchmarking and Metrics Committee is composed of representatives from both owner and contractor companies; it met for the first time in February 1994.

To provide quantitative measures of project performance, the CII Benchmarking and Metrics Committee established a benchmarking database in 1996. The benchmarking database is based on survey data collected from CII member companies. The Benchmarking and Metrics Committee is responsible for the design of the survey instrument, the training of benchmarking associates from member companies, and the compilation and analysis of respondent data.

The survey instrument focuses on information on project size, cost, schedule, overall performance, as well as on details of project execution. The survey instrument is designed to collect information both on performance metrics—cost, schedule, and safety—and on the use of CII practices. Perhaps most importantly, CII's analysis of respondent data seeks to quantify the impacts of CII practice usage on the values of performance metrics (e.g., how the use of CII practices translates into reductions in construction worker illnesses and injuries). Detailed information is collected on 6 of the 23 CII practices, including the following: (1) safety;[48] (2) pre-project planning;[49] (3) team

[48] Safety practices include the site-specific program and efforts to create a project environment and state of consciousness embracing the concept that all accidents are preventable and that zero accidents is an obtainable goal.

[49] Pre-project planning involves the process of developing sufficient strategic information with which owners can address risk and decide to commit resources to maximize the chance for a successful project.

building;[50] and (4) constructability.[51] These data are used to construct a series of indices for measuring the degree of usage both for individual practices (e.g., team building) and for the overall set. Having data which links practice use to reductions in construction worker illnesses and injuries is a valuable tool for identifying performance improvement opportunities. Thus, the inclusion of these data provides a valuable additional dimension to our effort to develop additional, specialized baseline measures for construction worker illnesses and injuries in the three non-residential sectors.

Safety-related information from 279 projects totaling $14.6 billion (installed cost) has been collected, compiled, analyzed, and made available to NIST. These project data provide the basis for all of the tables in this chapter (i.e., Tables 4-1 through 4-10) and for Figures 4-3 through 4-43. Consequently, the titles of the tables and figures throughout Section 4.2.2 are used to qualify the source as either the entire set of 279 projects (e.g., Figure 4-3) or a selected subset of the 279 projects (e.g., Figure 4-29). Therefore, a separate recounting of the source at the bottom of the table or figure was considered redundant and has been omitted. Figure 4-3 summarizes the project data received from both CII owners and contractors. Note that the number of projects is almost equally split between owners and contractors.

The Benchmarking and Metrics Committee uses four construction industry groups and allows for categorization of the database by these groups. The four industry groups are: (1) buildings; (2) heavy industrial; (3) infrastructure; and (4) light industrial. Figure 4-4 reports the distribution of projects in the database by industry group. Data on both owner respondent projects and contractor respondent projects are shown in Figure 4-4. The heavy industrial group comprises approximately 60 percent of the database. The remainder of the projects are fairly equally distributed among the other three industry groups. Throughout this document buildings are classified under the commercial/ institutional sector, both heavy industrial projects and light industrial projects are classified under the industrial sector, and infrastructure projects are classified under the public works sector.

The CII database currently represents a broad range of project size as measured by cost. As shown in Figure 4-5, approximately one-third of the projects have a cost of less than $15 million, one-third have a cost between $15 and $50 million, and one-third have a cost in excess of $50 million. The individual project costs range from slightly below $5 million to in excess of $500 million, with an average cost of approximately $50 million. Data on both owner and contractor respondent projects are shown in Figure 4-5.

[50] Team building is a process that brings together a diverse group of project participants and seeks to resolve differences, remove roadblocks, and proactively build and develop the group into an aligned, focused, and motivated work team that strives for a common mission for shared goals, objectives, and priorities.

[51] Constructability practices seek to achieve overall project objectives through the optimum use of construction knowledge and experience in planning, design, procurement, and field operations. Constructability is achieved through the effective and timely integration of construction input into planning and design as well as field operations.

Figure 4-3. CII Database by Respondent Type

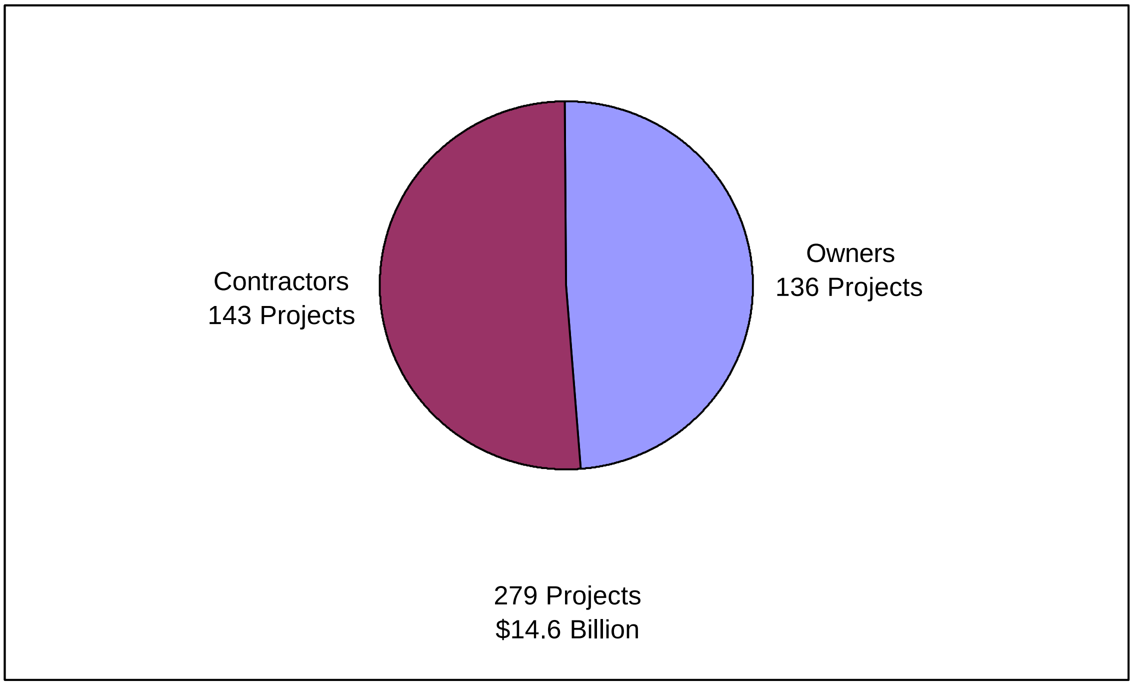
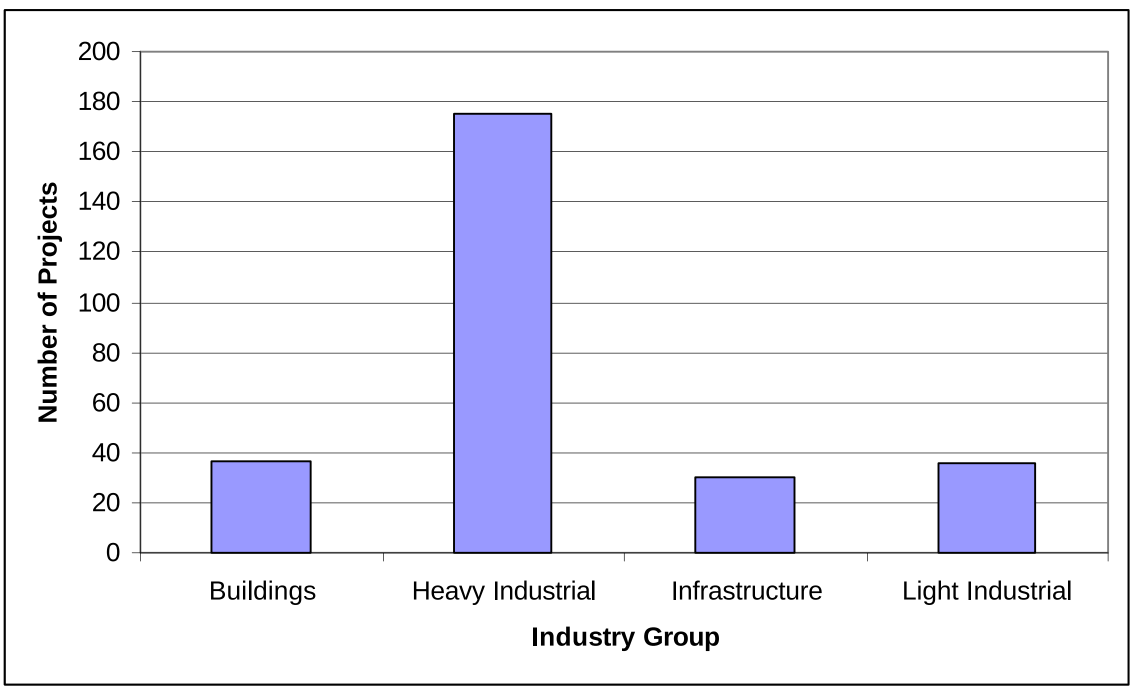


Figure 4-4. CII Database by Industry Type



Projects in the CII database can be identified and categorized by the nature of the project. Project nature indicates to which of the three categories a project belongs: (1) grassroots; (2) addition; and (3) modernization. The survey instrument defined grass roots as a new facility. An addition was defined as a new facility component that ties in to an existing facility, often intended to expand capacity. Modernization was defined as a facility for which a substantial amount of the equipment or structure is replaced or modified, and which may expand capacity. For purposes of this document, grassroots projects are classified under the heading of new construction, and addition and modernization projects are classified under the heading of additions and alterations (See Section A.2). Figure 4-6 shows how the projects in the database are distributed among the three categories of project nature. The projects are approximately equally distributed among all three categories. Data on both owner respondent projects and contractor respondent projects are shown in Figure 4-6.

Projects in the CII database can be identified and categorized by number of craft hours. The number of craft work hours expended during the execution of a project is of particular importance when looking at safety performance data. Figure 4-7 shows how the projects in the database are distributed among the four categories of craft workhours. Projects with less than 100,000 workhours and more than 500,000 workhours are approximately equally distributed in the database. The two remaining categories have fewer projects. Data on both owner and contractor projects are shown in Figure 4-7.

Figure 4-5. CII Database by Cost of Project

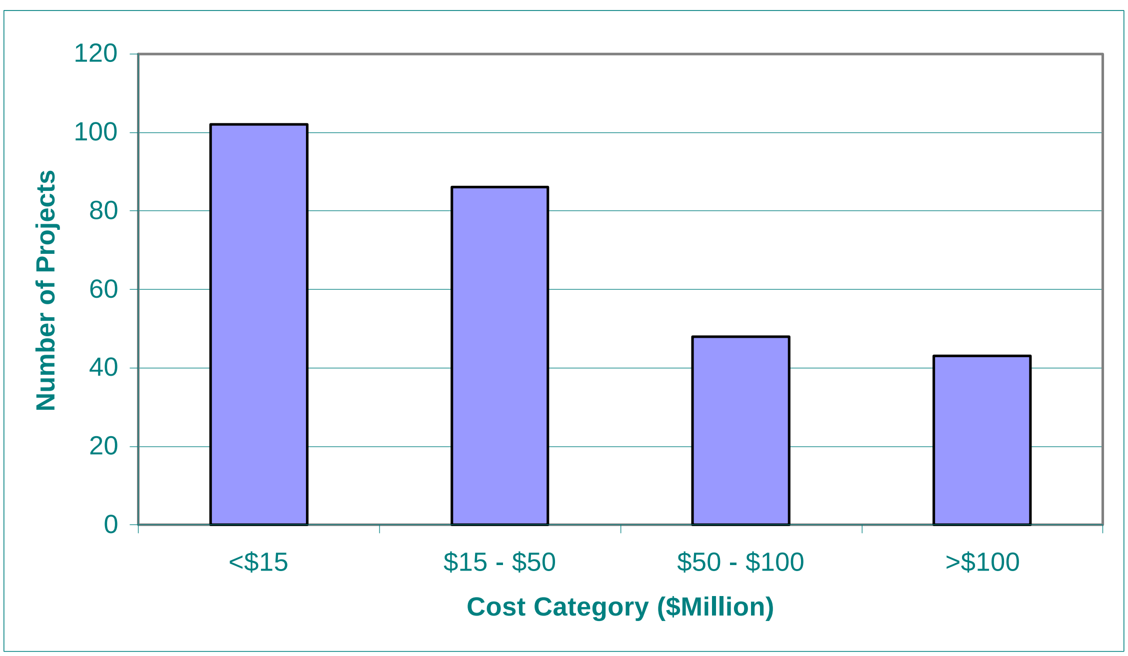


Figure 4-6. CII Database by Nature of Project

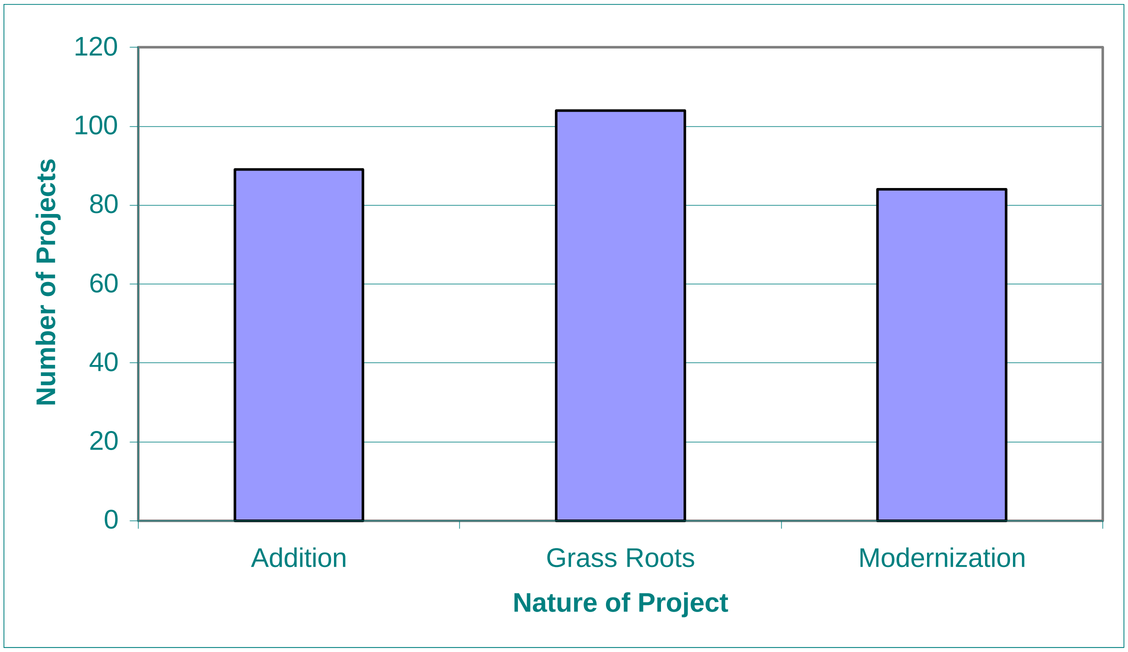
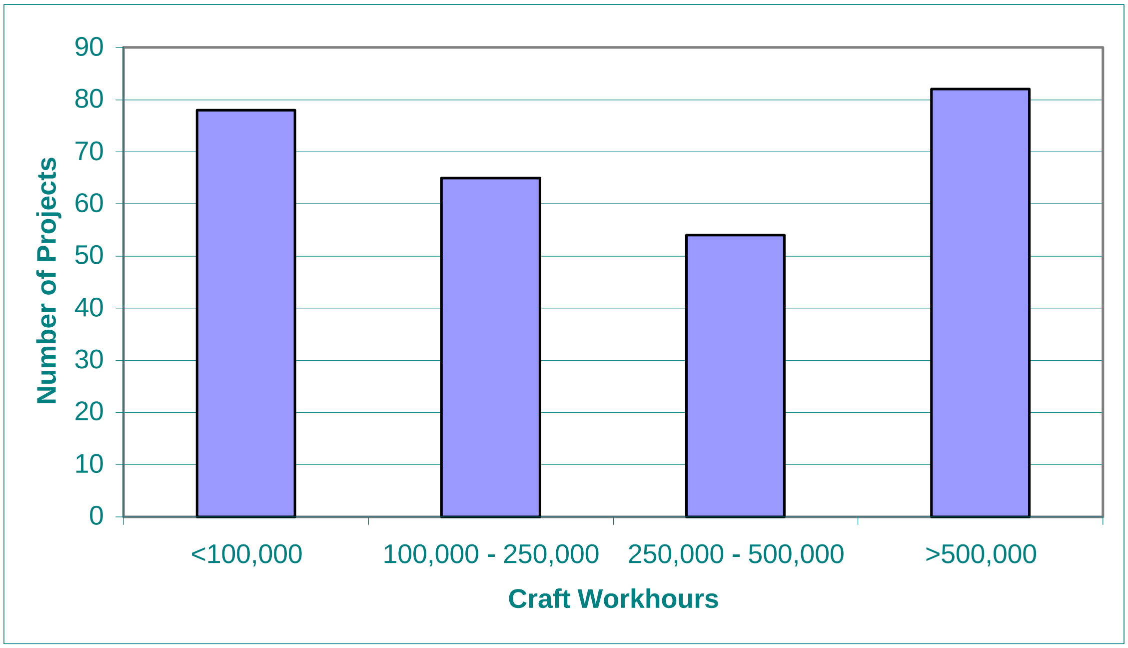


Figure 4-7. CII Database by Craft Workhours



Data from CII are used to produce estimates for the RIR and the LWCIR for the three non-residential sectors. The CII data used in this document include estimated values for four key statistical measures: (1) the 75^{th} percentile; (2) the mean; (3) the median; and (4) the 25^{th} percentile. Because these four measures cover the full interquartile range (i.e., the middle 50 percent of the data) for each subset of the overall CII data set, they provide a wealth of information. The mean—the arithmetic average—and the median—the middle value—are statistical measures of central tendency. These measures of central tendency provide opportunities for comparing the CII data to the Census data described in the previous chapter. The 75^{th} and 25^{th} percentiles provide a measure of variability. They also serve to point out opportunities for performance assessment. For example, users of this document can plot their own project data on the figure of interest to measure their projects' performance against the performance of similar projects in the CII data set.

The material presented in the remainder of this section is drawn from the CII Benchmarking and Metrics Database. As such, it represents both a different set of data and a more detailed frame of reference than the results presented in the annual *Safety Report*. Furthermore, because each respondent's benchmarking associate is trained on how to complete the Benchmarking and Metrics Database questionnaire prior to submitting it to CII and all entries to the Benchmarking and Metrics Database are rigorously screened, these data are considered more comprehensive than the results published in the annual *Safety Report*. Consequently, differences do result between the computed values for the RIR and the LWCIR published in the annual *Safety Report* and those derived from the Benchmarking and Metrics Database. Therefore, explanations are given whenever such differences are considered to be significant.

The first set of safety-related information serves to further characterize the types of data subsets contained in the CII Benchmarking and Metrics Database and to report on the calculated values for the RIR and the LWCIR for each data subset. This information is organized around a series of figures and tables. To facilitate comparisons among the various CII data subsets, Figures 4-8 through 4-17 are arranged in a sequence and use an identical format for data representation. The CII data subset sequence used in this subsection employs the following four major headings: (1) industry group subsets (i.e., buildings, heavy industrial, light industrial, and infrastructure); (2) cost categories ($million) subsets (i.e., <$15, $15 - $50, $50 - $100, and >$100); (3) project nature subsets (i.e., grass roots, addition, and modernization); and (4) craft workhours (in thousands) subsets (i.e., <100, 100 – 250, 250 – 500, >500). Within each figure, the CII data subsets for each major heading are listed on the horizontal axis. The vertical axis records the corresponding value of a response variable, such as the recordable incidence rate. For each subset, four key statistical measures are plotted on the figure: (1) the 75^{th} percentile, represented by a diamond (◆); (2) the mean, represented by a square (■); (3) the median, represented by a triangle (▲); and the 25^{th} percentile, represented by an x (×).

The data plotted on Figures 4-8 through 4-17 are recorded in Tables 4-1 through 4-10. Calculated values for the RIR for each data subset are presented first. The same data subset sequence is then repeated for the calculated values of the LWCIR. Figures 4-8 through 4-12 and Tables 4-1 through 4-5 record information on the calculated values of the RIR. Figures 4-13 through 4-17 and Tables 4-6 through 4-10 record information on the calculated values of the LWCIR. The tables also include information on the number of projects in each data subset, as well as the minimum and maximum values for the RIR and the LWCIR.

Figure 4-8 presents the interquartile range of values for the RIR by respondent type. The data used to construct Figure 4-8 are recorded in Table 4-1. Reference to the figure reveals that the interquartile range is much wider for contractors than for owners. In addition, at least 25 percent of all owner projects resulted in zero recordable incidents. Reference to the maximum values column of Table 4-1 reveals that the distribution of RIR values for contractors is more highly skewed than the distribution of RIR values for owners. Note that both distributions are skewed because the minimum value of the RIR is zero. On average, the RIR for owners is 3.64 whereas the RIR for contractors is 6.22. The average computed value for the RIR for owners and contractors combined is 4.96.

Figure 4-8. Recordable Incidence Rate by Respondent

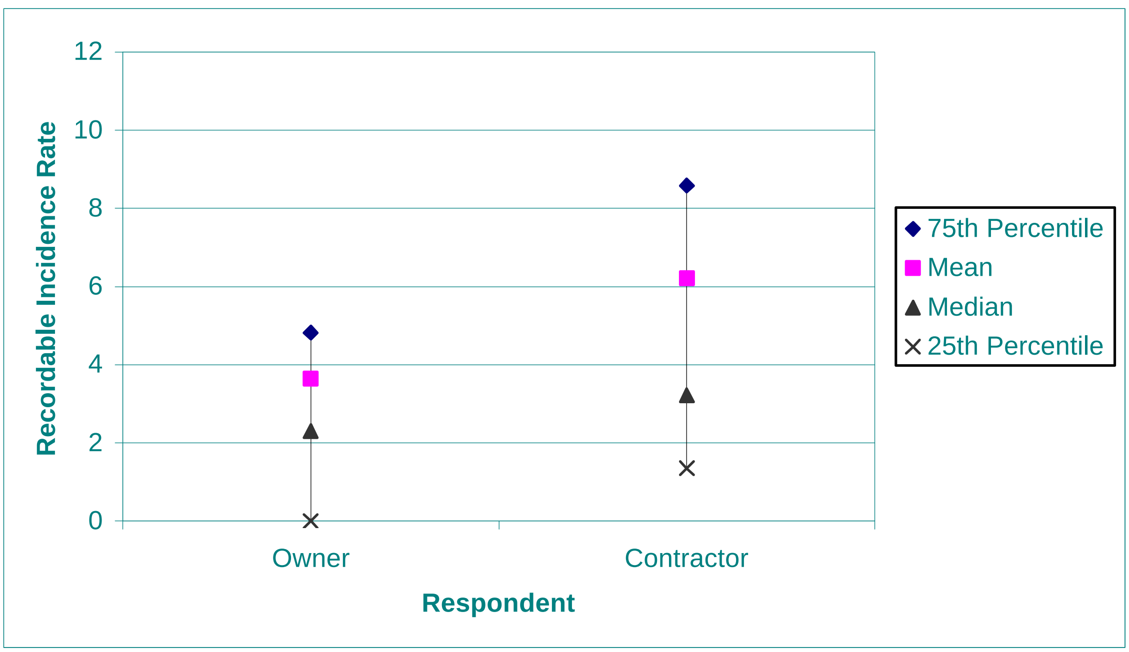


Table 4-1. Recordable Incidence Rate by Respondent

Respondent	Number of Projects	Recordable Incidence Rate by Respondent					
		Statistical Measure					
		Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean
Owner	136	0.00	0.00	2.31	4.82	21.72	3.64
Contractor	143	0.00	1.35	3.22	8.58	77.76	6.22

Figure 4-9 presents the interquartile range of values for the RIR by industry group. The data used to construct Figure 4-9 are recorded in Table 4-2. Reference to the figure reveals that the interquartile range is tighter for heavy industrial projects than for buildings, infrastructure, and light industrial projects. Note that for all four industry groups the mean exceeds the median. This is due to the influence of relatively high values (i.e., values between the 75th percentile and the maximum) on the mean. This influence is most evident in the case of buildings and heavy industrial projects, where the mean value is "pulled up" almost to the value of the 75th percentile. The mean values recorded in Table 4-2 are used to define the baseline values for the RIR (i.e., the additional, specialized baseline measures) for each of the four CII data sets. The mean value of the RIR for all industrial projects (i.e., heavy industrial and light industrial combined) is 4.40.

Figure 4-9. Recordable Incidence Rate by Industry Group

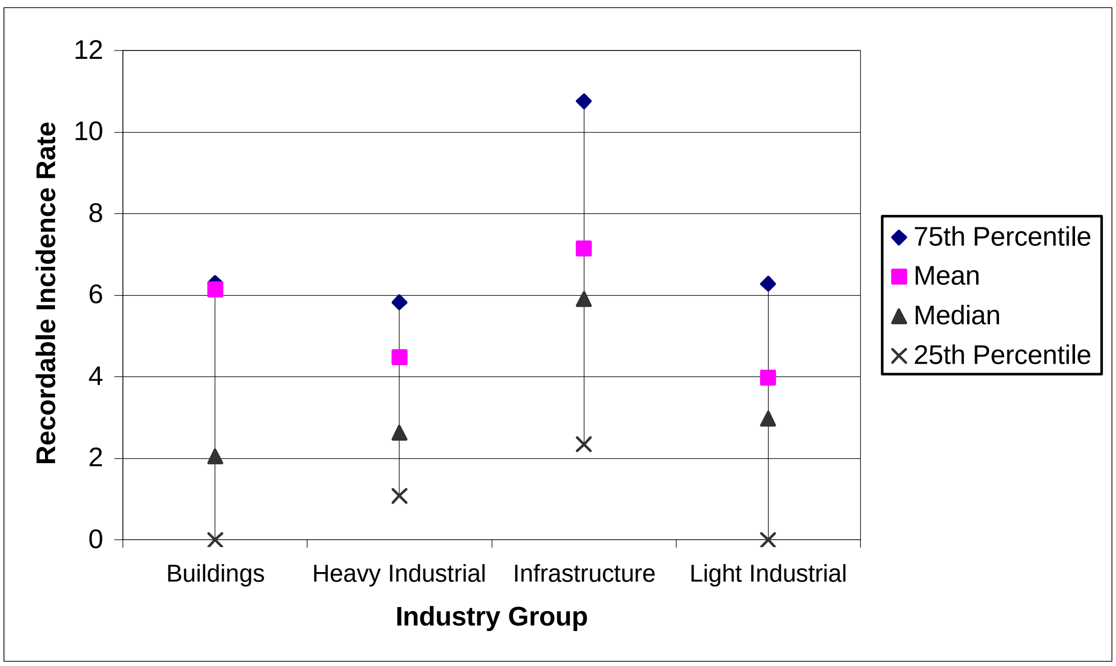


Table 4-2. Recordable Incidence Rate by Industry Group

Industry Group	Number of Projects	Recordable Incidence Rate by Industry Group					
		Statistical Measure					
		Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean
Buildings	37	0.00	0.00	2.04	6.30	50.00	6.14
Heavy Industrial	175	0.00	1.08	2.63	5.82	77.76	4.49
Infrastructure	30	0.00	2.34	5.90	10.76	22.04	7.15
Light Industrial	36	0.00	0.00	2.98	6.28	21.72	3.98

Figure 4-10 presents the interquartile range of values for the RIR by cost category. The data used to construct Figure 4-10 are recorded in Table 4-3. Reference to the figure reveals that the interquartile range is much tighter for projects costing between $50 million and $100 million than for the other cost categories. Note also that the value of the 25th percentile tends to rise as the cost of the project is increased. This reflects the increasing difficulty of achieving zero recordables on large and complex projects.

Figure 4-10. Recordable Incidence Rate by Cost Category

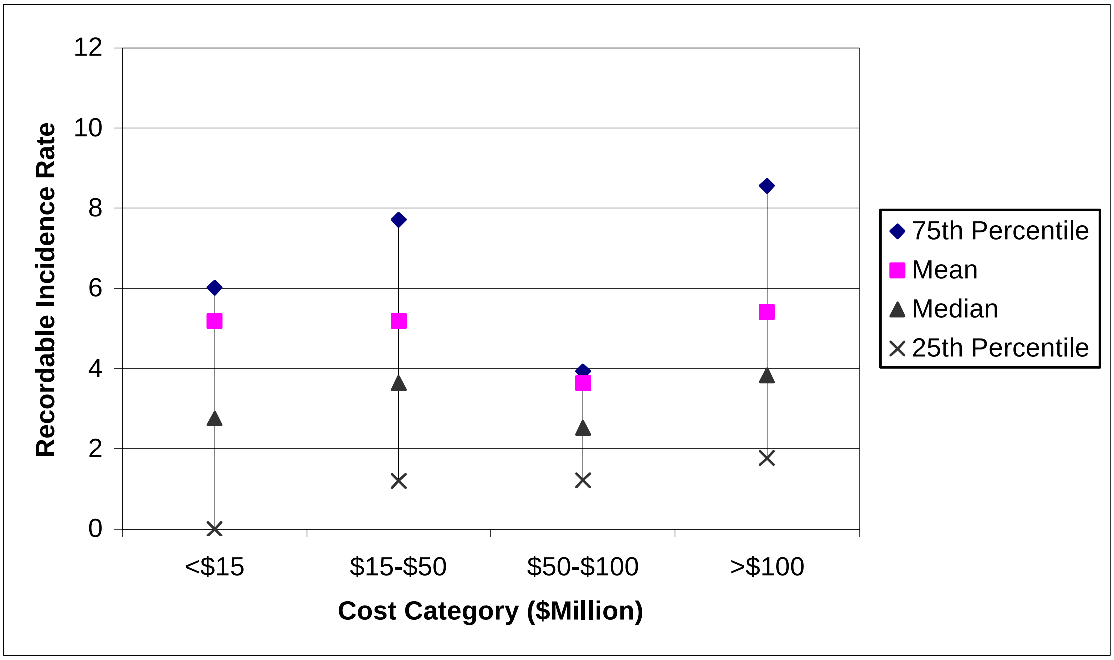


Table 4-3. Recordable Incidence Rate by Cost Category

Cost Category ($Million)	Number of Projects	Recordable Incidence Rate by Cost Category					
		Statistical Measure					
		Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean
<$15	102	0.00	0.00	2.76	6.02	77.76	5.20
$15-$50	86	0.00	1.21	3.65	7.72	22.04	5.19
$50-$100	48	0.00	1.22	2.52	3.93	16.06	3.64
>$100	43	0.34	1.77	3.84	8.56	21.72	5.42

Figure 4-11 presents the interquartile range of values for the RIR by the nature of the project. The data used to construct Figure 4-11 are recorded in Table 4-4. Reference to the figure reveals that the interquartile range is much tighter for additions than for grass roots and modernization projects. The figure also illustrates an interesting relationship between the value of the 25th percentile and the proportion of zero recordable incidents. Because a large proportion of modernization projects are relatively small (e.g., less than $15 million total installed cost), at least 25 percent of all modernization projects result in zero recordable incidents. The value of the 25th percentile for both grass roots projects and additions is greater than zero. On the other hand, the calculated value of the mean for modernization projects is "pulled up" due to the presence of a few relatively high RIR values. Note also how much wider is the spread between the mean and the median values for modernization projects versus additions. A similar pattern is evident for grass roots projects.

Figure 4-11. Recordable Incidence Rate by the Nature of the Project

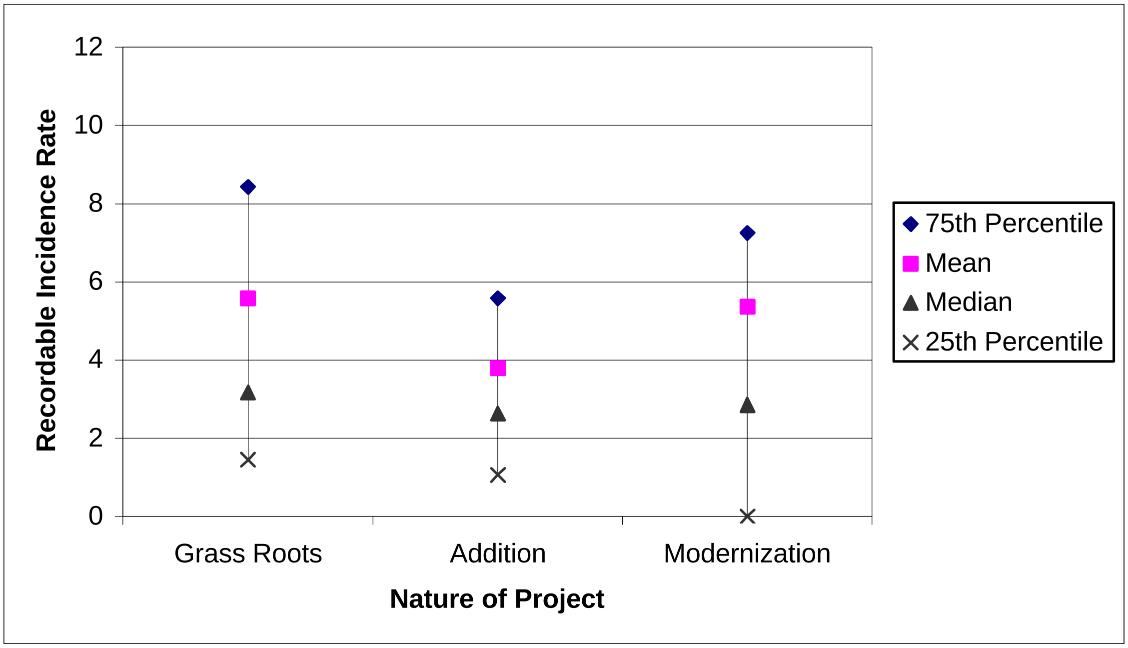


Table 4-4. Recordable Incidence Rate by the Nature of the Project

Nature of Project	Number of Projects	Recordable Incidence Rate by Nature of Project					
		Statistical Measure					
		Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean
Grass Roots	104	0.00	1.45	3.17	8.43	50.00	5.57
Addition	89	0.00	1.06	2.64	5.58	22.04	3.79
Modernization	84	0.00	0.00	2.85	7.25	77.76	5.36

Figure 4-12 presents the interquartile range of values for the RIR by craft workhours. The data used to construct Figure 4-12 are recorded in Table 4-5. Reference to the figure reveals that the interquartile range tightens slightly as the number of craft workhours is increased. This tightening of the interquartile range reflects two countervailing effects. First, as craft workhours increase, project managers place increased emphasis on safety. These efforts tend to reduce the likelihood of particularly bad safety performance as measured by the value of the 75th percentile. Second, as craft workhours are increased it becomes increasingly difficult to achieve zero recordable incidents. This effect is reflected through the increasing values of the 25th percentile as the number of craft workhours is increased.

Figure 4-12. Recordable Incidence Rate by Craft Workhours

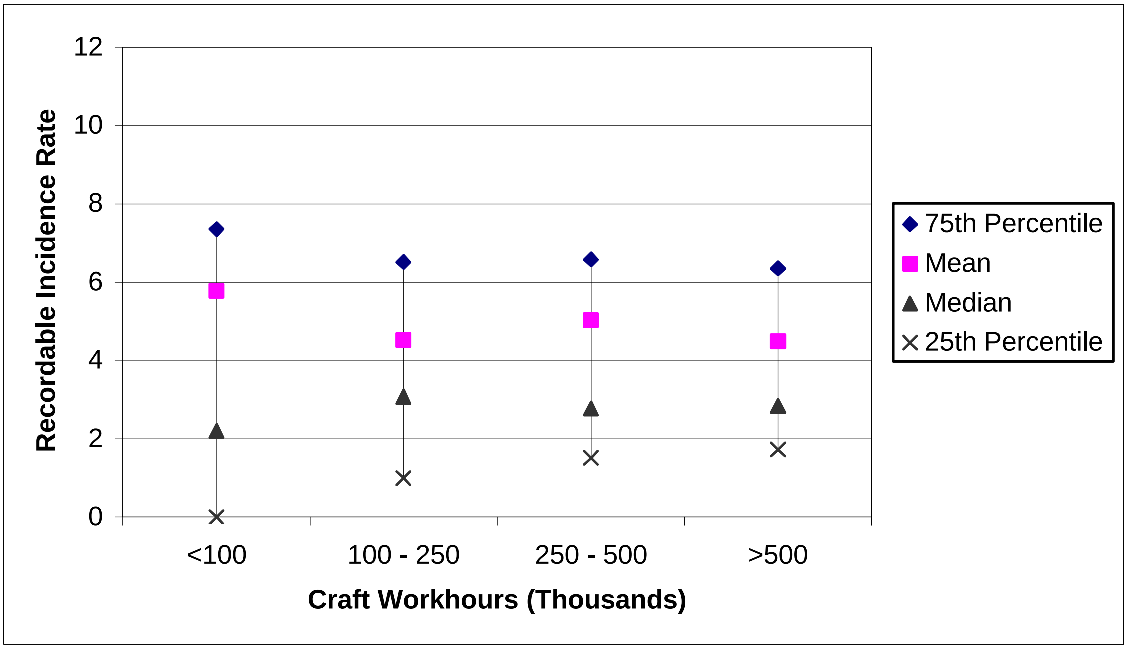


Table 4-5. Recordable Incidence Rate by Craft Workhours

Craft Workhours (Thousands)	Number of Projects	Recordable Incidence Rate by Craft Workhours					
		Statistical Measure					
		Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean
<100	78	0.00	0.00	2.20	7.35	77.76	5.79
100 – 250	65	0.00	1.00	3.08	6.52	16.06	4.53
250 – 500	54	0.00	1.52	2.79	6.59	22.04	5.03
>500	82	0.00	1.73	2.85	6.36	16.56	4.49

Figure 4-13 presents the interquartile range of values for the LWCIR by respondent type. The data used to construct Figure 4-13 are recorded in Table 4-6. Reference to the figure reveals that the interquartile range is much wider for contractors than for owners. In addition, at least 50 percent of all projects (i.e., both owner and contractor projects) resulted in zero lost workday incidents. On average, the LWCIR for owners is 0.78 whereas the LWCIR for contractors is 1.06. Note that the calculated mean value for owners falls outside of the interquartile range. This is due to the presence of relatively high values (i.e., values between the 75th percentile and the maximum). The average computed value for the LWCIR for owners and contractors combined is 0.93.

Figure 4-13. Lost Workday Case Incidence Rate by Respondent

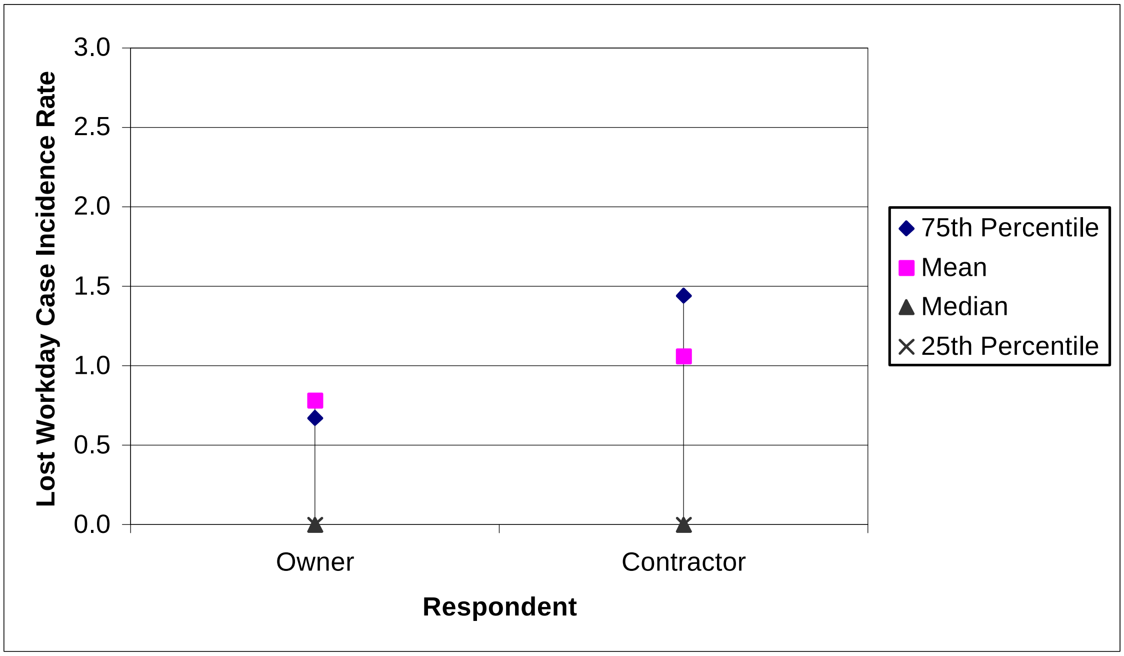


Table 4-6. Lost Workday Case Incidence Rate by Respondent

Respondent	Number of Projects	Lost Workday Case Incidence Rate by Respondent					
		Statistical Measure					
		Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean
Owner	134	0.00	0.00	0.00	0.67	23.02	0.78
Contractor	144	0.00	0.00	0.00	1.44	12.90	1.06

Figure 4-14 presents the interquartile range of values for the LWCIR by industry group. The data used to construct Figure 4-14 are recorded in Table 4-7. Reference to the figure reveals that the interquartile range is much tighter for heavy industrial projects than for buildings, infrastructure, and light industrial projects. Note that the calculated mean values for heavy industrial and infrastructure projects fall outside of the interquartile range. This is due to the presence of relatively high values (i.e., values between the 75th percentile and the maximum) associated with both industry groups. The mean values recorded in Table 4-7 are used to define the baseline values for the LWCIR (i.e., the additional, specialized baseline measures) for each of the four CII data sets. The mean value of the LWCIR for all industrial projects (i.e., heavy industrial and light industrial combined) is 0.66.

Figure 4-14. Lost Workday Case Incidence Rate by Industry Group

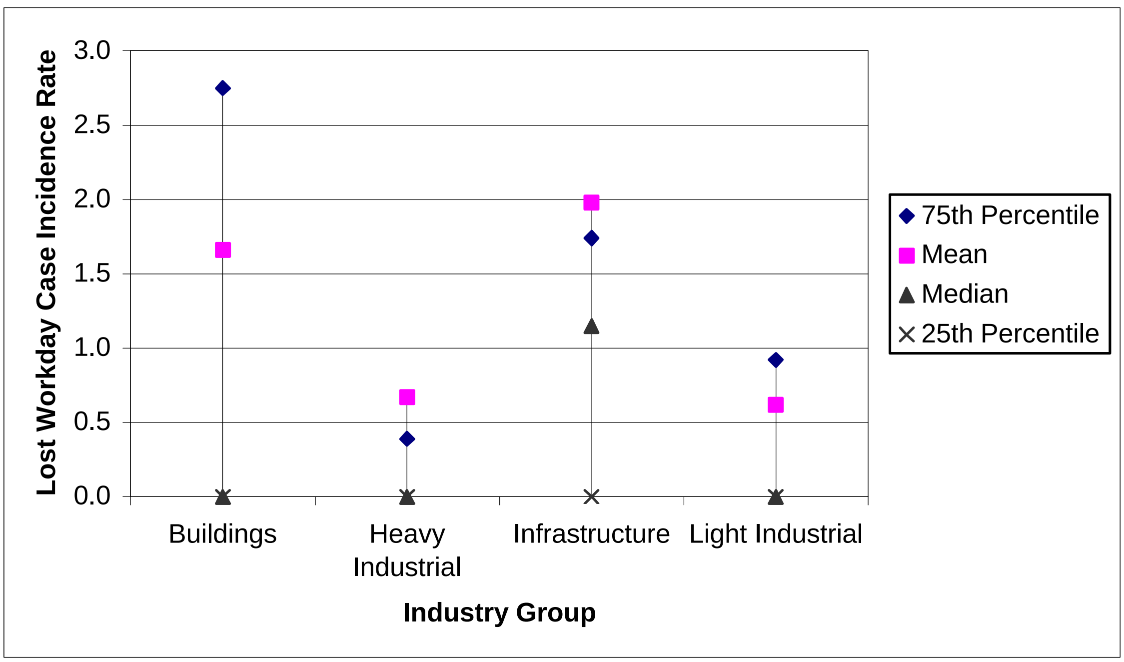


Table 4-7. Lost Workday Case Incidence Rate by Industry Group

Industry Group	Number of Projects	Lost Workday Case Incidence Rate by Industry Group					
		Statistical Measure					
		Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean
Buildings	36	0.00	0.00	0.00	2.75	12.90	1.66
Heavy Industrial	176	0.00	0.00	0.00	0.39	23.02	0.67
Infrastructure	29	0.00	0.00	1.15	1.74	10.72	1.98
Light Industrial	36	0.00	0.00	0.00	0.92	6.27	0.62

Figure 4-15 presents the interquartile range of values for the LWCIR by cost category. The data used to construct Figure 4-15 are recorded in Table 4-8. Figure 4-15 and Table 4-8 illustrate an interesting relationship between project cost and zero lost workday incidents. For projects costing less than $15 million, more than 75 percent result in zero lost workday incidents. Consequently, the mean value for the LWCIR for this cost category falls outside the interquartile range (i.e., the mean value exceeds the value of the 75th percentile). For projects costing between $15 million and $50 million, more than 50 percent result in zero lost workday incidents. For projects costing more than $50 million, more than 25 percent result in zero lost workday incidents.

Figure 4-15. Lost Workday Case Incidence Rate by Cost Category

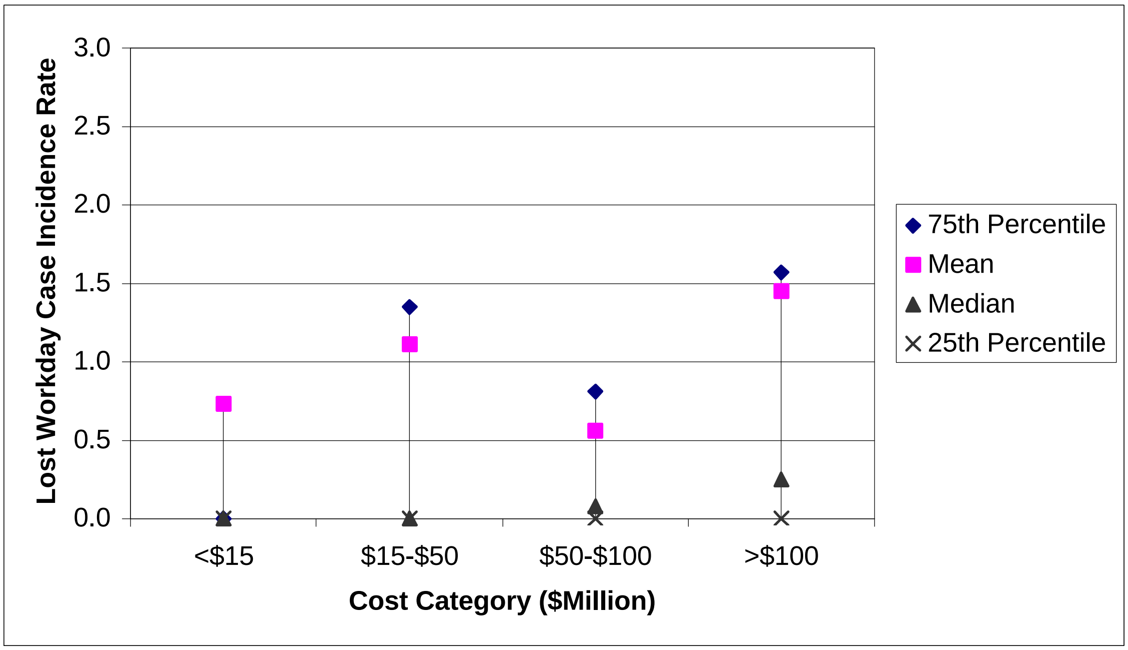


Table 4-8. Lost Workday Case Incidence Rate by Cost Category

Cost Category ($Million)	Number of Projects	Lost Workday Case Incidence Rate by Cost Category					
		Statistical Measure					
		Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean
<$15	102	0.00	0.00	0.00	0.00	9.78	0.73
$15-$50	86	0.00	0.00	0.00	1.35	12.90	1.11
$50-$100	48	0.00	0.00	0.08	0.81	2.83	0.56
>$100	42	0.00	0.00	0.25	1.57	23.02	1.45

Figure 4-16 presents the interquartile range of values for the LWCIR by the nature of the project. The data used to construct Figure 4-16 are recorded in Table 4-9. Reference to the figure reveals that the interquartile range is much tighter for additions than for grass roots and modernization projects. Note, however, that all three subsets result in at least 25 percent of their projects having zero lost workday incidents. Also, for additions and modernization projects, the proportion of projects resulting in zero lost workday incidents exceeds 50 percent of the total.

Figure 4-16. Lost Workday Case Incidence Rate by the Nature of the Project

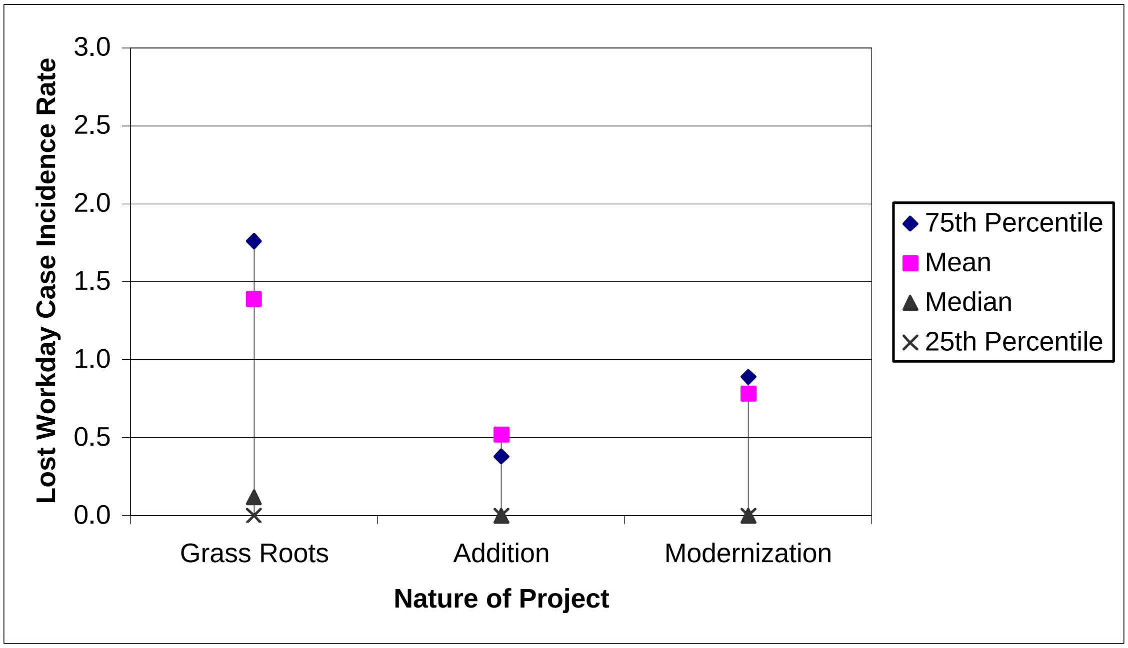


Table 4-9. Lost Workday Case Incidence Rate by the Nature of the Project

Nature of Project	Number of Projects	Lost Workday Case Incidence Rate by Nature of Project					
		Statistical Measure					
		Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean
Grass Roots	104	0.00	0.00	0.12	1.76	23.02	1.39
Addition	90	0.00	0.00	0.00	0.38	9.26	0.52
Modernization	82	0.00	0.00	0.00	0.89	8.33	0.78

Figure 4-17 presents the interquartile range of values for the LWCIR by craft workhours. The data used to construct Figure 4-17 are recorded in Table 4-10. Figure 4-17 and Table 4-10 illustrate an interesting relationship between craft workhours and zero lost workday incidents. For projects with less than 100,000 workhours, more than 75 percent result in zero lost workday incidents. Consequently, the mean value for the LWCIR for this craft workhour category falls outside the interquartile range (i.e., the mean value exceeds the value of the 75th percentile). For projects having between 100,000 and 250,000 workhours, more than 50 percent result in zero lost workday incidents. For projects having more than 250,000 workhours, more than 25 percent result in zero lost workday incidents. A similar relationship was seen between project cost and zero lost workday incidents (see Figure 4-15 and Table 4-8).

Figure 4-17. Lost Workday Case Incidence Rate by Craft Workhours

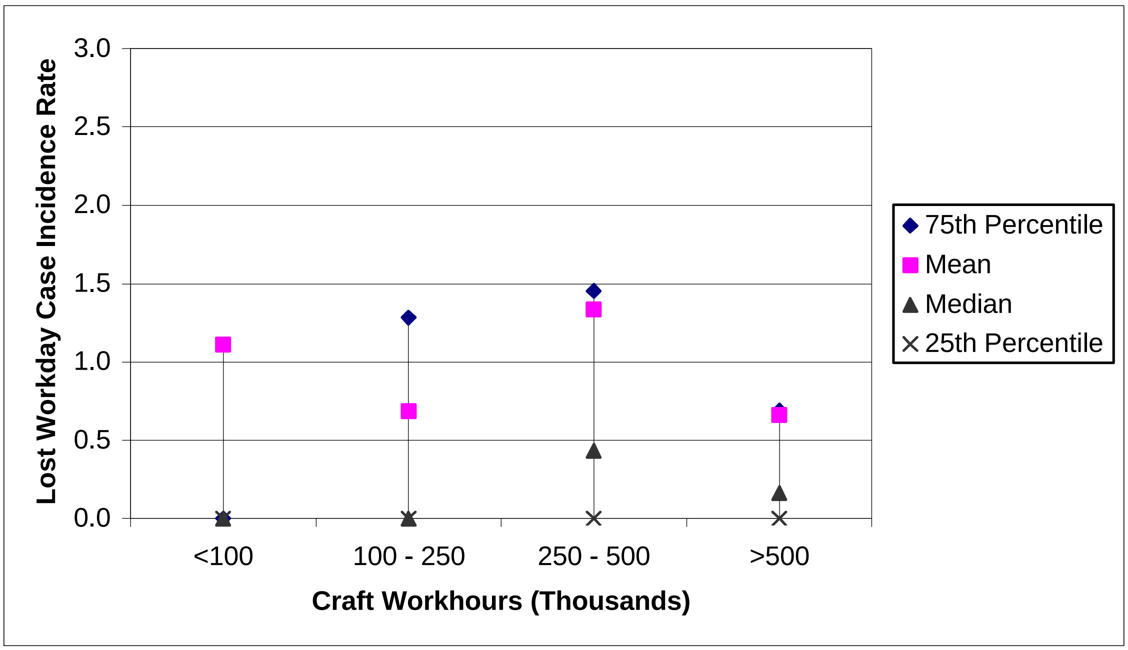


Table 4-10. Lost Workday Case Incidence Rate by Craft Workhours

Craft Workhours (Thousands)	Number of Projects	Lost Workday Case Incidence Rate by Craft Workhours					
		Statistical Measure					
		Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean
<100	78	0.00	0.00	0.00	0.00	12.90	1.11
100 – 250	65	0.00	0.00	0.00	1.28	7.85	0.69
250 – 500	54	0.00	0.00	0.43	1.45	23.02	1.33
>500	82	0.00	0.00	0.16	0.69	9.26	0.66

Before proceeding with a more detailed analysis of data on zero recordable incidents and zero lost workday incidents, it is instructive to discuss some of the differences in the mean values of the RIR and the LWCIR derived from the annual *Safety Report* and from the Benchmarking and Metrics Database. Note that the mean values for the RIR and the LWCIR derived from the Benchmarking and Metrics Database—4.96 and 0.93—exceed the values given in the *Safety Report for 1998*—1.6 and 0.31. There are two factors contributing to these differences. First, the values for the RIR and the LWCIR published in each *Safety Report* between 1990 and 1998 include an indeterminate number of home office hours. The values derived from the Benchmarking and Metrics Database—both the RIR and the LWCIR—are based solely on craft workhours. Thus, the mean values for the RIR and the LWCIR given in the annual *Safety Report* are biased downwards (i.e., are underestimates of the true values). Second, although the data from the CII Benchmarking and Metrics Database provided to NIST were collected in 1996 and 1997, the database includes a number of projects completed prior to 1996. Since the trend in both the RIR and the LWCIR has been downward, the presence of "older" projects biases upward (i.e., overestimates) the mean values of the RIR and the LWCIR derived from the Benchmarking and Metrics Database. Both factors serve to accentuate the differences between the two sets of mean values. Fortunately, both factors have been called to CII's attention; they are currently being addressed by CII. Beginning with the *Safety Report for 1999*, home office and craft workhours are being tabulated separately. This enables CII not only to continue to add to its original time series for the RIR and the LWCIR but also to produce a new time series which more accurately reflects the true values of the RIRs and LWCIRs for the companies submitting individual project data. In addition, beginning with the 1998 survey of projects for the Benchmarking and Metrics Database, the number of pre-survey- year projects has declined significantly. Consequently, data published in the *Safety Report for 1999* and data collected as part of the 1998 survey for the Benchmarking and Metrics Database produced mean values for the RIR and LWCIR that are remarkably close.[52]

Figures 4-18 through 4-22 provide information on the percent of projects achieving zero accident performance (i.e., zero recordable incidents or zero lost workday incidents). The figures are organized by major group heading. They use the same major group headings and sequencing as employed in Figures 4-8 through 4-17. In each figure, the vertical axis records the percent of projects achieving zero recordable incidents and zero lost workday incidents. Within each figure, the CII data subsets for each major heading are listed on the horizontal axis. All data are plotted as bars in the figure—one set of lightly shaded bars for the RIR and one set of darkly shaded bars for the LWCIR. To facilitate comparisons across data subsets, the percent of projects achieving zero accident performance is recorded above each bar.

Figure 4-18 records zero accident performance by respondent type. Reference to the figure shows that owners achieve better zero accident performance than contractors. For example, 27 percent of all owner projects achieved zero recordable incidents while only 15 percent of contractor projects achieved zero recordable incidents. The same pattern is

[52] Personal communication with Stephen R. Thomas, Assistant Director – Benchmarking, Construction Industry Institute, September 15, 1999.

evident for lost workday incidents; owners achieved zero lost workday incidents on nearly two thirds of their projects while contractors achieved zero lost workday incidents on slightly more than half of their projects.

Figure 4-18. Zero Accident Performance by Respondent Type

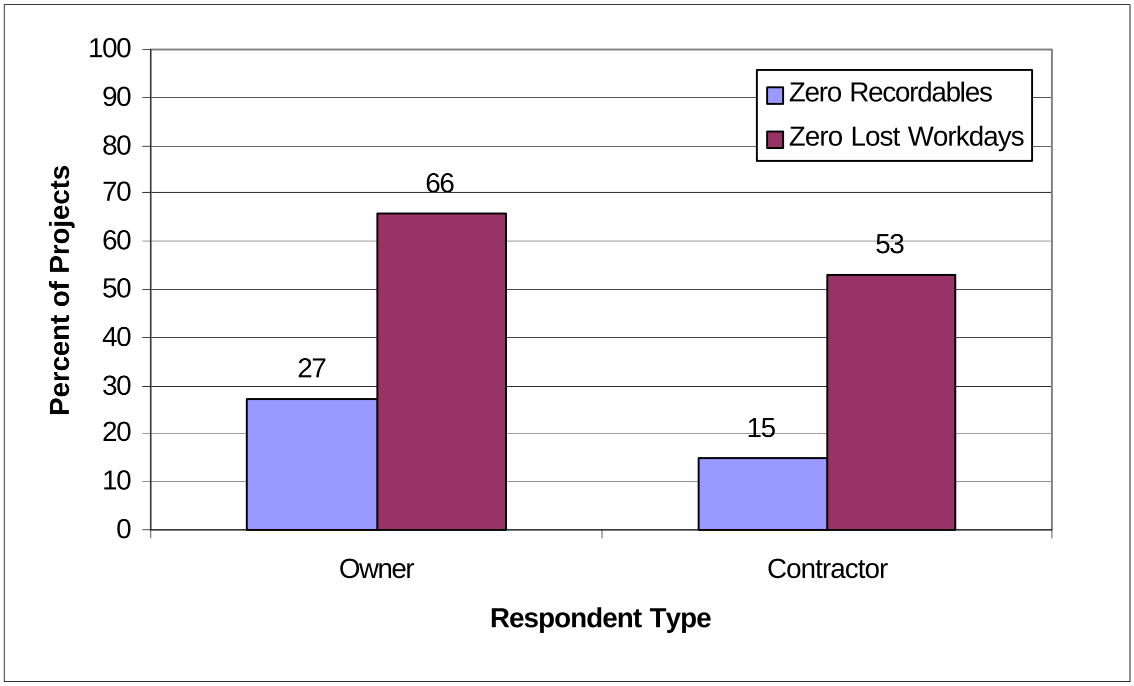


Figure 4-19 records zero accident performance by industry group. Reference to the figure shows that zero accident performance varies considerably across the four industry groups. Infrastructure projects have the poorest zero accident performance; only 13 percent achieved zero recordable incidents and only 41 percent achieved zero lost workday incidents. Heavy industrial projects had the highest percentage of projects achieving zero lost workday incidents (63 percent), but performed rather poorly in terms of zero recordable incidents (only 19 percent). On the other hand, light industrial projects achieved zero lost workday incidents 61 percent of the time and zero recordable incidents 30 percent of the time. Building projects performed well for zero recordable incidents (30 percent) but not for zero lost workday incidents (53 percent).

Figure 4-20 records zero accident performance by cost category. Reference to the figure shows a clear pattern, as project cost goes up, zero accident performance goes down. This outcome is to be expected, since it reflects the increasing difficulty of achieving zero recordable/lost workday incidents on large and complex projects. However, it is encouraging to see that 78 percent of all projects costing less than $15 million and half of all projects costing between $50 million and $100 million result in zero lost workday incidents.

Figure 4-19. Zero Accident Performance by Industry Group

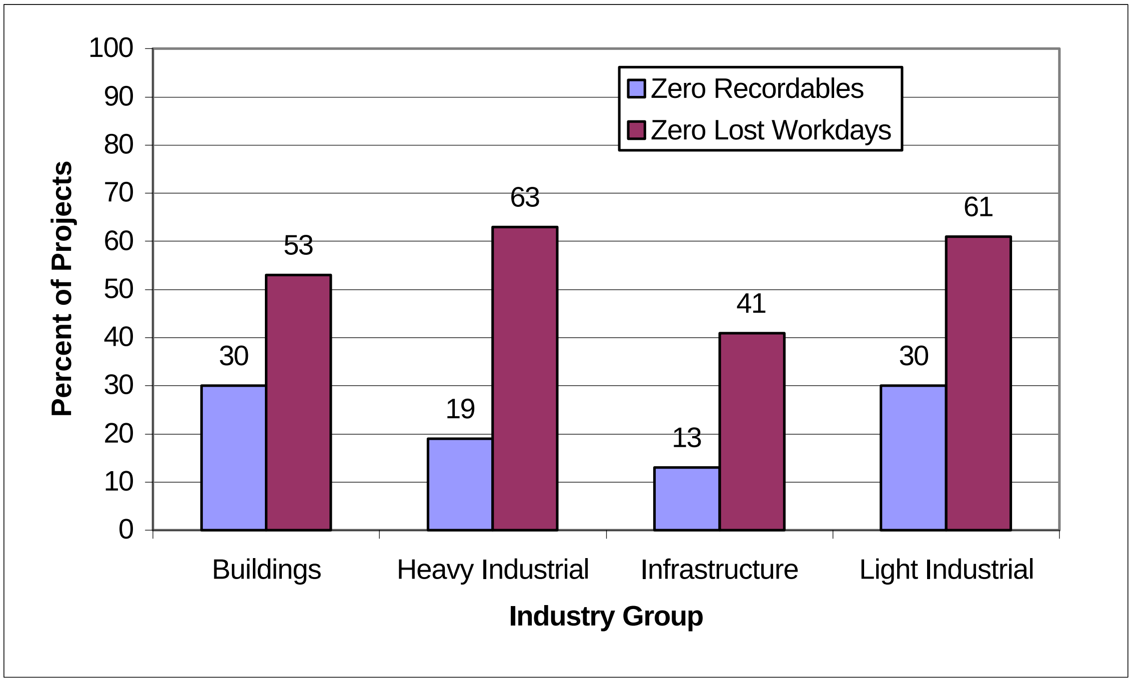


Figure 4-20. Zero Accident Performance by Cost Category

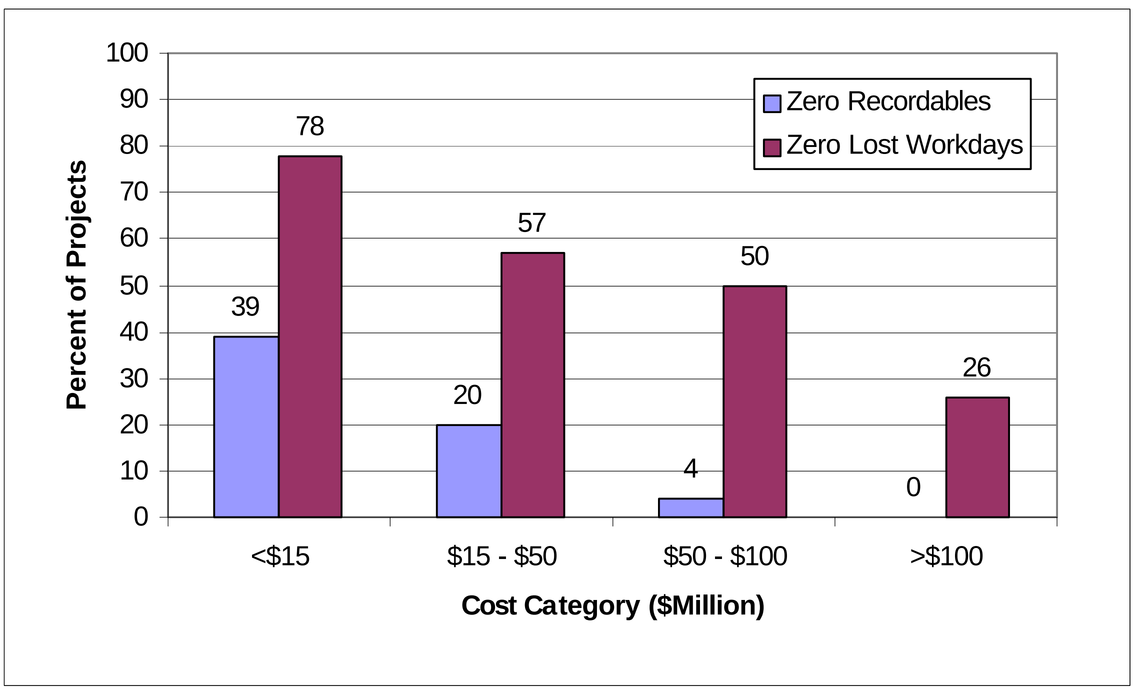


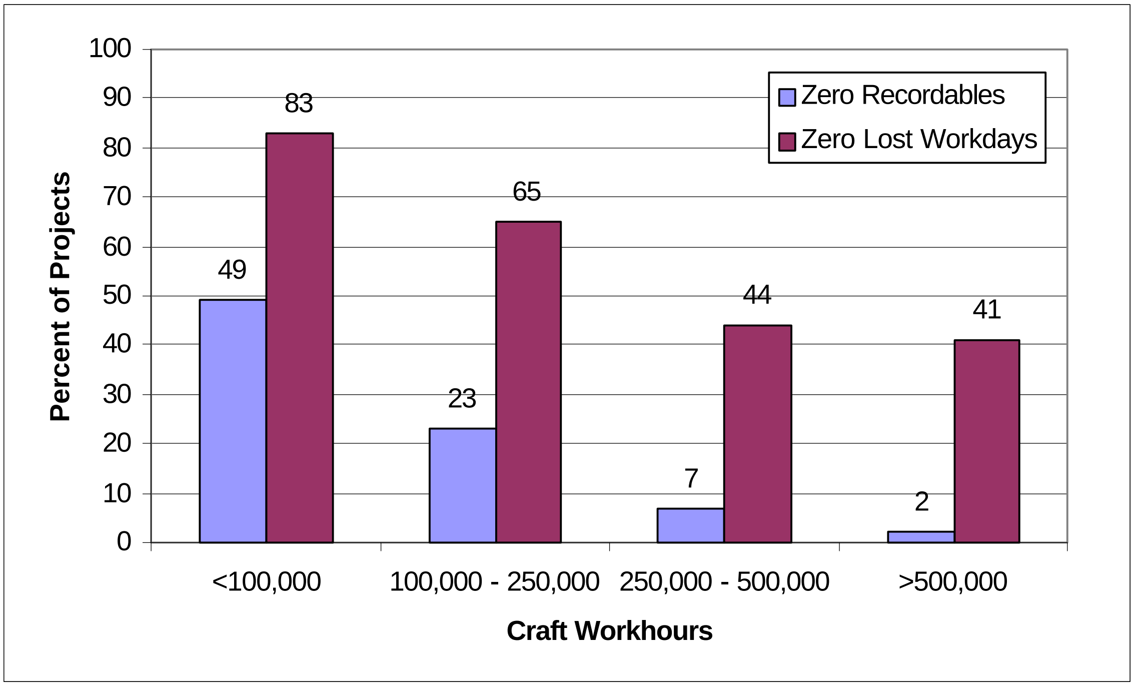
Figure 4-21 records zero accident performance by the nature of the project. Reference to the figure shows that zero accident performance varies considerably across the three types of projects. Grass roots projects have the poorest zero accident performance; only 15 percent achieved zero recordable incidents and only 48 percent achieved zero lost workday incidents. Additions had the highest percentage of projects achieving zero lost workday incidents (67 percent), but performed rather poorly in terms of zero recordable incidents (only 19 percent). On the other hand, modernization projects achieved zero lost workday incidents 65 percent of the time and zero recordable incidents 33 percent of the time. Because a large proportion of modernization projects are relatively small (e.g., less than $15 million total installed cost), other things being equal, they have a higher likelihood of achieving zero accident performance.

Figure 4-21. Zero Accident Performance by Nature of Project

Figure 4-22 records zero accident performance by craft work hours. Reference to the figure shows a clear pattern, as project craft work hours go up, zero accident performance goes down. This outcome is to be expected, since it reflects the increasing difficulty of achieving zero recordable/lost workday incidents on large and complex projects. However, it is encouraging to see that 83 percent of all projects having less than 100,000 craft workhours (i.e., smaller projects) and 41 percent of all projects having 500,000 or more craft workhours (i.e., very large projects) result in zero lost workday incidents. Also, nearly half of all projects having less than 100,000 craft workhours (i.e., smaller projects) result in zero recordable incidents.

Figures 4-23 through 4-27 record information on the degree to which respondents make use of the CII safety practice. The CII safety practice, also referred to as Zero Accidents, is one of 23 CII practices. CII has performed considerable research on these practices and has defined indices for many of them, including the safety practice. These indices are scored from 0 to 10, with a score of 0 indicating no use of the practice and a score of 10 indicating extensive or full use of the practice.

Figure 4-22. Zero Accident Performance by Craft Workhours



The CII Zero Accidents safety practice consists of 18 elements. Five of these elements were designated as high-impact elements. Although CII research concluded that these elements were the most significant, implementing them alone will not necessarily result in safety performance approaching excellence.[53] Therefore, CII recommends institutionalizing a comprehensive basic safety process using the 170 safety techniques. The five high-impact elements are: (1) pre-project/pre-task planning for safety; (2) safety orientation and training; (3) written safety incentive program; [54] (4) alcohol and substance abuse program; and (5) accident/incident investigations. These five elements and their key techniques are summarized in Exhibit 4-1. A brief description of each element is

[53] Construction Industry Institute, *Zero Injury Techniques*, p.6.

[54] Within the occupational safety and health community, there is much concern over the merits of safety incentive programs. An OSHA-sponsored review of the literature concluded that there was no basis for employer claims that their safety incentives programs actually make workplaces safer (see, *BNAC Safety Communicator* (Winter 1999): p.5.). As reported in the *BNAC Safety Communicator*, OSHA's review of safety incentive programs also found that there is "often a chilling effect when the programs discourage the reporting of injuries and illnesses." These findings, coupled with a potential bias towards under-reporting by small construction establishments, raise a concern about the appropriateness of the CII Zero Accidents safety practice for smaller construction establishments. Although CII research has shown safety incentive programs to be a high-impact element (see, *Zero Injury Techniques*, p.4.), more research is needed to ascertain how these programs impact the subcontractor tier—especially smaller subcontractors.

given in the text that follows to provide a better understanding of the CII philosophy on safety and its Zero Accident safety practice. Readers interested in a more detailed description of the Zero Accidents safety practice are referred to the CII source document.

Pre-project/pre-task planning for safety includes a systematic review of the scope of the project or task focused on identifying potentially hazardous tasks, conditions, toxic or hazardous materials, or special training or procedures required to perform work. Safety orientation and training activities include both the owner and the contractor. The orientation is the “safety first” step given an employee before going out on the job site. It is given to all personnel and visitors who wish to spend field time on the project site. Incentives for safety performance may be stand-alone or can be part of a broader project incentive program that includes cost, schedule, and quality. Drug and alcohol abuse programs are often used in the construction industry. The investigation of an accident or incident (i.e., near miss) sends a message of management concern to all employees on a project. Failure to investigate also sends a message; one of management disinterest and apathy toward worker safety. CII research has shown that owners and contractors who are able to achieve zero or near zero injuries on their projects have rigorous procedures on all aspects of accident investigations.[55] Such investigations find the root causes of accidents, result in recommendations for accident prevention, and insure that follow-up actions do occur.

The procedure for measuring the use of the CII Zero Accidents practice is summarized in Exhibit 4-2. A sample calculation based on responses taken from the Benchmarking and Metrics questionnaire is shown in Exhibit 4-3. The entries in Exhibit 4-2 are extracted from the CII Benchmarking and Metrics Questionnaire. Each row in Exhibit 4-2 is numbered and corresponds to a question. The number of the question indicates its placement within the CII Benchmarking and Metrics questionnaire.[56] Each question has two or more possible responses. Each response has a potential value, which reflects its relative importance. Responses to the questions are indicated by shaded cells in Exhibit 4-3. Each response is entered in the appropriate row under the "score" column. The sample calculation results in a raw score of 11.67. The raw score is normalized by dividing it by 1.6. This produces a value for the safety practice index of 7.29. The raw score must be normalized to insure that the value of the safety practice index lies between 0 and 10. It is important to note that the questions in the CII Benchmarking and Metric Questionnaire do not cover all 18 elements of the Zero Accidents safety practice. Since the questions in the Questionnaire focus primarily on the five high-impact elements, it is likely that the current procedure for computing the safety practice use index overestimates the degree to which respondents use the Zero Accidents safety practice. NIST has recommended that CII expand the list of safety-related questions in the Questionnaire to capture the full range of elements in the Zero Accidents safety practice.

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[55] Construction Industry Institute. *Zero Injury Techniques,* p. 20.

[56] The first question on the CII questionnaire dealing with the Zero Accidents safety practice is question 19. The previous 18 questions collect background information on the project. This includes company contact information and information on: type of project (e.g., chemical manufacturing), project nature (e.g., new construction), project budget and actual cost, the planned and actual schedule, scope changes, field rework, and craft workhours and injury data.

Figures 4-23 through 4-27 are organized by major group heading. They use the same major group headings and sequencing as employed in Figures 4-18 through 4-22. In each figure, the vertical axis records the degree of practice use. The degree of practice use is recorded via the computed value of the safety practice index, which ranges from 0 to 10. Within each figure, the CII data subsets for each major heading are listed on the horizontal axis. The degree of safety practice use is displayed by using a "modified" box plot—a form of stacked-bar chart—that shows all four quartiles of data. The darkly shaded box at the top of each plot depicts the upper quartile (i.e., the highest scoring quartile of projects). The middle two boxes represent the interquartile range (i.e., the middle 50 percent of the projects). The upper interquartile records the top half of the projects in the interquartile range; it is designated by light shading. The lower interquartile records the bottom half of the interquartile range; it is designated by light/moderate shading. The moderately shaded box at the bottom of each plot depicts the lower quartile (i.e., the lowest scoring quartile of projects). The small solid square on each plot indicates the mean value for the index of safety practice use for each CII data subset.

Exhibit 4-1. CII Zero Accidents Safety Practice: The Five Zero Injury Elements and Their Most Significant Techniques

1. **Safety Pre-Project/Pre-Task Planning**
   - Safety Goals
   - Safety Person/Personnel
   - Pre-Placement Employee Evaluation
   - Task Hazard Analysis
   - Task Training

2. **Safety Orientation and Training**
   - Site Orientation
   - Owner Involved in Orientation
   - Safety Policies and Procedures
   - Project Specific Orientation
   - Formal Safety Training

3. **Written Safety Incentive Program**
   - Cents per Hour for Workers
   - Spot Cash Incentives Used with Workers
   - Milestone Cash Incentives Given to Workers
   - End of Project Incentives Given to Workers

4. **Alcohol and Substance Abuse Program (ASAP)**
   - Screening Done for Alcohol and Drugs
   - Screening Conducted at Random
   - Inspections for Contraband Conducted
   - Post Accident Screening Done for All Employees
   - All Project Contractors Have ASAPs

5. **Accidents/Incidents Investigations**
   - Incidents Investigated
   - Accidents Without Injury Investigated
   - Accidents Reported to Home Office
   - Project Accident Review Team Established for All Accidents or Incidents
   - Project Work Exposure Hours and Safety Statistics Reported to Home Office

Exhibit 4-2. CII Procedure for Calculating the Safety Practice Use Index

Question	Yes	No	Score
19. This project had a written site-specific safety plan.	1.00	0.00	
20. This project had a written site-specific emergency plan.	1.00	0.00	
21. This project had a site safety supervisor.	1.00	0.00	
22. The site safety supervisor for this project was full-time.	1.00	0.00	
23. This project had a written safety incentive program for hourly craft employees.	1.00	0.00	
24. Toolbox safety meetings were required.	1.00	0.00	
25. This project required prehire substance abuse testing of contractor employees.	1.00	0.00	
26. Contractor employees were randomly screened for alcohol and drugs.	1.00	0.00	

Question	Always	Sometimes	Seldom	Never	NA	Score
27. Substance abuse tests were conducted after an accident:	1.00	0.67	0.33	0.00	1.00	
28. Accidents were formally investigated:	1.00	0.67	0.33	0.00	1.00	
29. Near-misses were formally investigated:	1.00	0.67	0.33	0.00	1.00	
30. Senior management reviewed accidents:	1.00	0.67	0.33	0.00	1.00	
31. Safety was a high priority topic at all pre-construction and construction meetings:	1.00	0.67	0.33	0.00	1.00	
32. Safety records were a criterion for contractor/subcontractor selection:	1.00	0.67	0.33	0.00	1.00	
33. Pre-task planning for safety was conducted by contractor foremen:	1.00	0.67	0.33	0.00	1.00	
34. Jobsite-specific orientation was conducted for new contractor and subcontractor employees:	1.00	0.67	0.33	0.00	1.00	
TOTAL						
16 Questions, Maximum Score of 16 implies Divide total by 1.6 to scale to 0 - 10 point range						
Safety Practice Use Index						

Exhibit 4-3. Example of Safety Practice Use Index Calculation

Question	Yes	No	Score
19. This project had a written site-specific safety plan.	1.00	0.00	1.00
20. This project had a written site-specific emergency plan.	1.00	0.00	1.00
21. This project had a site safety supervisor.	1.00	0.00	1.00
22. The site safety supervisor for this project was full-time.	1.00	0.00	0.00
23. This project had a written safety incentive program for hourly craft employees.	1.00	0.00	1.00
24. Toolbox safety meetings were required.	1.00	0.00	1.00
25. This project required prehire substance abuse testing of contractor employees.	1.00	0.00	1.00
26. Contractor employees were randomly screened for alcohol and drugs.	1.00	0.00	0.00

Question	Always	Sometimes	Seldom	Never	NA	Score
27. Substance abuse tests were conducted after an accident:	1.00	0.67	0.33	0.00	1.00	1.00
28. Accidents were formally investigated:	1.00	0.67	0.33	0.00	1.00	0.67
29. Near-misses were formally investigated:	1.00	0.67	0.33	0.00	1.00	0.33
30. Senior management reviewed accidents:	1.00	0.67	0.33	0.00	1.00	0.67
31. Safety was a high priority topic at all pre-construction and construction meetings:	1.00	0.67	0.33	0.00	1.00	1.00
32. Safety records were a criterion for contractor/subcontractor selection:	1.00	0.67	0.33	0.00	1.00	0.00
33. Pre-task planning for safety was conducted by contractor foremen:	1.00	0.67	0.33	0.00	1.00	1.00
34. Jobsite-specific orientation was conducted for new contractor and subcontractor employees:	1.00	0.67	0.33	0.00	1.00	1.00
TOTAL						11.67
16 Questions, Maximum Score of 16 implies Divide total by 1.6 to scale to 0 - 10 point range						
Safety Practice Use Index						**7.29**

Combined owner and contractor data for safety practice use are presented in Figure 4-23. This figure demonstrates that ***all projects report some use of the safety practice*** (i.e., the minimum value of the safety practice index is 2.3). The mean, shown as a small black square, indicates that the safety practice is used heavily—the safety practice index averages 8.5 on a scale of 0 to 10. The median value of the safety practice index is 8.75 (e.g., the 50 percent of the projects that make heavy use of the safety practice produce values of the safety practice index that equal or exceed 8.75 on a scale of 0 to 10). Note that the greatest variability in safety practice use is in the lower quartile, which ranges between the minimum value of the safety practice index (i.e., 2.3) and the value of the safety practice index corresponding to the 25th percentile (i.e., 7.7). Note that the upper quartile occupies a narrow band at the top of the chart. This is due in part to the fact that about half of the projects in the upper quartile made full use of the safety practice (i.e., their value of the safety practice index was 10.0).

Figure 4-24 presents data on safety practice use by each of the four industry groups. The figure shows considerable variation in the use of the safety practice across the four industry groups. The range of values for the safety practice index is smallest for light industrial projects and greatest for heavy industrial projects. However, on average, heavy industrial projects make the most extensive use of the safety practice and building projects make the least extensive use of the safety practice. Note that the means and the medians are nearly identical to each other for three of the four industry group data subsets (e.g., the mean value and the median value of the safety practice index for building projects are nearly equal). The clear exception to this pattern is the category of heavy industrial projects. Reference to the figure reveals that at least 25 percent of all heavy industrial projects reported full use of the safety practice. Thus, the entire upper quartile for heavy industrial projects is collapsed into a single value of the safety practice index of 10.0. Note also that the median value of the safety practice index for heavy industrial projects equals or exceeds the 75th percentile for each of the other three industry group data subsets.

Project cost and safety practice use tend to be positively correlated (i.e., as project cost goes up, the degree to which the safety practice is used tends to go up). Figure 4-25 presents data on safety practice use by cost category. Reference to the figure shows considerable variation in safety practice use across the four cost categories. However, a clear relationship between project cost and safety practice use is present. Consider first the value of the safety practice index equal to the 25th percentile (i.e., the point at which the lower quartile meets the lower interquartile) for each cost category data subset. As project cost goes up (i.e., moving from left to right across the four cost category data subsets), the value of the 25th percentile increases steadily. A similar, though less well-defined, upward progression is also present for the mean, the median, and the 75th percentile. Also note that for projects costing $100 million or more, the entire upper quartile is collapsed into a single value of the safety practice index of 10.0.

Figure 4-23. Safety Practice Use for All Projects

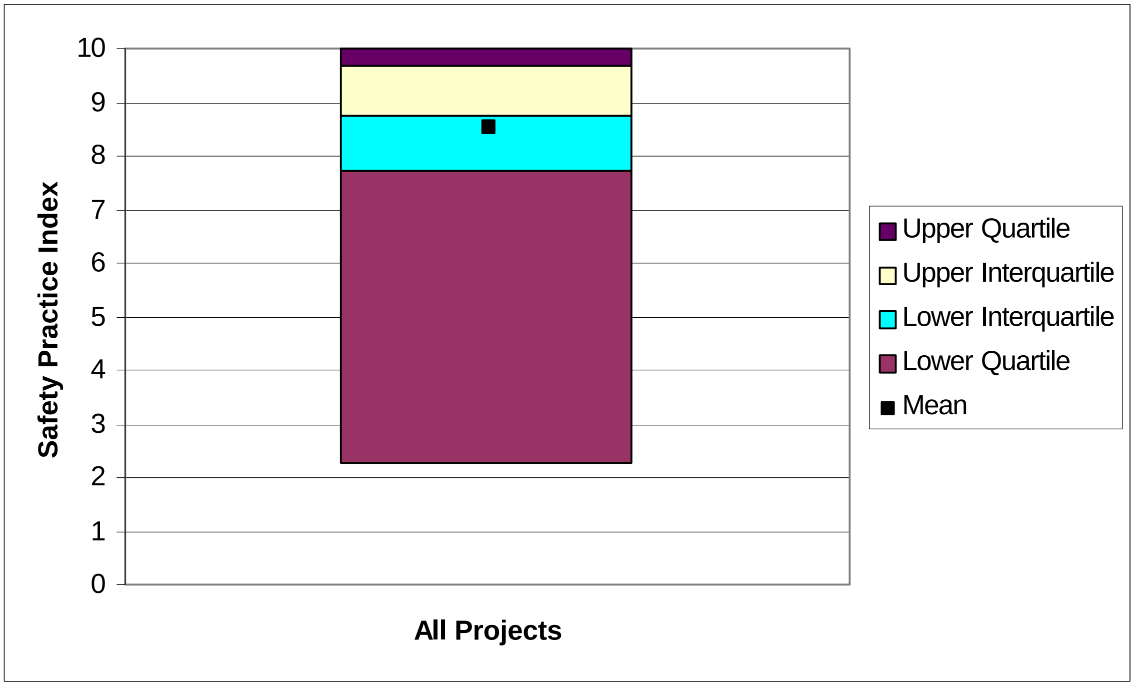


Figure 4-24. Safety Practice Use by Industry Group

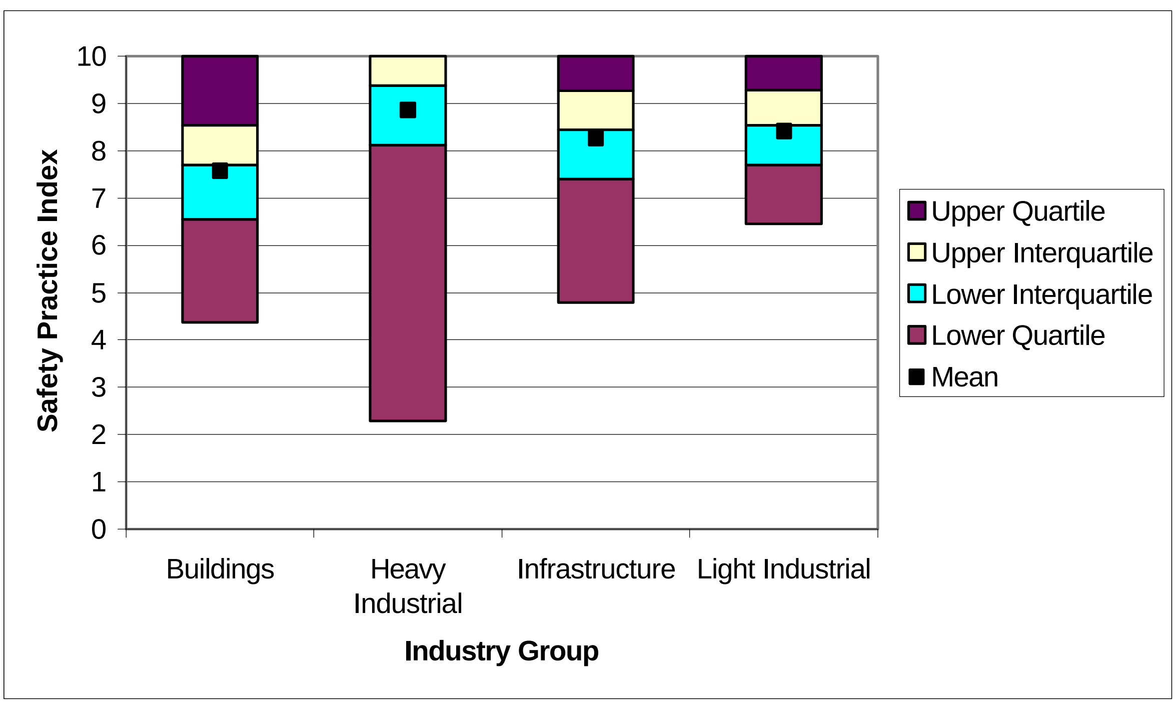


Figure 4-25. Safety Practice Use by Cost Category

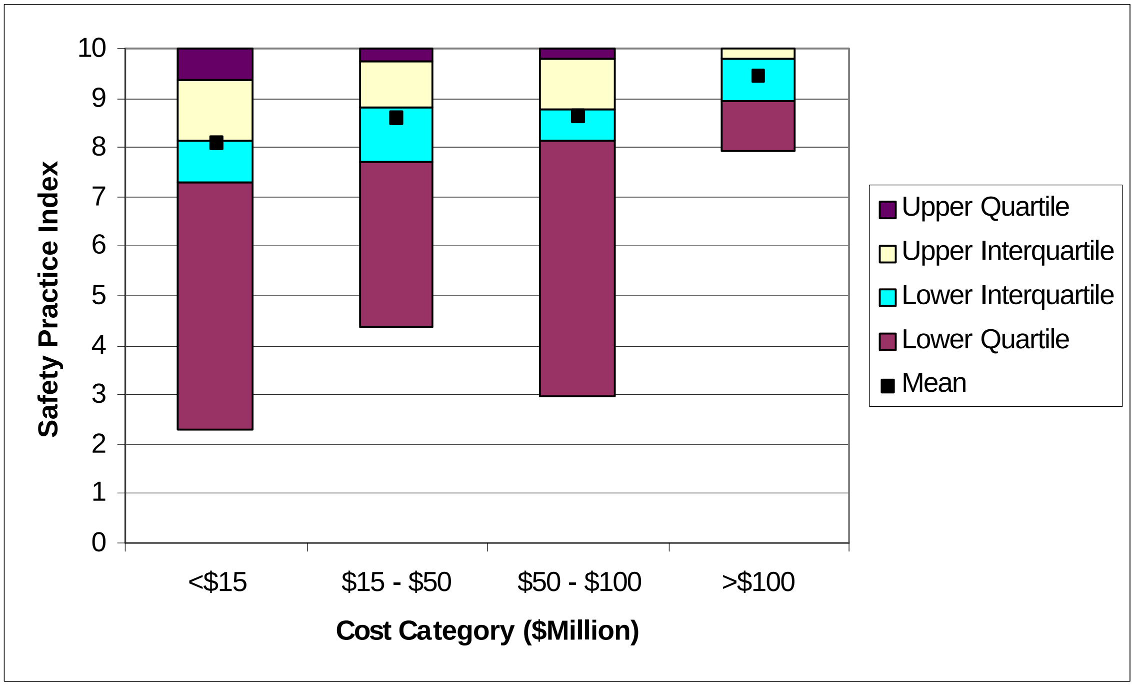


Figure 4-26 presents data on safety practice use by the nature of the project. The figure shows less variation in the degree of safety practice use across the three data subsets as was seen across the two previous major group data subsets (see Figures 4-24 and 4-25). Although grass roots projects exhibit less variability in the degree of use of the safety practice than the other two types of projects, the mean values of the safety practice index for each of the three types of projects are nearly equal.

Craft workhours and safety practice use tend to be positively correlated (i.e., as craft workhours go up, the degree to which the safety practice is used tends to go up). Figure 4-27 presents data on safety practice use by craft workhours. Reference to the figure shows considerable variation in safety practice use across the four craft workhour categories. However, a clear relationship between craft workhours and safety practice use is present. Basically, the discussion given below follows the same pattern as for the relationship between project cost[57] and safety practice use. Consider first the value of the safety practice index equal to the 25th percentile (i.e., the point at which the lower quartile meets the lower interquartile) for each craft workhour category data subset. As craft workhours go up (i.e., moving from left to right across the four craft workhour category data subsets), the value of the 25th percentile increases steadily. A similar, though less well-defined, upward progression is also present for the mean, the median, and the 75th percentile. Also note that for projects having 500,000 craft workhours or more, the entire upper quartile is collapsed into a single value of the safety practice index of 10.0.

[57] Craft workhours and project cost tend to be highly positively correlated. Thus, the basis for the two sets of relationships—safety practice use versus project cost/craft workhours—is essentially the same.

Figure 4-26. Safety Practice Use by Nature of Project

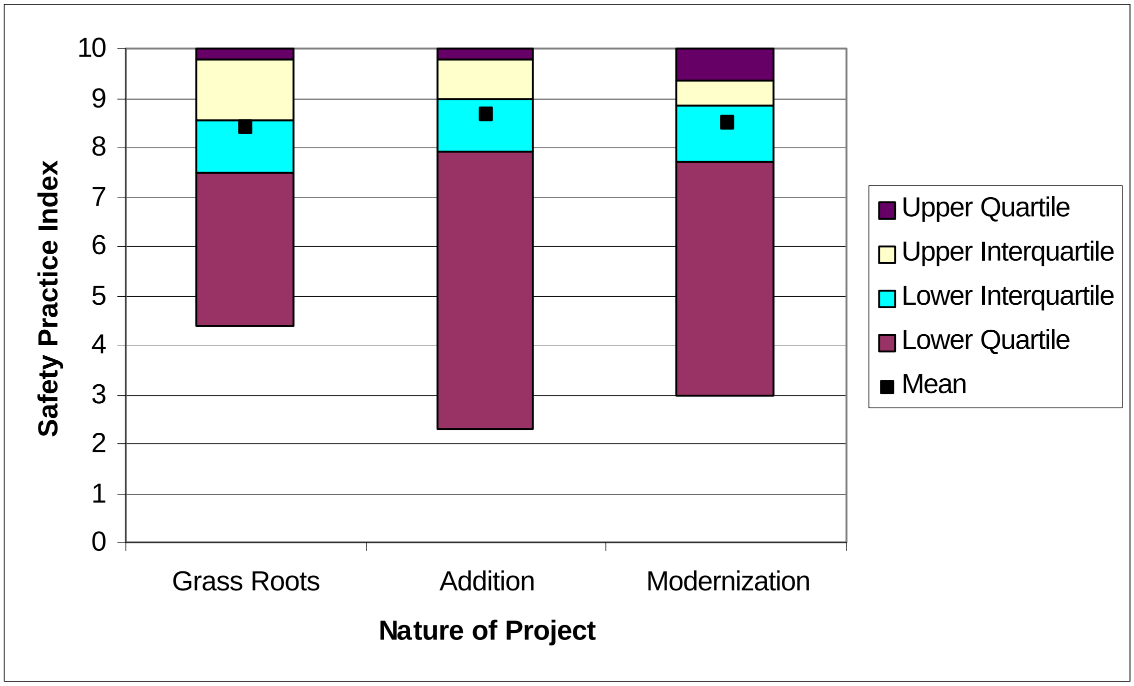
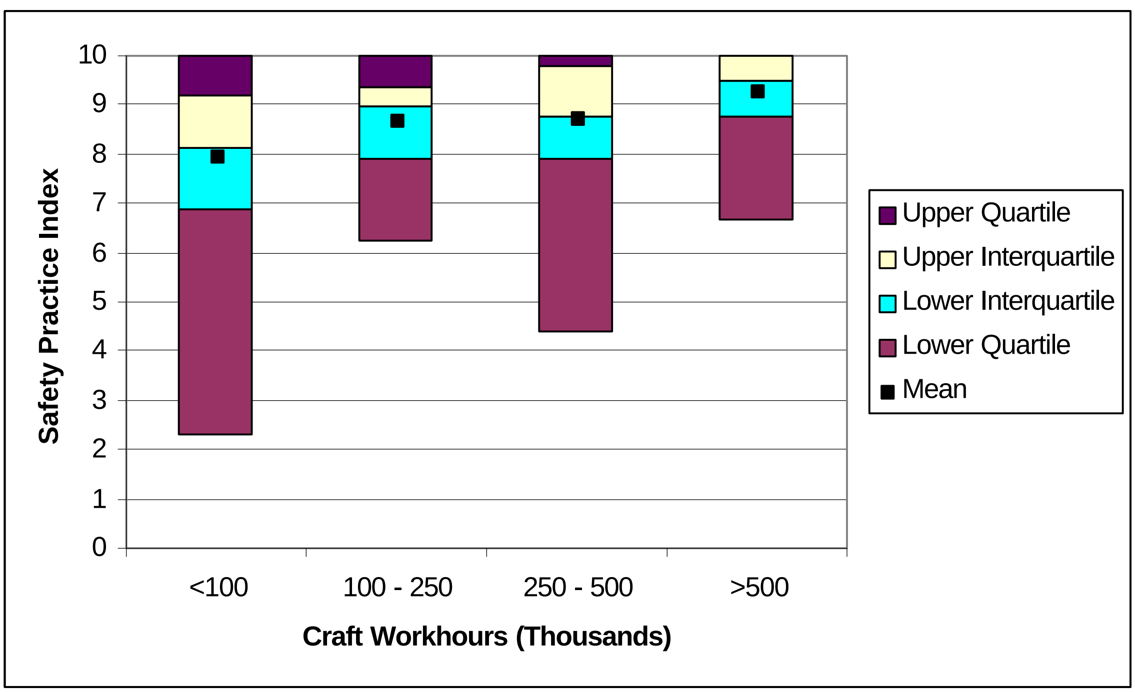


Figure 4-27. Safety Practice Use by Craft Workhours



Figures 4-28 through 4-43 illustrate the relationship between safety practice use and the two key safety metrics—the RIR and the LWCIR. Figures 4-28 through 4-35 illustrate the relationship between safety practice use and the calculated values of the RIR. Figures 4-36 through 4-43 illustrate the relationship between safety practice use and the calculated values of the LWCIR.

As has been done throughout this section, the figures are organized by major heading/ data subset. However, due to data limitations, it was necessary to modify the data subset sequence from the sequence used earlier in this section. This step was necessary to ensure that each data subset quartile contained at least 20 projects—the minimum number from which meaningful statistics could be calculated. For example, because there were relatively few projects in the buildings, infrastructure, and light industrial industry group categories, the only industry group for which relationships are presented is the heavy industrial category. Similarly, it was necessary to combine data from the $50 million to $100 million cost category and the >$100 million cost category to form a new category that satisfied the data requirements. The new cost category is designated by >$50 million.

In each figure, the vertical axis records the calculated value of the RIR or of the LWCIR for the data subset under analysis. To help in interpreting the results presented in the figures, lower values of either the RIR or the LWCIR are considered more desirable. The horizontal axis provides information on safety practice use. The horizontal axis is divided into four quartiles. The four quartiles span the entire range of the calculated values of the safety practice use index for all projects contained in the data subset under analysis. The quartiles measure the degree to which these projects have made use of the safety practice. The calculated value of the practice use index is used to rank order all projects contained in the data subset under analysis from lowest use to highest use. The four quartiles are: (1) the lower quartile (i.e., the bottom 25 percent of practice use among all projects contained in the data subset under analysis); (2) the lower interquartile (i.e., projects with practice use index values between the 25^{th} and 50^{th} percentiles); (3) the upper interquartile (i.e., projects with practice use index values between the 50^{th} and 75^{th} percentiles); and (4) the upper quartile (i.e., the top 25 percent of practice use). The lower interquartile and the upper interquartile taken together are equivalent to the interquartile range. The mean value of either the RIR or the LWCIR is plotted as a square (■) on each figure for each safety practice use quartile.

Figure 4-28 records the relationship between the use of the safety practice and the RIR for all owner and contractor projects combined. Reference to the figure demonstrates that the mean value of the RIR within each safety practice use quartile declines steadily (i.e., moving from left to right across the four safety practice use quartiles). Projects making the least use of the safety practice experienced on average an RIR of 7.68, whereas those projects making the most use of the safety practice had an RIR of 2.81. Projects in the lower interquartile for safety practice use had an RIR of 6.04. Projects in the upper interquartile for safety practice use had an RIR of 3.58. Thus, even modest increases in safety practice use for projects within the interquartile range are able to generate a significant reduction in the mean value of the RIR.

Figure 4-28. Safety Practice Use vs. Recordable Incidence Rate for All Projects

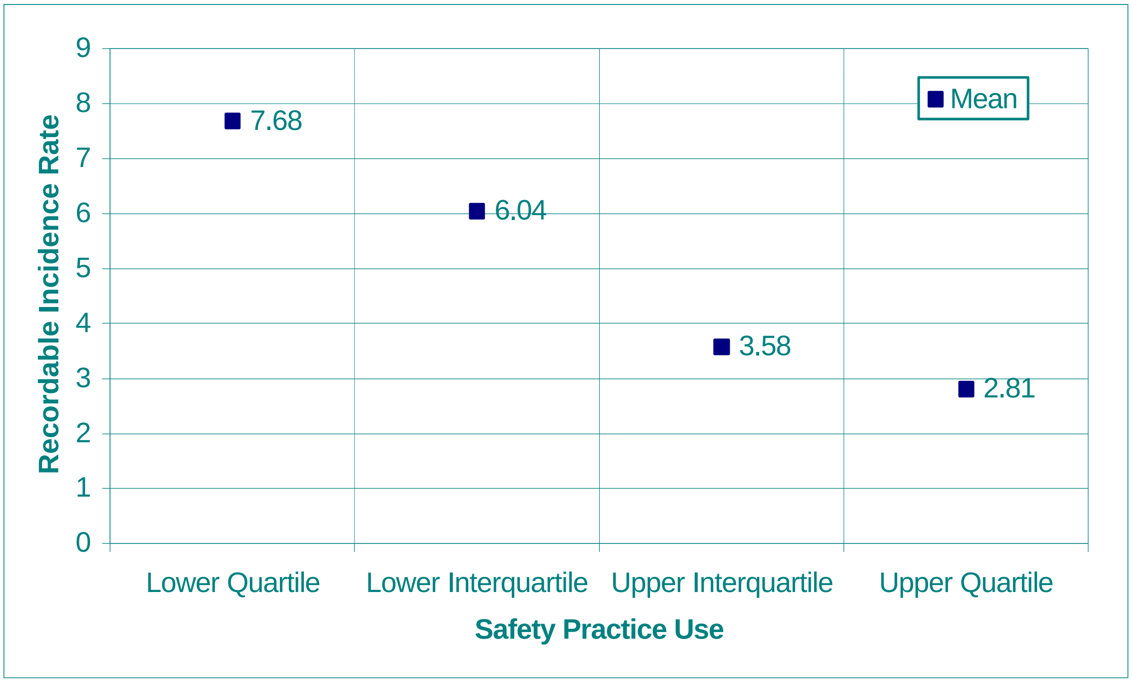


Figure 4-29 shows an even more pronounced relationship between use of the safety practice and the RIR for heavy industrial projects than was seen for all projects. Specifically, heavy industrial projects making the least use of the safety practice had an RIR of 7.99, whereas those projects making the most use of the safety practice had an RIR of 2.61. Thus, on average, moving from the lower safety practice use quartile to the upper safety practice use quartile reduces the RIR by a factor of three.

Figure 4-30 illustrates the relationship between the use of the safety practice and the RIR for projects costing less than $15 million. This figure demonstrates the same basic relationship as was seen in Figures 4-28 and 4-29 with one important exception. Reference to the figure shows that the mean value of RIR for the lower interquartile is only marginally lower than for the lower quartile (i.e., 7.38 versus 8.01). However, once the value of the safety practice use index exceeds the median (i.e., moves into the upper interquartile), the mean value of the RIR drops from 7.38 to 3.88. Projects in the upper quartile had a mean value of the RIR equal to 1.81.

Figure 4-31 illustrates the relationship between the use of the safety practice and the RIR for projects costing between $15 million and $50 million. Figure 4-31 plots two measures of central tendency—the mean value and the median value—for each safety practice use quartile. The mean value is represented by a square (■); the median value is represented by a triangle (▲). Reference to the figure reveals that the median value of the RIR within each safety practice use quartile declines steadily, whereas the mean declines for only three of the four quartiles. This outcome is not uncommon, since it reflects the effect that a few high values of the RIR can exert on the mean.

Figure 4-29. Safety Practice Use vs. Recordable Incidence Rate for Heavy Industrial Projects

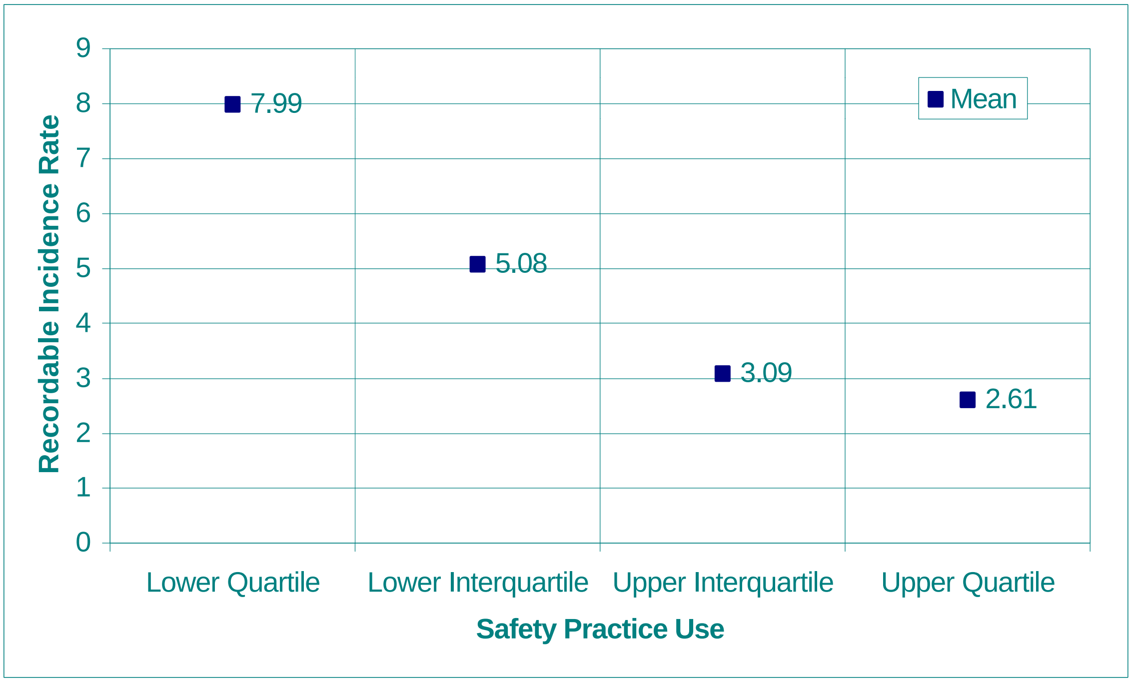


Figure 4-30. Safety Practice Use vs. Recordable Incidence Rate for Projects Costing Less Than $15 Million

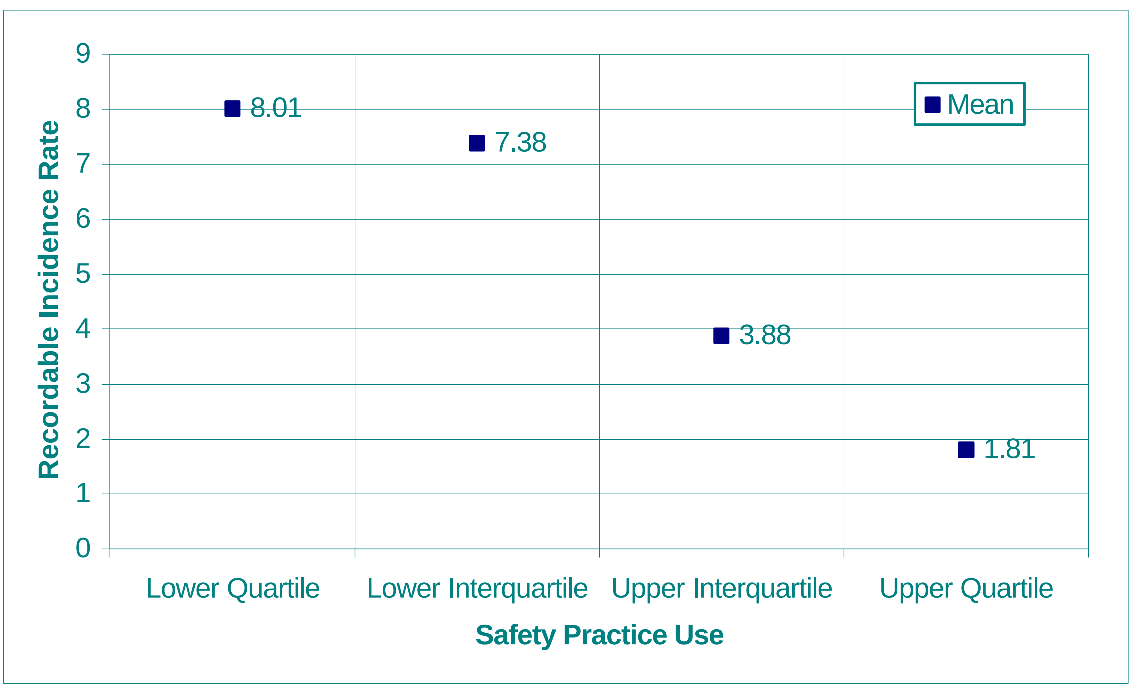


Figure 4-31. Safety Practice Use vs. Recordable Incidence Rate for Projects Costing Between $15 and $50 Million

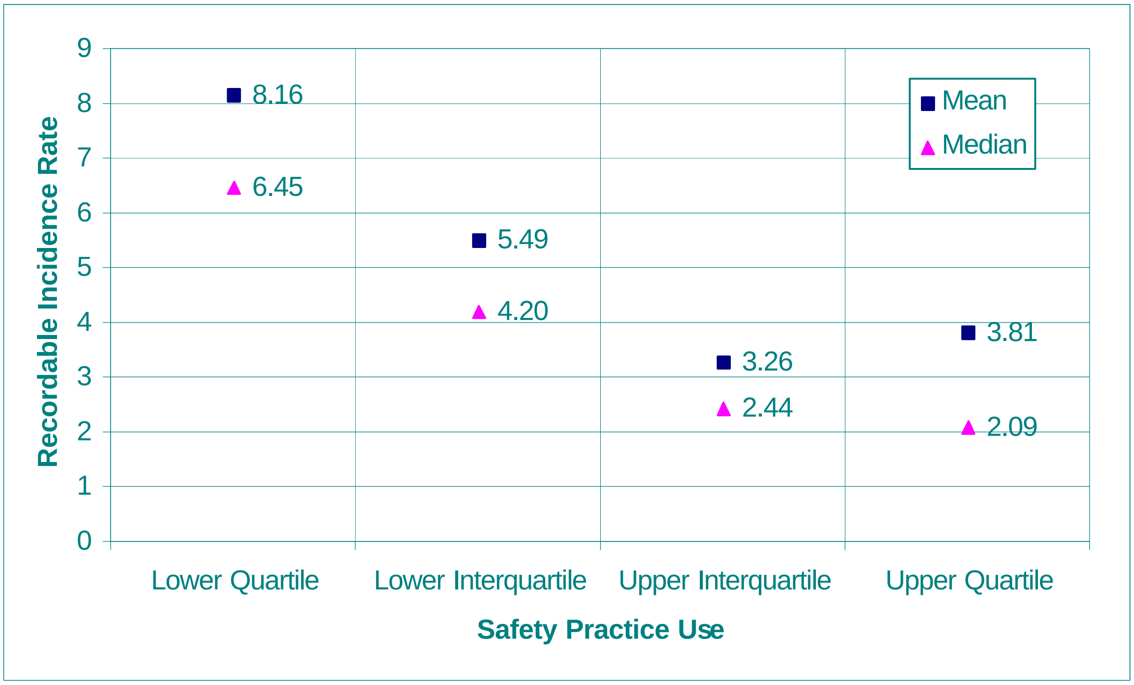


Figure 4-32 illustrates the relationship between the use of the safety practice and the RIR for projects costing more than $50 million. Reference to the figure reveals an interesting outcome. Namely, the mean value of the RIR for the lower safety practice use quartile is less than the mean value of the RIR for the lower interquartile (i.e., 4.36 versus 5.43). Although this outcome is a bit puzzling, Figure 4-32 still exhibits the same general relationship witnessed earlier (i.e., higher safety practice use produces a lower RIR). For example, the lower safety practice use quartile has a mean value of the RIR of 4.36 whereas the upper safety practice use quartile has a mean value of the RIR of 1.52.

Figures 4-33 through 4-35 illustrate the relationship between the use of the safety practice and the RIR classified by the nature of the project. Figure 4-33 covers grass roots projects. Figure 4-34 covers additions. Figure 4-35 covers modernization projects. All three figures exhibit the same general relationship between the use of the safety practice and the RIR. Namely, higher safety practice use produces a lower RIR. By and large, for each project type, the relationship between the use of the safety practice and the RIR is clear, with a strong trend downward. The one exception is associated with modernization projects. For modernization projects, the mean value for the RIR for the upper safety practice use quartile exceeds the mean value for the upper interquartile (i.e., 3.63 versus 2.78). This discrepancy may be due to the presence of several high values for the RIR in the upper quartile, which serve to "pull up" the mean value. Comparisons between the lower safety practice use quartile and the upper safety practice use quartile for modernization projects show a clear trend (i.e., a mean value of 8.86 for the RIR for projects in the lower quartile and a mean value of 3.63 for projects in the upper quartile).

Figure 4-32. Safety Practice Use vs. Recordable Incidence Rate for Projects Costing More Than $50 Million

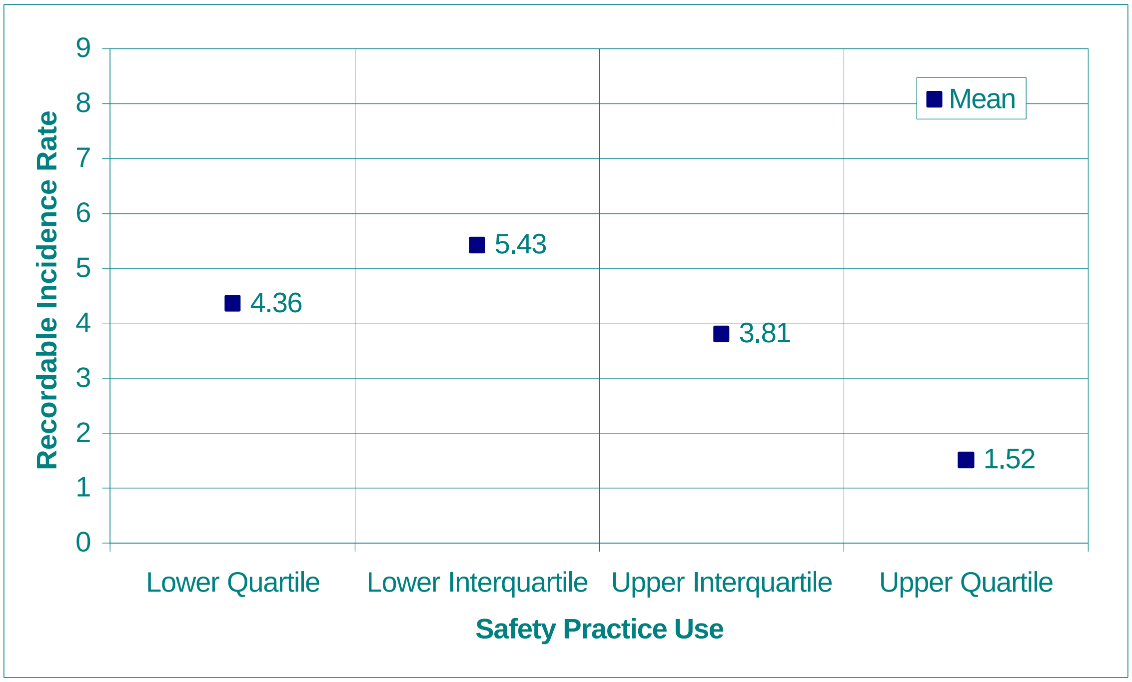


Figure 4-33. Safety Practice Use vs. Recordable Incidence Rate for Grass Roots Projects

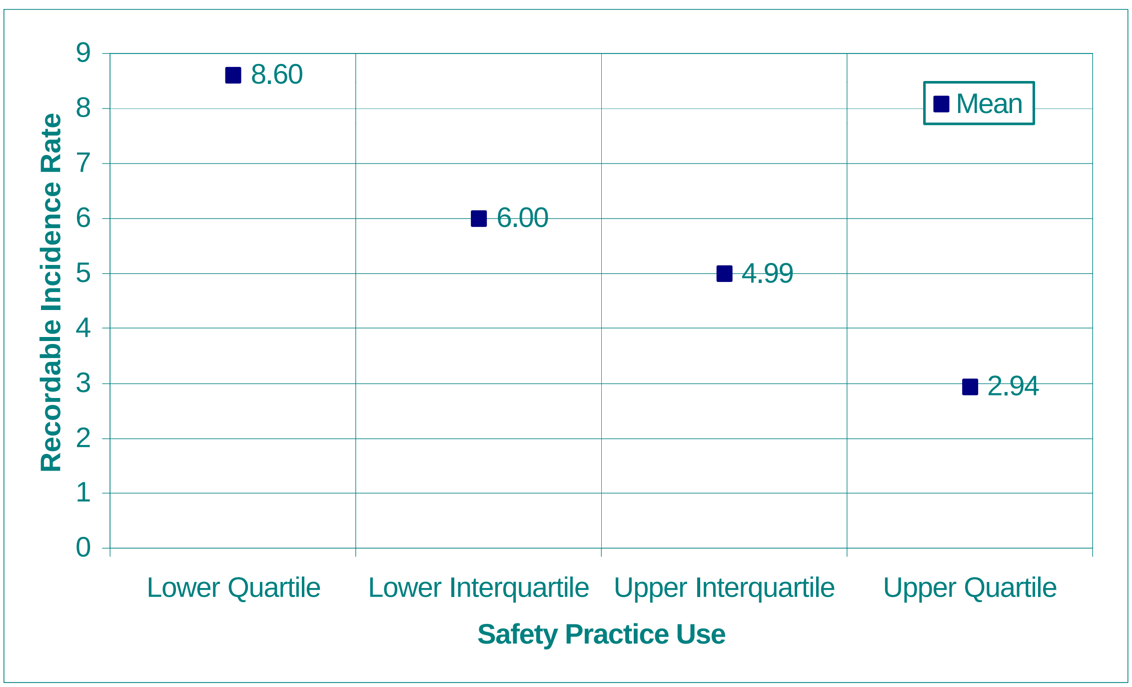


Figure 4-34. Safety Practice Use vs. Recordable Incidence Rate for Additions

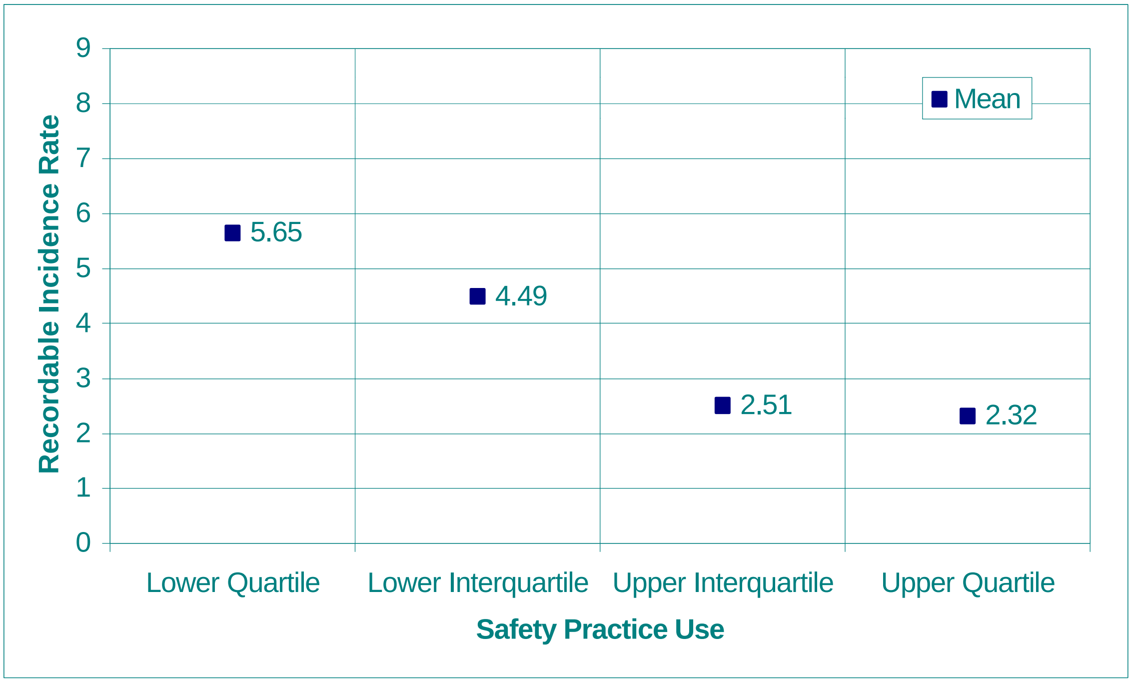


Figure 4-35. Safety Practice Use vs. Recordable Incidence Rate for Modernization Projects

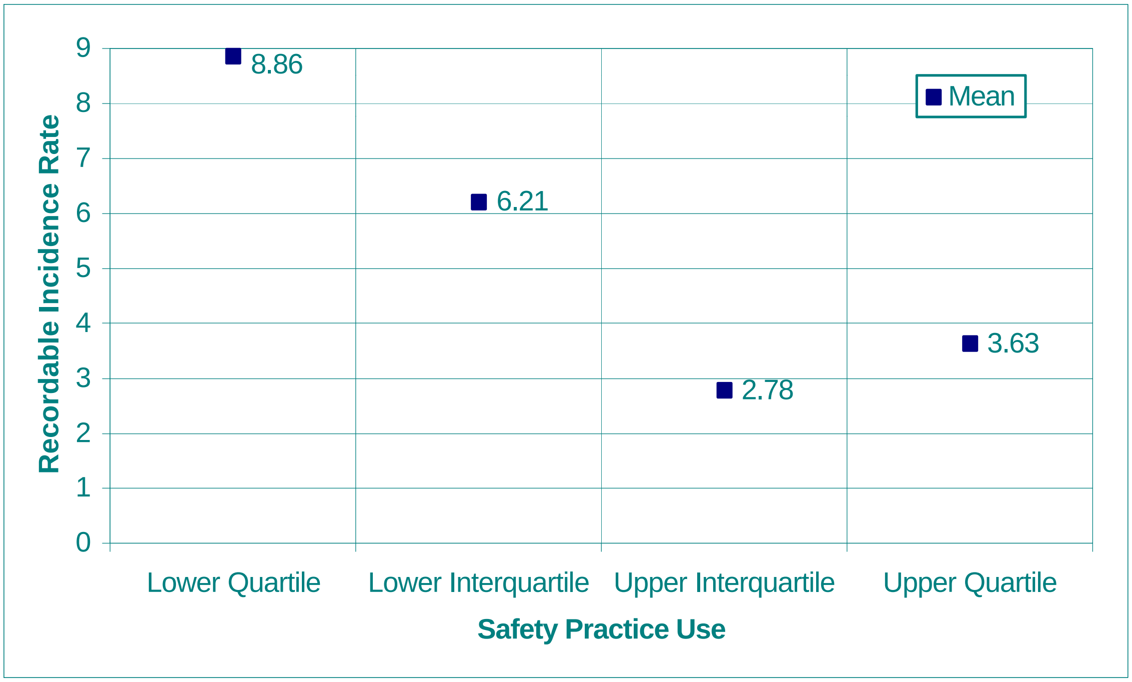


Figure 4-36 records the relationship between the use of the safety practice and the LWCIR for all owner and contractor projects combined. Reference to the figure demonstrates that the mean value of the LWCIR within each safety practice use quartile declines (i.e., moving from left to right across the four safety practice use quartiles). Projects making the least use of the safety practice experienced on average an LWCIR of 1.64, whereas those projects making the most use of the safety practice had an LWCIR of 0.18. While this difference is significant, the decline in the LWCIR is not steady. Reference to the figure shows that the LWCIR declines in a step-wise fashion. Specifically, the transition from the lower interquartile to the upper interquartile, is where the "step down" in mean value occurs. Projects in the lower interquartile for safety practice use had an LWCIR of 1.51. Projects in the upper interquartile for safety practice use had an LWCIR of 0.45. Thus, even modest increases in safety practice use for projects within the interquartile range are able to generate a significant reduction in the mean value of the LWCIR.

Figure 4-37 records the relationship between the use of the safety practice and the LWCIR for heavy industrial projects. Reference to the figure demonstrates that the mean value of the LWCIR within each safety practice use quartile declines in a step-wise fashion. The pattern seen in Figure 4-37—a slight decline, followed by a sharp decline, followed by a slight decline—is essentially the same as was seen in Figure 4-36.

Figure 4-38 records the relationship between the use of the safety practice and the LWCIR for projects costing less than $15 million. Reference to the figure demonstrates that the mean value for the LWCIR is a constant 1.16 across the two lower safety practice use quartiles (i.e., the bottom 50 percent of this subset of projects). For the three higher safety practice use quartiles, there is a clear—almost linear—downward trend. Note that the mean value for the upper safety practice use quartile is 0.05. Thus, for this class of projects, CII's goal of "Zero Accidents" is close to reality.

Figure 4-39 records the relationship between the use of the safety practice and the LWCIR for projects costing between $15 million and $50 million. Reference to the figure demonstrates a sharp drop off, followed by a gradual tailing off. For example, the mean value of the LWCIR for the lower safety practice use quartile is 2.28. Moving to the lower interquartile, reduces the mean value of the LWCIR by almost 50 percent to 1.15. The mean value for the LWCIR in the upper interquartile then declines less sharply to 0.51. Finally, the mean value for the LWCIR in the upper safety practice use quartile declines to 0.35.

Figure 4-40 records the relationship between the use of the safety practice and the LWCIR for projects costing more than $50 million. Reference to the figure reveals a steady decline in the mean value of the LWCIR as the use of the safety practice becomes more extensive. Specifically, the mean value of LWCIR declines from 1.02 to 0.82 to 0.33 to 0.07.

Figure 4-36. Safety Practice Use vs. Lost Workday Case Incidence Rate for All Projects

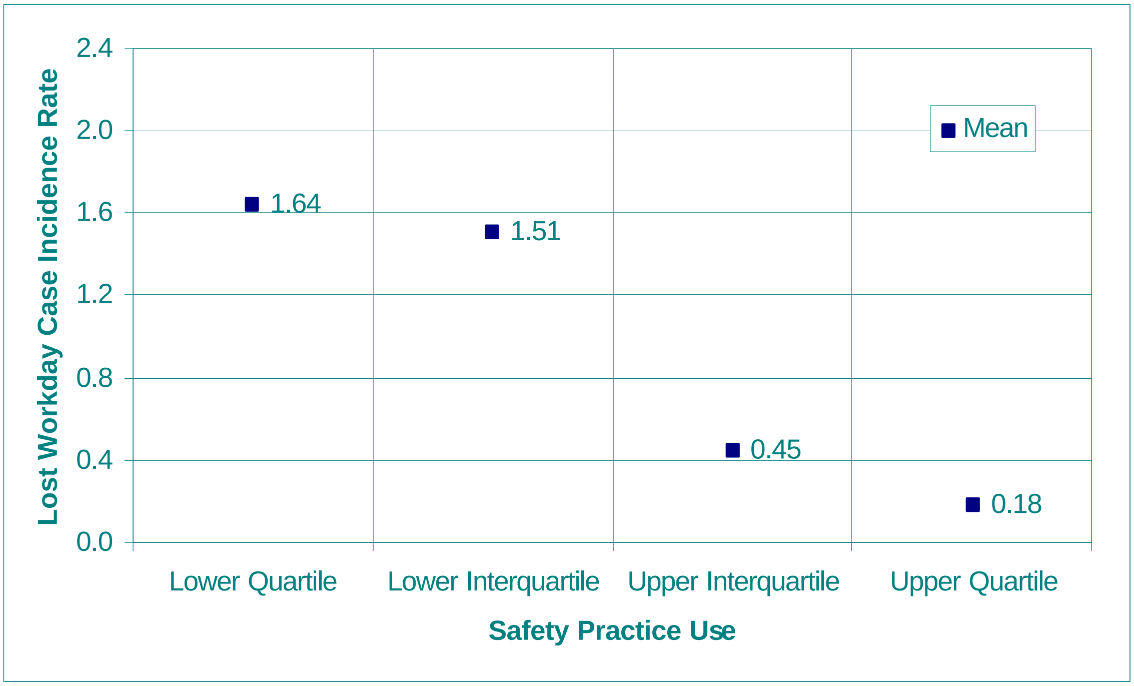


Figure 4-37. Safety Practice Use vs. Lost Workday Case Incidence Rate for Heavy Industrial Projects

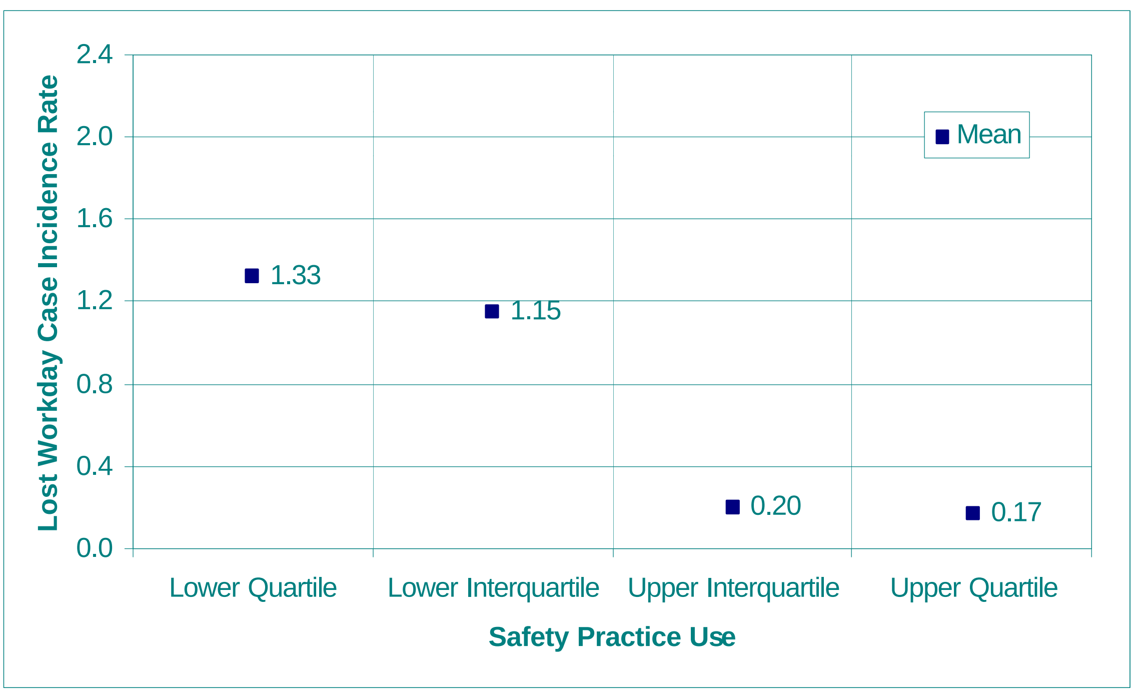


Figure 4-38. Safety Practice Use vs. Lost Workday Case Incidence Rate for Projects Costing Less Than $15 Million

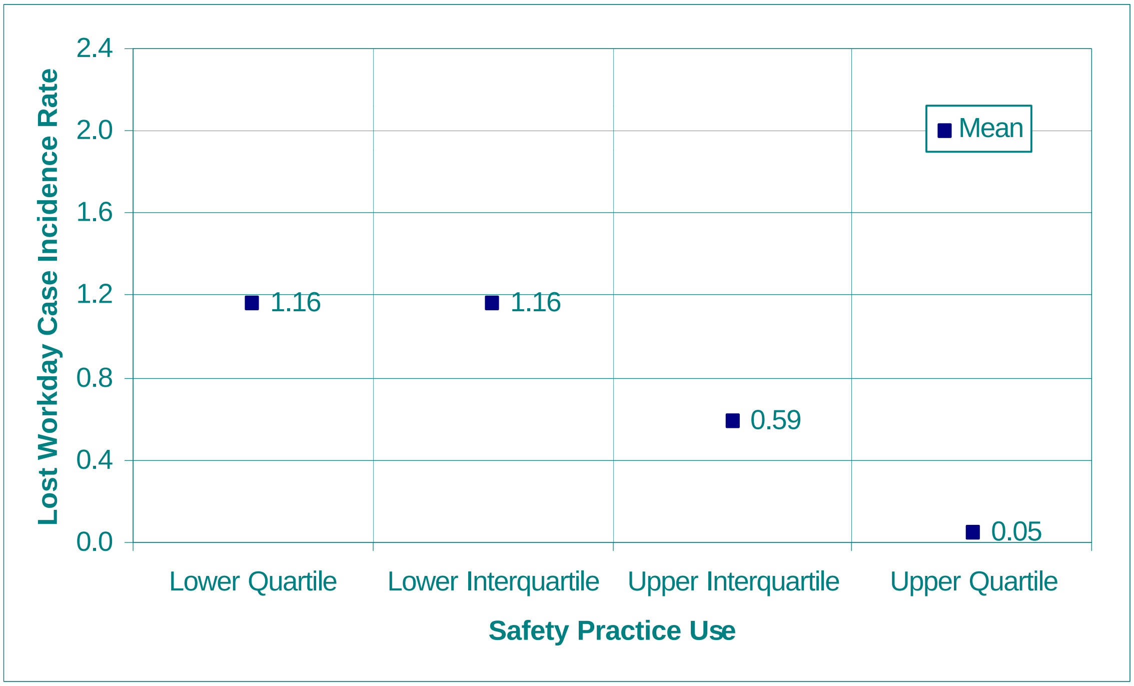


Figure 4-39. Safety Practice Use vs. Lost Workday Case Incidence Rate for Projects Costing Between $15 and $50 Million

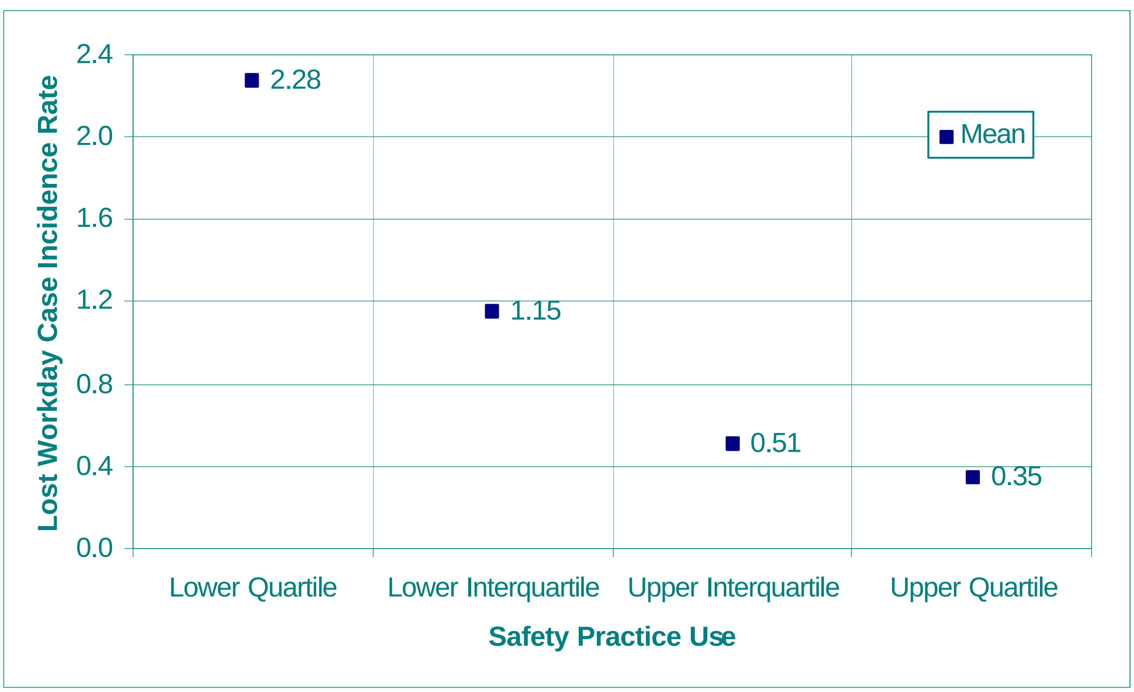
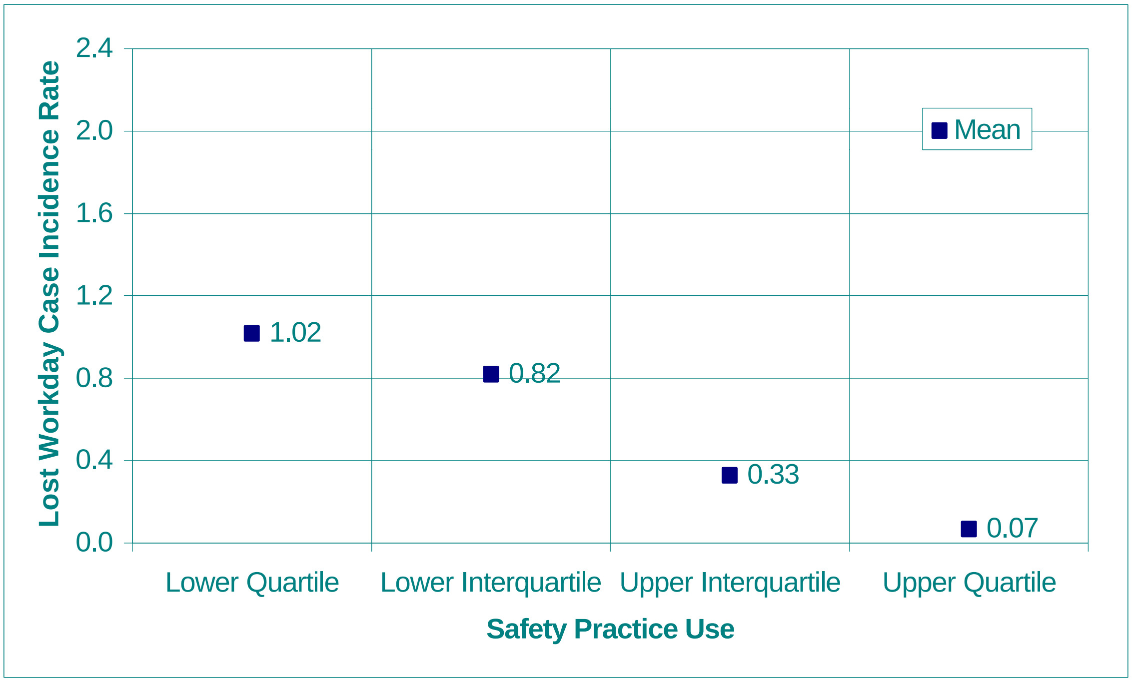


Figure 4-40. Safety Practice Use vs. Lost Workday Case Incidence Rate for Projects Costing More Than $50 Million



Figures 4-41 through 4-43 illustrate the relationship between the use of the safety practice and the LWCIR classified by the nature of the project. Figure 4-41 covers grass roots projects. Figure 4-42 covers additions. Figure 4-43 covers modernization projects. All three figures exhibit the same general relationship between the use of the safety practice and the LWCIR. Namely, higher safety practice use produces a lower LWCIR. By and large, for each project type, the relationship between the use of the safety practice and the LWCIR exhibits a clear trend downward. However, it is worth noting that for both grass roots projects and for additions, the mean value of the LWCIR experiences a slight "up tic" in moving from the lower safety practice use quartile to the lower interquartile. On the other hand, the three higher safety practice use quartiles exhibit a strong downward trend. For modernization projects, the mean value for the LWCIR for the upper safety practice use quartile exceeds the mean value for the upper interquartile (i.e., 0.53 versus 0.21). This discrepancy may be due to the presence of several high values for the LWCIR in the upper quartile, which serve to "pull up" the mean value. Comparisons between the lower safety practice use quartile and the upper safety practice use quartile for modernization projects show a clear trend (i.e., a mean value of 1.40 for the LWCIR for projects in the lower quartile and a mean value of 0.53 for projects in the upper quartile).

Figure 4-41. Safety Practice Use vs. Lost Workday Case Incidence Rate for Grass Roots Projects

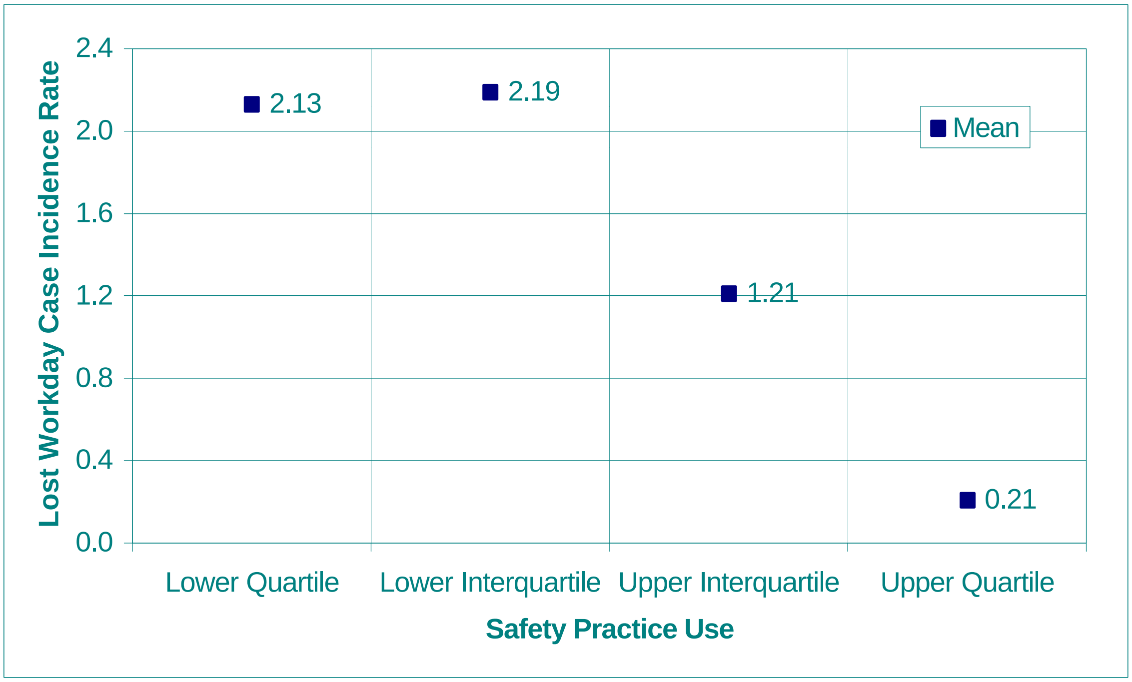


Figure 4-42. Safety Practice Use vs. Lost Workday Case Incidence Rate for Additions

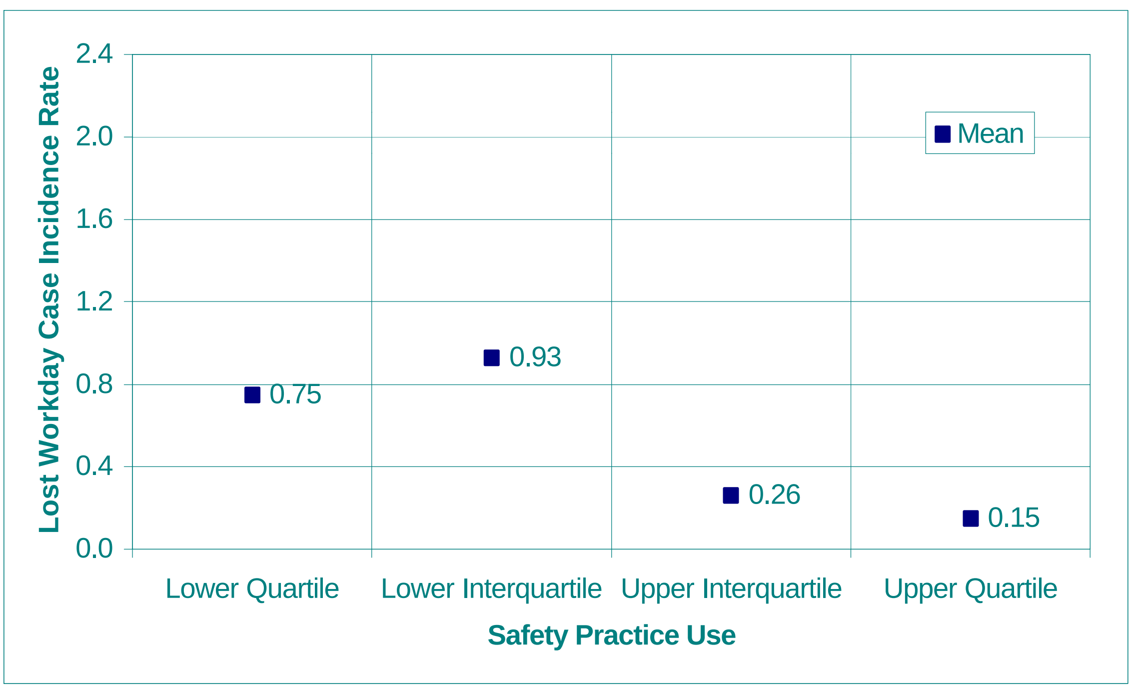
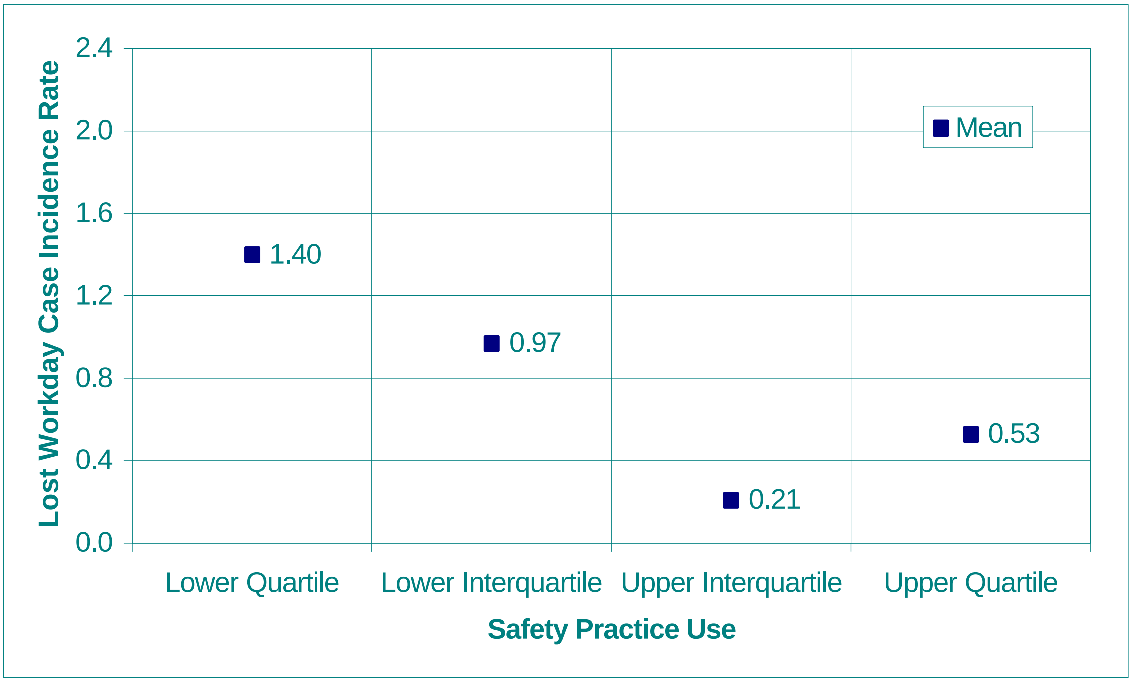


Figure 4-43. Safety Practice Use vs. Lost Workday Case Incidence Rate for Modernization Projects



4.3 Lessons Learned

The purpose of this section is threefold. First, it reviews some of the findings from the analysis of the CII data. A discussion of the limitations of this analysis is also included. Second, it reviews the role of safety practices in achieving the 50 % reduction in construction worker illnesses and injuries called for in National Construction Goal 7. Finally, it provides the basis for a number of recommendations for further research.

The results shown in Figures 4-28 through 4-43 are very encouraging. In all cases, the mean values of the RIR and of the LWCIR were reduced significantly—often by as much as 75 percent—as the degree of safety practice use moved from the lower quartile to the upper quartile. It is also very encouraging to note that even modest increases in the degree of safety practice use can translate into significant reductions in the mean values of the RIR and of the LWCIR. For example, moving from the lower interquartile to the upper interquartile often results in a reduction of the mean value of the RIR/LWCIR of 30 to 50 percent. Thus, among CII member companies, the more intensive use of the CII Zero Accidents safety practice can be expected to translate into significant reductions in construction-related injuries and illnesses.

Although these results offer great promise for improved safety performance among CII member companies, they can not be extrapolated to the construction industry at large. There are two reasons supporting the previous statement. First, with 18 elements and 170 techniques, the full CII Zero Accidents safety practice is better suited for use by larger construction companies. As was seen in Chapter 3, larger construction companies account for only a small fraction of construction industry employees. Larger construction companies also tend to have better safety performance (see Tables 3-4, 3-5, and 3-12). Second, the smallest projects in the CII Benchmarking and Metrics Database range between $2 million and $5 million. Within the construction industry, such projects would be considered large. Thus, there would likely be a fairly large number of subcontractors involved and coordination and communication among project participants would be more formal than in a smaller project. Such projects would also be more likely to have in place a formal safety practice governing all project participants. In addition, the prime contractors for such projects would be—relatively speaking—large construction firms. Therefore, given the preponderance of small construction firms in the construction industry, we are led to the hypothesis that the analysis presented in Section 4.2.2 does not imply that smaller construction firms using the CII Zero Accidents safety practice would achieve similar results.

Five different safety practices were introduced in Section 4.1. As was seen there, some of these practices were general in nature and some were designed for a special purpose. Because the construction industry is so diverse, there is a real need to adapt safety practices and their associated elements to meet the differing requirements and capabilities of smaller construction firms and special trade contractors—areas where other empirical studies have demonstrated relatively poorer safety performance.[58] Because "what gets measured gets managed," safety practices have a real role in reducing construction worker illnesses and injuries by 50 %. Lowery *et al* have shown that the risk of worksite injury is heightened for older workers, workers new to a site, workers on contracts for building construction and site development, workers on contracts with sizable overtime payroll, and contracts belonging to small and mid-sized companies. Furthermore, the occurrence of minor injuries increases the risk of having major injuries (i.e., lost workday cases) on the same contracts.[59] These topics are integral components in many of the elements in the safety practices introduced in Section 4.1.

The key to achieving National Construction Goal 7, and perhaps to even achieving the superior level of safety performance enjoyed by CII member companies, is a better understanding of implementation effectiveness. Two separate sets of analyses could help promote such an understanding. One such analysis could focus on administrative databases established for Owner Controlled Insurance Programs. Such databases address the "underreporting" problem discussed in Chapter 3 and provide the means for detailed, project-level analyses of safety performance.[60] Another promising area involves additional analyses with the CII Benchmarking and Metrics Database to determine to what degree smaller subcontractors use the CII Zero Accidents safety practice and how it affects their safety performance. These and other topics are explored in Section 5.2.

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[58] Lowery, Jan T., Joleen A. Borgerding, Boguang Zhen, Judith E. Glazner, Jessica Bondy, and Kathleen Kreiss. 1998. "Risk Factors for Injury Among Construction Workers at Denver International Airport," *American Journal of Industrial Medicine* (Vol. 34): pp. 113-120.
[59] *Ibid*., pp. 117-118.
[60] *Ibid*., p. 119.

5. Summary and Suggestions for Further Research

5.1 Summary

The Construction and Building Subcommittee of the National Science and Technology Council is developing baseline measures of current construction industry practices and measures of progress with respect to each of the seven National Construction Goals. The seven National Construction Goals are concerned with: (1) reductions in the delivery time of constructed facilities; (2) reductions in operations, maintenance, and energy costs; (3) increases in occupant productivity and comfort; (4) reductions in occupant-related illnesses and injuries; (5) reductions in waste and pollution; (6) increases in the durability and flexibility of constructed facilities; and (7) reductions in construction worker illnesses and injuries. Baseline measures and measures of progress are being produced for each of the four key construction industry sectors. The four sectors are: (1) residential; (2) commercial/institutional; (3) industrial; and (4) public works.

This report provides a detailed set of baseline measures for National Construction Goal 7 (reductions in construction worker illnesses and injuries). As such, it describes data sources, data classifications, and the metrics used to develop the baseline measures. Extensive use of charts and tables is made throughout this document to illustrate the process by which the baseline measures were developed. These baseline measures will assist in determining the success of actions taken to improve the competitiveness of the US construction industry.

Chapter 1 provides background information about the project, its purpose, and scope. Chapter 2 introduces the National Construction Goals and describes how a well-defined set of metrics is used to develop the baseline measures and measures of progress. Chapter 3 presents the baseline measures. These measures are based on data published by the Bureau of Labor Statistics (BLS). The BLS data cover both nonfatal construction worker illnesses and injuries and construction-related fatalities. Nonfatal illnesses and injuries are classified into three case types: (1) recordable; (2) lost workday; and (3) illness. BLS produces incidence rates for each case type. The incidence rates are : (1) the recordable incidence rate (RIR); (2) the lost workday case incidence rate (LWCIR); and (3) the illness incidence rate (IIR). BLS also produces incidence rates for fatalities. Chapter 4 introduces the concept of a safety practice and gives several examples of safety practices currently in use within the construction industry. An analysis of the impact of safety practice use on reducing nonfatal construction worker illnesses and injuries is then presented. This analysis is based on data provided to NIST by the Construction Industry Institute (CII). The chapter concludes with a discussion of why the aggressive use of safety practices is a key instrument in achieving the 50 percent reduction in construction worker illnesses and injuries set forth in National Construction Goal 7.

5.2 Suggestions for Further Research

The work for this document uncovered five areas of research that might be of value to government agencies and private sector organizations who are concerned about reducing construction worker illnesses and injuries. These areas of research are concerned with: (1) the dissemination of more detailed illness and injury data by the BLS that would facilitate the construction of sector-specific measures as opposed to general measures; (2) the development of an action plan for disseminating information on safety practices and for establishing guidelines on how to adapt safety practices for use by small and mid-sized construction firms; (3) the collection of additional project-level data to analyze the relationships between safety practice use and reductions in construction worker illnesses and injuries; (4) the role of the Construction and Building Subcommittee member organizations in promoting the achievement of National Construction Goal 7; and (5) the measurement and evaluation of progress toward achievement of National Construction Goal 7.

In order to be able to generate more useful baseline measures, detailed source information is required. As this document has shown, the BLS data are not made available in a form that is sufficiently detailed to permit the construction of definitive sector-specific measures for each of the four sectors defined by the Construction and Building Subcommittee. If the BLS were to make available a time series of statistics[61] for the RIR and the LWCIR for each of the four-digit Standard Industrial Classification (SIC) Codes in the construction industry (see Section A.2), it would be possible to better define baselines for each sector.

Because the vast majority of firms in the construction industry are small, research is needed on the efficacy and efficiency of the various safety practices and their associated elements. Specifically, which practices/elements work well (i.e., deliver results) and for which type of construction firm (e.g., small contractors involved in residential construction). Research aimed at determining why particular practices/elements work well can then be used to develop guidelines on how to adapt that practice and its associated elements to a particular type/size of construction firm or for a special requirement.

Information presented in Section 4.2 showing the relationship between the use of the CII Zero Accidents safety practice and the RIR and the LWCIR provides an indication of the potential of this practice for reducing construction-related injuries on large construction projects. More research and analysis is needed in order to better understand these relationships and to identify ways in which this understanding can be used to: (1) drive performance improvement on large projects; and (2) promote the use of appropriate safety elements/techniques by small and mid-sized subcontractors.

[61] The time series needs to include not only the key incidence rates (i.e., the RIR and the LWCIR) but also the number of recordable incidents, the number of lost workday incidents, and the total number of craft workhours for each four-digit SIC Code. This information is necessary to enable the supporting data associated with each four-digit SIC Code to be allocated to one of the four construction industry sectors in such a way that an incidence rate for each sector can be computed and checked against the supporting data.

The federal agencies comprising the Construction and Building Subcommittee are encouraged to take a leadership role in achieving National Construction Goal 7. As construction industry customers with research capabilities, the agencies are well positioned to promote both research on and the demonstration and dissemination of best practices for construction safety. Collaboration across agencies and with the private sector could provide a very real contribution to raising the level of safety performance nationwide. For example, agencies could take steps to encourage the use of project level reporting to track and promote safety performance on federally-supported construction projects. Such projects might also provide important research opportunities to further national understanding of construction hazards and how to best address them.

Finally, in order to be able to measure progress toward achievement of National Construction Goal 7, periodic reports need to be produced which re-visit the same data sources used to generate the original baselines, and refine or expand the original baselines as necessary to meet the changing needs of the construction industry stakeholders.

Appendix Overview of the Construction Industry

The construction industry is a key component of the US economy and is vital to the continued growth of the US economy. Investment in plant and facilities, in the form of construction activity, provides the basis for the production of products and the delivery of services. Investment in infrastructure promotes the smooth flow of goods and services and the movement of individuals. Investment in housing accommodates new households and allows existing households to expand or improve their housing. It is clear that construction activities affect nearly every aspect of the US economy. However, construction activities are also strongly affected by the health of the economy and the associated business cycle.[62]

This appendix provides a snapshot of the US construction industry. As such, it provides the context within which baseline measures are developed. The appendix contains three sections. Each section deals with a particular topic.

First, information on the value of construction put in place is provided to show the size of the construction industry and each of its four sectors--residential, commercial/ institutional, industrial, and public works. Second, information on the nature of construction activity for each sector of the industry is presented. The Standard Industrial Classification (SIC) Codes for the construction industry are introduced and described as a means for organizing construction activity. Information on the nature of construction activity includes breakouts between new construction activities, maintenance and repair activities, and additions and alterations. The challenge of developing annual estimates for each sector by nature of construction activity is described. Examples are given which demonstrate how different data sources result in major differences in a particular year's estimates. Third, information on employment in the construction industry is summarized and a series of employment-related statistics are presented. The SIC Codes for the construction industry are used as a means for organizing key employment-related information.

A.1 Value of Construction Put in Place

This section provides information on a key indicator of construction activity, the value of construction put in place. Data published by the US Bureau of the Census are used to establish the composition of construction expenditures by type of construction/function (e.g., non-residential/office building). These expenditures are then assigned to the four key construction industry sectors. The reference document used throughout this section is the **Current Construction Reports** series C30 publication *Value of Construction Put*

[62] Readers interested in learning more about construction statistics, their sources and interpretation, are referred to the document by Rogers (Rogers, R. Mark. 1994. *Handbook of Key Economic Indicators*. Burr Ridge, IL: Irwin Professional Publishing).

in Place.[63] A brief description of the "C30 report" follows. Special attention is given to the organization of the data in the C30 report and how these data map into the four key construction industry sectors. The section concludes with tabular and graphical summaries of the value of construction put in place.

Construction expenditures data are published monthly in the **Current Construction Reports** series C30 publication *Value of Construction Put in Place*. Construction expenditures refer to actual construction rather than planned or just initiated activity. It is noteworthy that the C30 report covers both private residential and non-residential construction activities and public sector construction activities.

The value of construction put in place is a measure of the value of construction installed or erected at a site during a given period. For an individual project, this includes: (1) cost of materials installed or erected; (2) cost of labor (both by contractors and force account (i.e., construction done for own use)) and a proportionate share of construction equipment rental; (3) contractor's profit; (4) cost of architectural and engineering work; (5) miscellaneous overhead and office costs chargeable to the project on the owner's books; and (6) interest and taxes paid during construction. Expenses do not include the cost of land nor do they include maintenance and repairs to existing structures or service facilities.

The C30 data are compiled via survey and through indirect estimation. In the context of the C30 survey, construction includes the following: (1) new buildings and structures; (2) additions, alterations, conversions, expansions, reconstruction, renovations, rehabilitations, and major replacements (e.g., the complete replacement of a roof or a heating system); (3) mechanical and electrical installations (e.g., plumbing, heating, electrical work, and other similar building services); (4) site preparation and outside construction of fixed structures or facilities (e.g., sidewalks, highways and streets, water supply lines, sewers, and similar facilities which are built into or fixed to the land); (5) installation of boilers, overhead hoists and cranes, and blast furnaces; (6) fixed, largely site-fabricated equipment not housed in a building (e.g., petroleum refineries and chemical plants); and (7) cost and installation of construction materials placed inside a building and used to support production machinery (e.g., concrete platforms, overhead steel girders and pipes, etc.). *It is important to note that the C30 survey produces information not only on the value of new construction put in place but also contains an unquantified component for additions and alterations for the non-residential sectors.*

The data presented in the C30 report are divided into two parts: (1) private construction; and (2) public construction. These data are summarized in Table A-1. The table records annual values (in millions of constant 1992 dollars) for the years 1992 through 1996. Separate column headings showing the type of construction/function and the assigned sector--R for residential, C for commercial/institutional, I for industrial, and P for public works--are also included. The sector assignment was made by the author.

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[63] Throughout this appendix, reference is made to the **Current Construction Reports** series C30 publication. These references include both how it is used as the basis for other sets of calculations presented in this appendix and as a vehicle for comparing calculations based on other Census publications.

Private construction contains two major components--residential buildings and non-residential buildings--plus a number of subcomponents. Both the two major components and the various subcomponents are shown as headings in the first column of Table A-1.

The residential buildings component includes new private housing and improvements. New private housing includes new houses, apartments, condominiums, and town houses. New private housing units are classified as “1 unit” or “2 or more units.” The value of improvements put in place are a direct measure of the value of *residential additions and alterations* activities. Consequently, improvements are not included in the “new construction” residential sector totals recorded at the bottom of Table A-1.

The non-residential buildings component includes industrial, office buildings, hotels and motels, and “other commercial” (e.g., shopping centers, banks, service stations, warehouses, and other categories). Also falling under the non-residential buildings component are religious, educational, hospital and institutional, and “miscellaneous” non-residential buildings.

Rounding out the private construction component are farm non-residential, public utilities, and “all other private.” These are generally of a non-residential nature but are not part of non-residential buildings. Farm non-residential construction includes structures such as barns, storage houses, and fences. Land improvements such as leveling, terracing, ponds, and roads are also a part of this subcomponent. Privately owned public utilities construction is categorized by industry rather than function of the building or structure. This subcomponent includes expenditures made by utilities for telecommunications, railroads, petroleum pipelines, electric light and power, and natural gas. “All other private” includes privately owned streets and bridges, sewer and water facilities, airfields, and similar construction.

For public construction, there are two major components--building and non-building. Both the two major components and the various subcomponents are shown as headings in the first column of Table A-1. The building component contains subcomponents similar to those for private construction, with educational buildings being the largest subcomponent. Expenditures for the non-building component overwhelmingly consist of outlays for highways and streets, with sewer systems being a distant second subcomponent.

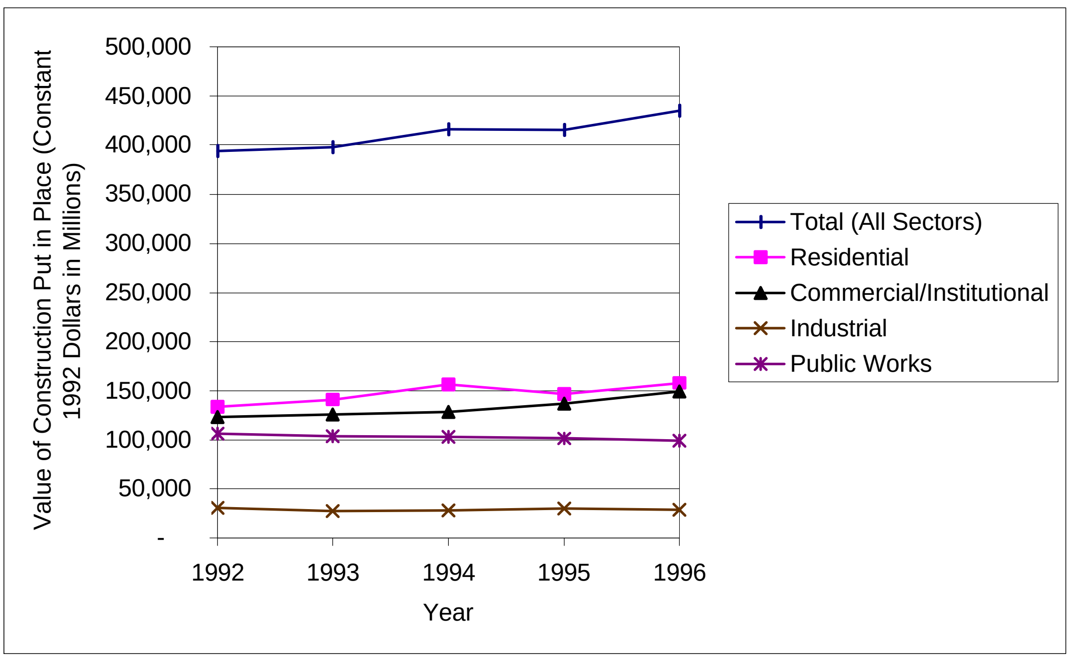
To get the “new construction” sector totals, which appear in the bottom portion of Table A-1, each subcomponent was assigned to a sector and summed. The sector assignments are recorded in the second column of Table A-1. Reference to the bottom portion of the table reveals that sector totals vary considerably, with residential being the largest and industrial the smallest.

Table A-1. Value of New Construction Put in Place

Type of Construction	Assigned Sector	VALUE OF CONSTRUCTION PUT IN PLACE (SERIES C30) Constant 1992 Dollars in Millions				
		1992	1993	1994	1995	1996
Total construction		*451,998*	*461,078*	*480,965*	*474,426*	*493,587*
Private construction		336,126	347,851	367,265	359,411	378,150
Residential buildings		187,687	200,502	218,005	201,682	212,069
New housing units		129,522	137,243	153,250	142,413	153,965
1 unit	R	116,419	126,960	140,416	126,773	136,516
2 or more units	R	13,103	10,283	12,833	15,640	17,449
Improvements		58,165	63,259	64,755	59,268	58,104
Nonresidential buildings		105,615	106,729	111,416	120,627	130,394
Industrial	I	29,027	25,554	26,803	29,043	28,003
Office	C	20,271	20,197	20,553	22,891	24,099
Hotels, motels	C	3,690	4,405	4,308	6,351	10,263
Other commercial	C	29,172	31,292	34,756	38,098	41,301
Religious	C	3,483	3,748	3,584	3,864	3,961
Educational	C	4,475	4,484	4,471	4,908	5,790
Hospital and institutional	C	11,485	12,050	11,377	10,051	10,460
Miscellaneous	C	4,011	5,000	5,565	5,421	6,516
Farm nonresidential	C	2,396	3,271	3,008	2,693	2,736
Public utilities	P	36,859	34,120	32,074	31,767	30,842
Telecommunications	P	9,005	9,468	9,785	10,071	10,420
Other public utilities	P	27,854	24,652	22,289	21,696	20,422
Railroads	P	2,926	3,056	3,186	3,202	4,030
Electric light and power	P	17,184	15,096	13,877	12,656	11,191
Gas	P	6,895	5,536	4,308	5,004	4,291
Petroleum pipelines	P	849	965	918	834	910
All other private	P	3,569	3,229	2,763	2,644	2,109
Public construction		115,872	113,227	113,700	115,014	115,437
Buildings		49,988	46,813	45,177	47,832	49,415
Housing and development	R	4,136	3,833	3,326	3,754	3,881
Industrial	I	1,875	1,658	1,358	1,348	1,216
Educational	C	20,645	18,465	17,593	19,237	20,131
Hospital	C	3,383	3,579	3,787	3,854	3,981
Other	C	19,949	19,279	19,114	19,638	20,207
Highways and streets	P	33,132	34,164	36,151	33,500	33,297
Military facilities	P	2,502	2,405	2,196	2,729	2,225
Conservation and development	P	5,946	5,771	6,091	5,773	5,244
Sewer systems	P	9,658	8,622	8,592	8,975	9,060
Water supply facilities	P	5,170	4,868	4,443	4,923	5,121
Miscellaneous public	P	9,475	10,583	11,050	11,282	11,075
New Construction						
SECTOR TOTALS and SUMMARY						
Residential (R)		133,658	141,076	156,576	146,167	157,846
Commercial/Institutional (C)		122,960	125,770	128,116	137,006	149,445
Industrial (I)		30,902	27,212	28,161	30,391	29,219
Public Works (P)		106,311	103,762	103,360	101,593	98,973
Total for all Sectors		393,831	397,820	416,213	415,157	435,483

Table A-1 highlights an important distinction between the residential sector and the three non-residential sectors. Reference to the “Residential Buildings” component of the table (i.e., the entry immediately below the heading **Private Construction**) for the year 1992 produces a value of $187,687 million. This value differs from the value for the residential sector, $133,658 million, given immediately below the heading of **SECTOR TOTALS and SUMMARY** in the bottom portion of the table. The reason for the difference is due to the *exclusion* of the value of private residential improvements (i.e., additions and alterations) and the *inclusion* of the value of public housing and development. Because the values given in the bottom portion of Table A-1 are estimates of the values of *new construction put in place*, it is necessary to net out the value of residential improvements. While this is a straightforward process for the private residential sector, no specific information on additions and alterations is published in the C30 report for either the three non-residential sectors or for public housing and development. Consequently, we have assumed that the values for additions and alterations for the three non-residential sectors and for public housing and development are zero. This implies that the sector totals for commercial/institutional, industrial, and public works are the values of *new construction put in place* for each of the years 1992 through 1996. A rationale for this assumption is given in the next section, which covers the nature of construction activities.

Figure A-1. Value of New Construction Put in Place



The Table A-1 sector totals and the overall construction industry totals for the value of *new construction put in place* are shown graphically in Figure A-1. The horizontal axis of the figure records the year, from 1992 through 1996. The vertical axis records the value of new construction put in place, in millions of constant 1992 dollars. Each trace is keyed to designate either the sector or the overall total.

A.2 Nature of Construction Activity

The nature of construction activity may be conveniently classified as either new construction, additions and alterations, or maintenance and repair. Definitions of each are as follows.

> *New construction* activities include the complete original building of structures and essential service facilities and the initial installation of integral equipment such as elevators and plumbing, heating, and air-conditioning supplies and equipment.
>
> *Additions and alterations* include construction work which adds to the value or useful life of an existing building or structure, or which adapts a building or structure to a new or different use. Included are major replacements of building systems such as the installation of a new roof or heating system and the resurfacing of streets or highways. This contrasts to the repair of a hole in a roof or the routine patching of highways and streets, which would be classified as maintenance and repair.
>
> *Maintenance and repair* activities include incidental construction work which keeps a property in ordinary working condition. Excluded are trash and snow removal, lawn maintenance and landscaping, cleaning and janitorial services.

This section presents information from three different data sources: (1) the **1992 Census of the Construction Industry**; (2) **Current Construction Reports** series C30, *Value of Construction Put in Place*; and (3) **Current Construction Reports** series C50, *Expenditures for Residential Improvements and Repairs*. Although each data source provides insights into the nature of construction activity, they differ in degree of detail, frequency of publication, and sector coverage. Brief descriptions of the **1992 Census of the Construction Industry** and the "C50 report" are given in the text that follows. Readers seeking information on the C30 report are referred to Section A.1 of this report. Statistics from each source are also presented and, where appropriate, comparisons are made.

The Census of the Construction Industry is conducted every five years. The construction industry is one of seven industries tabulated as part of the Economic Census. The Economic Census is highly detailed. The Economic Census is performed only in years ending with 2 or 7. Although much of the information from the 1997 Census of the Construction Industry is currently available, material presented in this appendix uses information from the 1992 Census of the Construction Industry. This was done to facilitate comparisons with material presented in the two companion documents.

The census of the construction industry enumerates establishments with paid employees engaged primarily in one of the following three areas: (1) ***constructing new homes and other buildings***; (2) ***heavy construction***, such as highways; and (3) ***special trades***, such as plumbing and electrical work. Most construction establishments are described as contractors (e.g., general contractors and special trades contractors), but the census also includes operative builders who construct buildings or other structures on their own account to be sold when completed.

A "construction establishment" is defined as a relatively permanent office or other place of business where the usual business activities related to construction are conducted. With some exceptions, a relatively permanent office is one that has been established for the management of more than one project or job and which is expected to be maintained on a continuing basis. Such "establishment" activities include, but are not limited to estimating, bidding, purchasing, supervising, and operation of the actual construction work being conducted at one or more construction sites. The census did not require separate construction reports for each project or construction site. However, companies with more than one construction establishment were required to submit a separate report for each such establishment operated during all or any part of 1992.

For purposes of the census, construction establishments are classified by kind of business according to the principal work performed. There are three major Standard Industrial Classification (SIC) groups--two-digit SIC codes--in the construction industry:

15	Building construction--general contractors and operative builders
16	Heavy construction other than building construction--contractors
17	Special trade contractors

These major SIC groups are sub-divided into 13 three-digit SIC codes which in turn are sub-divided into 26 four-digit SIC codes. Table A-2 provides a description of each of the 26 four-digit SIC codes. Part A of the table covers the two-digit SIC codes 15 (building construction--general contractors and operative builders) and 16 (heavy construction other than building construction--contractors); Part B of the table covers the two-digit SIC code 17 (special trade contractors).

Data tabulated in the 1992 Census of the Construction Industry provide information grouped by the types of buildings, structures, or other facilities being constructed or worked on by construction establishments in 1992. Respondents were instructed to classify each building, structure, or other facility in terms of its function. For example, a restaurant building was to be classified in the restaurant category whether it was designed as a commercial restaurant building or an auxiliary unit of an educational institution. If respondents worked on more than one type of building or structure in a multi-building complex, they were instructed to report separately for each building or type of structure. If they worked on a building that had more than one purpose (e.g., office and residential), they were asked to classify the building by major purpose. In addition, all respondents were requested to report the percentage of the value of construction work done for new construction, additions and alterations, and maintenance and repair activities for each type of building, structure, or facility.

The detailed breakout for new construction, additions and alterations, and maintenance and repair activities provided by the 1992 census is noteworthy because prior to 1987, construction receipts only were collected. In 1987 and 1992, the value of construction work was collected to better measure actual construction activity done during the year. This conceptual change was made because receipts during a calendar year may include advance payments or payments for work done in a prior year, and thus may not accurately reflect construction work done during the census year. For certain key industries, such as operative builders and developers, receipts and work done may also differ because receipts do not include work contractors perform for their own account and use, which can be substantial.

At the time of the 1992 census, there were about 1.4 million construction establishments, and about one third of them had paid employees. Establishments without payroll, typically one-person operations or partnerships, were not surveyed by the US Bureau of the Census. The Bureau of the Census did, however, obtain a limited amount of data on self-employed construction workers from the administrative records of other Federal agencies.

The C50 report is published quarterly; it presents improvement and repair expenditures by property owners for residential properties. Data presented in the C50 report are based on personal interviews obtained from household members as part of the Consumer Expenditure Surveys conducted by the Bureau of the Census for the Bureau of Labor Statistics. These data cover single and multi-unit structures, publicly and privately owned structures, non-farm and farm properties, and residential properties that are occupied by owners or renters or are vacant.[64]

The expenditures covered in the C50 report are those connected with construction activity intended to maintain or improve the property. These expenditures involve expenses for maintenance and repair, additions, alterations, and major replacements that are made to the property by the owners. Included are all costs, for both the inside and outside of the house, whether on the main dwelling, on other structures on the property incidental to the residential use of the main dwellings, or for the grounds on which the structures are erected.

[64] Expenditures made by renters are not included in the C50 report. A study of renters' expenditures conducted in 1989 showed that they accounted for less than one percent of all expenditures for improvements and repairs.

Table A-2. Four-Digit SIC Codes for the Construction Industry

Part A: Two-Digit SIC Codes 15 (Building Construction - General Contractors and Operative Builders) and 16 (Heavy Construction Other than Building Construction - Contractors)

SIC code	Label	Description
1521	General contractor - single-family houses	Includes townhouses, repair of mobile homes on site, and assembly of premanufactured and modular units
1522	General contractors - residential buildings other than single-family	Includes hotels, motels, and dormitories
1531	Operative builders	Condominiums, cooperative apartments, and single-family houses built by developers to sell, instead of as contractors working for other companies
1541	General contractors - industrial buildings and warehouses	Includes grain elevators and automobile assembly, pharmaceutical manufacturing, and aluminum plants
1542	General contractors - nonresidential buildings, other than industrial buildings and warehouses	Commercial, institutional, religious, and amusement and recreational buildings
1611	Highway and street construction, except elevated highways	Roads, streets, alleys, public sidewalks, guardrails, parkways, and airports (general and special-trade contractors)
1622	Bridge, tunnel, and elevated highway construction	Bridges, viaducts, elevated highways, and highway, pedestrian, and railway tunnels (general construction)
1623	Water, sewer, pipeline, and communications and power-line construction	Includes transmission towers (general and special-trade contractors)
1629	Heavy construction, not elsewhere classified	For instance, athletic fields, blasting (except building demolition), canals, dams, hydroelectric plants, land clearing, nuclear reactor containment, petroleum refineries, piers (general and special-trade contractors)

Part B: Two-Digit SIC Code 17 (Special Trade Contractors)

SIC code	Label	Description
1711	Plumbing, heating, and air conditioning	Includes drainage system installation, cesspool, and septic tank; lawn sprinkler system; sewer hookups for buildings; solar heating; and related sheet metal work
1721	Painting and paper hanging	Excludes roof painting
1731	Electrical work	Covers work on site, including installation of telephones and alarms
1741	Masonry, stone setting, and other stone work	Excludes foundation digging and concrete work
1742	Plastering, drywall, acoustical, and insulation work	Includes installation of lathing and other accessories to receive plaster
1743	Terrazzo, tile, marble, and mosaic work	Excludes manufacture of precast terrazzo steps, benches, and other terrazzo articles
1751	Carpentry work	Includes on-site installation of cabinets, folding doors, framing, ship joinery, store fixtures, trim and finish, and prefab windows and doors
1752	Floor laying, and other floor work, not elsewhere classified	Includes laying and removal of carpet, finishing of parquet flooring, installation of asphalt tile. Excludes ceramic floor tile, concrete floors
1761	Roofing, siding, and sheet metal work	Includes metal ceilings skylight, gutter, and downspout installation; roof painting and spraying
1771	Concrete work	Includes private driveways and walks of all materials. Excludes concrete foundations, excavations, public sidewalks, and highways
1781	Water well drilling	Excludes oil- or gas-field water intake wells
1791	Structural steel erection (ironwork)	Includes similar products of prestressed or precast concrete and placing of concrete reinforcement
1793	Glass and glazing work	Excludes automotive
1794	Excavation work	Includes grading (except for highways, streets and airport runways) and incidental concrete work
1795	Wrecking and demolition	Includes concrete breaking for streets and dismantling of steel oil tanks. Excludes marine wrecking and demolition
1796	Installation or erection of building equipment, not elsewhere classified	Includes elevators, pneumatic tube systems, small incinerators, dust-collecting equipment, and revolving doors. Also includes dismantling and maintenance
1799	Special trade contractors, not elsewhere classified	Includes construction of swimming pools and fences, house moving, shoring work, fireproofing, and sandblasting and steamcleaning of building exteriors

As a general principle, expenses connected with items not permanently attached or affixed to some part of the house or property are outside the scope of the C50 report. Thus, expenses connected with the repair or replacement of household appliances (e.g., stoves, refrigerators, etc.) are excluded, as are costs connected with house furnishings. While the costs of appliances are excluded, the construction costs of building in such appliances (e.g., the cost of building in a wall oven) are included in the scope of the C50 report. Expenditures for grading, draining, fencing, and paving are included, but the costs of landscaping are not included in the C50 report.

The kinds of expenditures included cover work done under contract or with hired labor, and the costs of purchasing or renting tools and equipment for purposes of carrying out jobs which fall within the scope of the C50 report. However, no attempt is made to estimate or include the value of labor in do-it-yourself jobs.

The types of expenditures are classified broadly as either maintenance and repair or construction improvements. Maintenance and repair expenditures represent current costs for incidental maintenance and repair activities that keep a property in ordinary working condition, rather than additional investment in the property. Expenditures for construction improvements are capital expenditures that add to the value or useful life of a property. Improvements are further classified as additions to residential structures (e.g., enlargement of the structure by adding a room), alterations within residential structures (e.g., changes or improvements made within or on the structure), additions and alterations on property outside residential structures (e.g., laying or improving walks or driveways), and major replacements (e.g., a roof replacement).

At this point, it is useful to compare the three data sets and examine the differing values for new construction, maintenance and repair, and additions and alterations which result for a single year (1992) or across years for a single sector (residential). The first set of comparisons and data summaries are for the 1992 census of the construction industry (CCI) and the estimates for new construction, maintenance and repair, and additions and alterations "derived" from the C30--value of construction put in place--report (VIP). The second set of comparisons and data summaries trace annual expenditure estimates for residential maintenance and repair and additions and alterations "derived" from the C30 report data alongside data published in the C50 report.

The Bureau of the Census recognizes that only about two-thirds of the construction as defined in VIP is actually done by the construction industry as defined by the CCI.[65] Examples of construction work included within the VIP estimates but excluded from the CCI are architectural and engineering design and force-account construction. Also outside the scope of the CCI is work done by non-employers (i.e., self-employed construction workers). Thus, in developing comparisons between VIP and CCI data, estimates and assumptions have to be made for these differences.[66]

[65] US Department of Commerce. 1997. *Overview of Construction Statistics Programs*. Draft Mimeo. Washington, DC: Bureau of the Census.
[66] *Ibid.*, p.26.

The VIP, C30 report data, were used as the basis for deriving estimates for new construction, maintenance and repair, and additions and alterations expenditures for each sector for each year between 1992 and 1996. Information from the CCI was used to construct a series of multipliers; one set for each sector. One component of each sector's set of multipliers recorded the ratio of maintenance and repair expenditures to new construction expenditures. The other component of each sector's set of multipliers recorded the ratio of expenditures for additions and alterations to new construction expenditures. To develop a framework for deriving these estimates, it was necessary to make eight assumptions. These assumptions are as follows; they are enumerated from A.1 to A.8.

A.1 Expenditures for new residential construction for each year, derived from the C30 report data, equal expenditures for private residential buildings *plus* expenditures for public housing and development *less* expenditures for residential improvements (see Table A-1).

A.2 Expenditures for new non-residential construction for each year, derived from the C30 report data, equal the unadjusted sector expenditure totals (see Table A-1).[67]

A.3 Multipliers for maintenance and repair activities for each sector for each year are a fixed proportion equal to the ratio of that sector's CCI expenditures for maintenance and repair activities to that sector's CCI expenditures for new construction.

A.4 Multipliers for additions and alterations for each sector for each year are a fixed proportion equal to the ratio of that sector's CCI expenditures for additions and alterations to that sector's CCI expenditures for new construction.

A.5 Expenditures for residential maintenance and repair activities in a given year equal that year's new construction value as defined in A.1 times the fixed proportion multiplier for the residential sector defined in A.3.

A.6 Expenditures for non-residential maintenance and repair activities for a given sector in a given year equal that year's new construction value as defined in A.2 times the fixed proportion multiplier for the appropriate non-residential sector as defined in A.3.

A.7 Expenditures for residential additions and alterations in a given year equal that year's new construction value as defined in A.1 times the fixed proportion multiplier for the residential sector defined in A.4.

[67] Note that the C30 report data contain an unquantified component for additions and alterations.

A.8 Expenditures for non-residential additions and alterations for a given sector in a given year equal that year's new construction value as defined in A.2 times the fixed proportion multiplier for the appropriate non-residential sector as defined in A.4.

Figure A-2 shows the results of applying these assumptions to the C30 report (VIP) data for 1992 and plotting them side-by-side with the CCI data. Notice that each component--new construction, maintenance and repair, and additions and alterations--is higher for the "derived" VIP data than for the CCI data. The underlying assumptions, however, are plausible because the CCI contains only about two-thirds of the construction activity covered in the VIP (e.g., CCI only includes establishments with payroll and excludes items such as architectural and engineering services which in 1992 amounted to approximately $50 billion).

The "derived" total for all construction expenditures shown in Figure A-2 may be broken down into its constituent parts. This breakdown is shown in Figure A-3 for the year 1992. Reference to Figure A-3 reveals that 61 percent, or $393.8 billion, of all construction expenditures are associated with the value of new construction put in place. Expenditures for additions and alterations amounted to $156.5 billion, or 24 percent of the total. Expenditures for maintenance and repair activities amounted to $93.3 billion, or 15 percent of the total.

When assumptions A.5 and A.6 are applied, annual estimates for the value of maintenance and repair expenditures for each sector result. These sector estimates are plotted, as multi-year traces keyed to each sector, in Figure A-4. These "derived" estimates exhibit a slight upward trend. Maintenance and repair expenditures in the commercial/institutional sector are the highest in each year while maintenance and repair expenditures in the industrial sector are the lowest in each year.

When assumptions A.7 and A.8 are applied, annual estimates for the value of expenditures for additions and alterations for each sector result. These sector estimates are plotted, as multi-year traces keyed to each sector, in Figure A-5. As was the case for maintenance and repair expenditures, expenditures for additions and alterations exhibit a slight upward trend. Reference to Figure A-5 reveals that the dollar value of expenditures for additions and alterations in the commercial/institutional sector are about two to three times the amount for the other sectors.

Figure A-2. Total Value of Construction Work: Comparison of Value Put in Place and 1992 Census of the Construction Industry

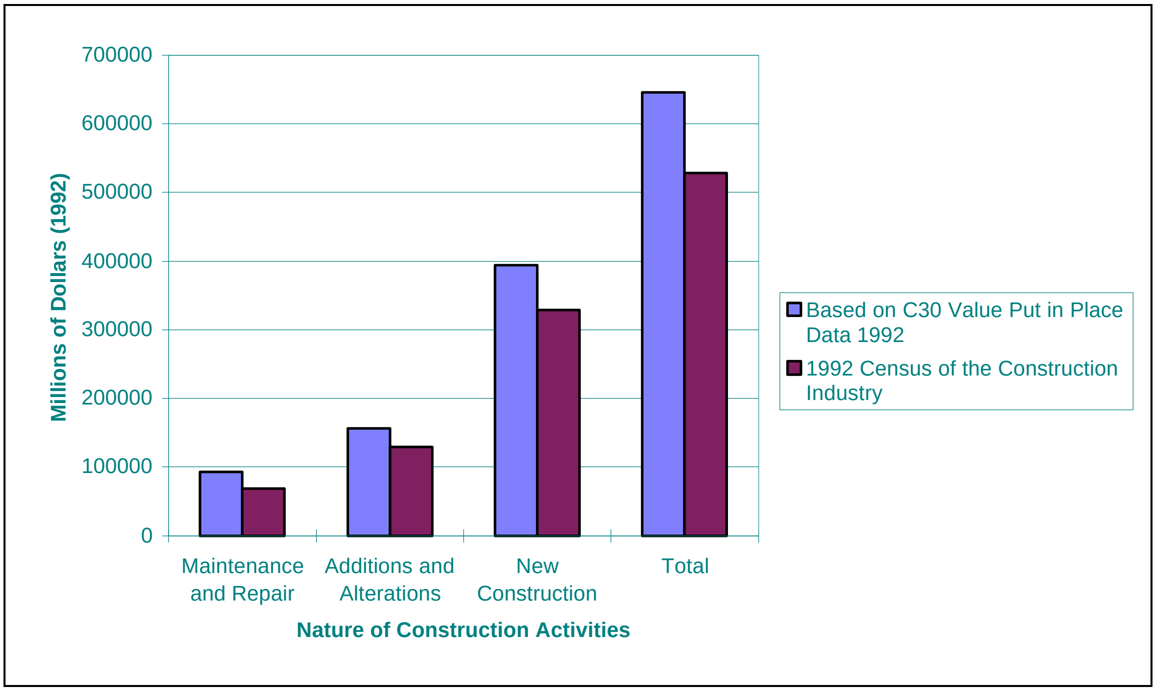


Figure A-3. Distribution of Total Construction Expenditures in 1992 by Nature of Construction Activity

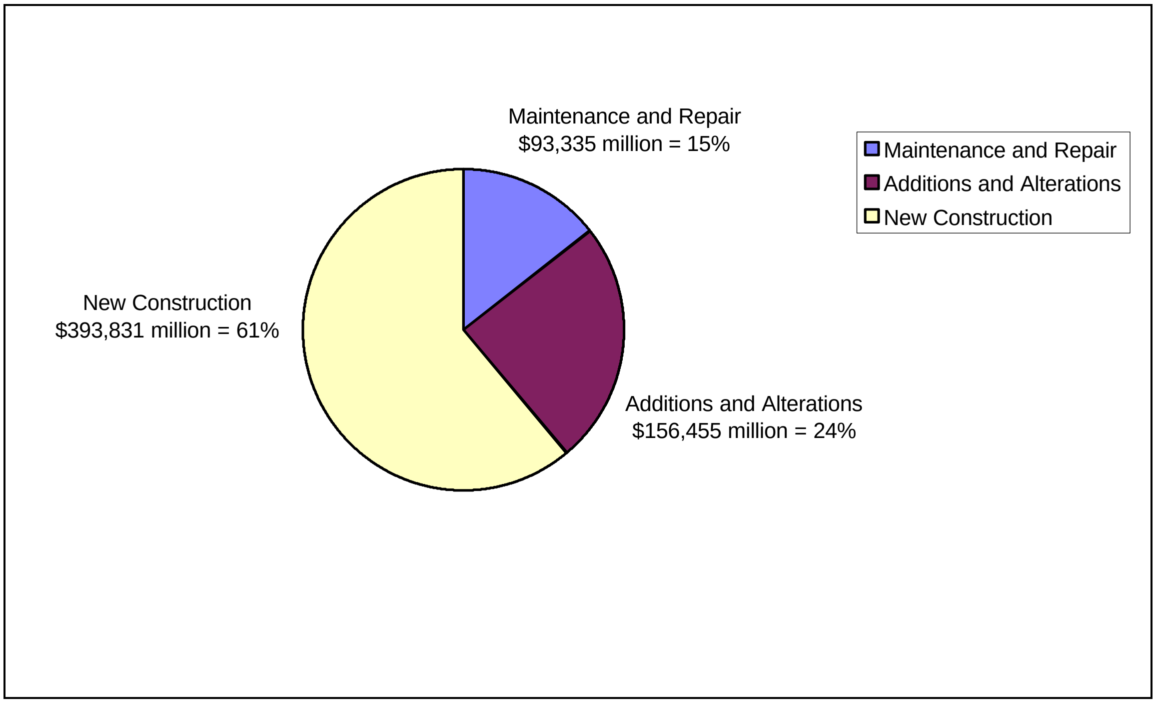


Figure A-4. Annual Expenditures for Maintenance and Repair Activities by Sector

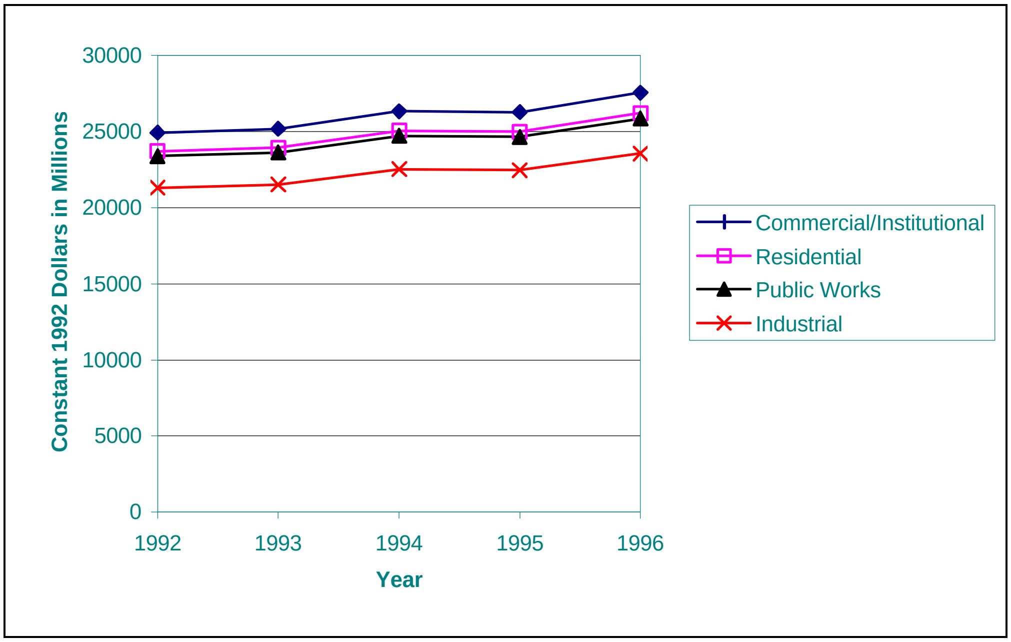
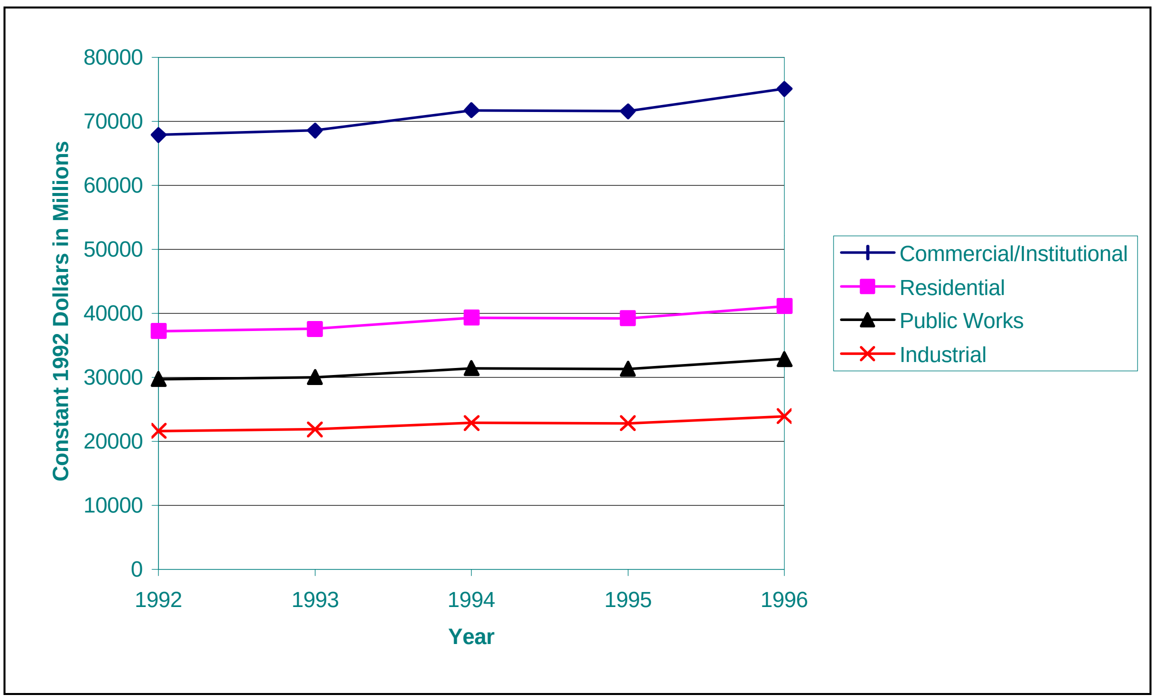


Figure A-5. Annual Expenditures for Additions and Alterations by Sector



Although information on expenditures for maintenance and repairs and additions and alterations are not available for all four construction industry sectors, such information is available for the residential sector via the C50 report. Figure A-6 shows these data side-by-side with the derived C30 data. Figure A-6 consists of a series of bar charts; four bars for each year. For each year, maintenance and repair expenditures are the two leftmost bars and expenditures for additions and alterations are the two rightmost bars. For each two-bar set (i.e., maintenance and repair ***or*** additions and alterations), the left-hand bar records the annual combined total for estimates derived from the C30 report data and the CCI multipliers (i.e., based on assumptions A.1, A.3, A.4, A.5, and A.7). Similarly, for each two-bar set, the right-hand bar records the annual combined total for data published in the C50 report. The values underlying each year's set of bars are given in Table A-3. Reference to Figure A-6 and Table A-3 shows that the estimated values for the C30/CCI derived data are about two-thirds of the expenditures resulting from the C50 report data. There are two plausible explanations for these differences. First, the CCI does not capture information on construction establishments without employees. Although such establishments are not expected to be major players in the non-residential sector, they are often very active in the residential maintenance and repair and additions and alterations markets. These activities are captured through the C50 survey process. Second, the CCI does not capture information on materials and equipment purchases by residential property owners for use in maintenance and repair and additions and alterations activities. Because the C50 survey is aimed at residential property owners, it captures information on purchases of materials and equipment.

Table A-3. Comparison of Derived Data and Household Survey Data for Total Expenditures on Improvements and Maintenance and Repairs in the Residential Sector

RESIDENTIAL SECTOR	Value (Millions of Constant 1992 Dollars) By Year				
	1992	1993	1994	1995	1996
Maintenance and Repair (Derived Data)	23,709	23,949	25,057	24,993	26,217
Improvements (Derived Data)	37,204	37,581	39,319	39,219	41,139
Total (Derived Data)	60,913	61,530	64,376	64,212	67,356
Maintenance and Repair (C50 Data)	45,121	40,198	39,731	37,338	32,113
Improvements (C50 Data)	58,580	64,208	66,671	61,837	67,636
Total (C50 Data)	103,734	104,405	106,402	99,733	99,749

For the non-residential sectors, it is unclear whether the estimates derived from the C30/CCI data can be expected to exhibit a similar trend (i.e., are about two-thirds of the value resulting from a survey of the respective sector) or not. Consequently, we have adopted a conservative approach and opted to use the estimates derived from the C30/CCI data for each of the four construction industry sectors. These data are plotted as multi-year traces in Figure A-7. Detailed estimates by year, by sector, and by nature of construction activity are recorded in Table A-4.

Figure A-6. Comparison of Derived Data and Household Survey Data for Total Expenditures on Improvements and Maintenance and Repairs in the Residential Sector

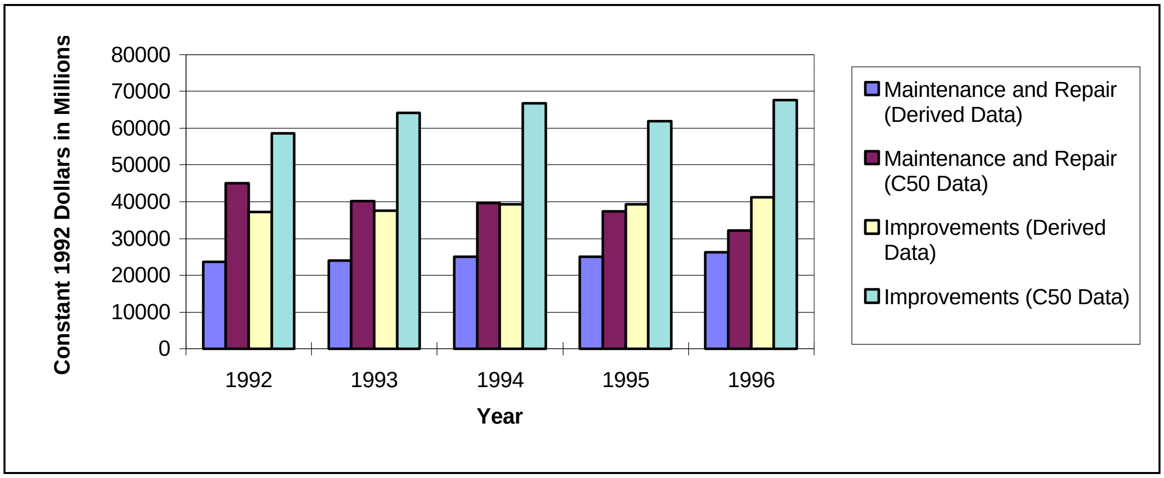


Figure A-7. Total Value of Construction Work

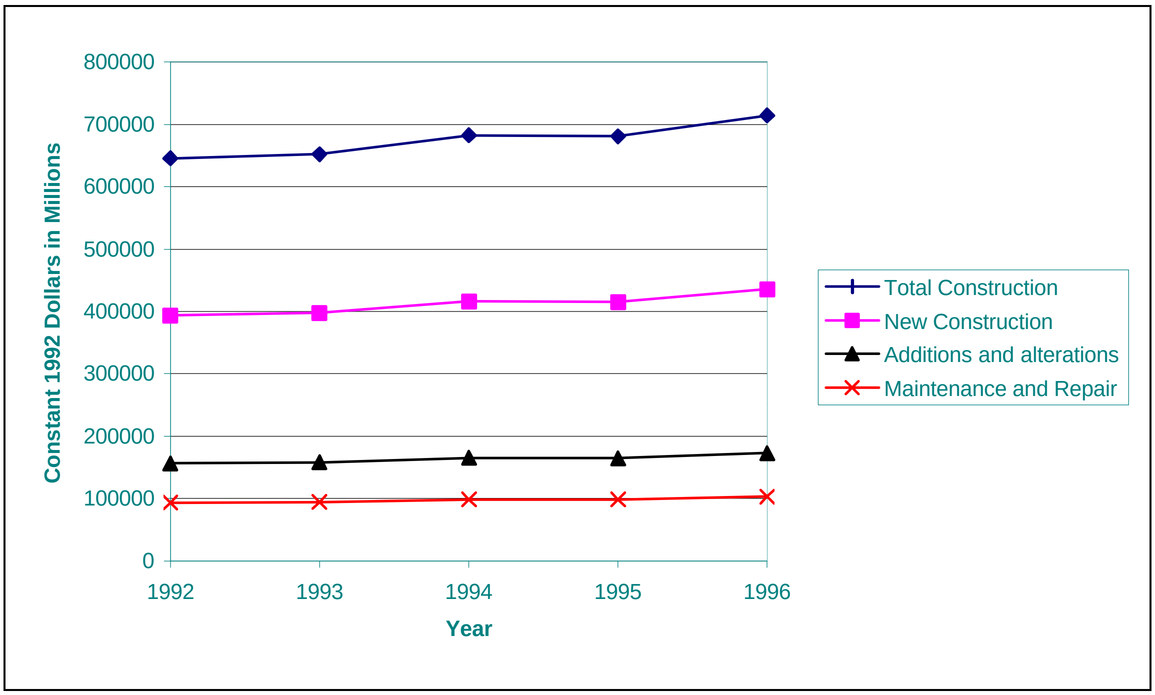


Table A-4. Value of Construction Work: 1992 - 1996

Part A: Total Value of Construction Work in Millions of Constant 1992 Dollars: 1992 - 1996

DERIVED DATA - ALL SECTORS	Total Construction	New Construction	Additions and alterations	Maintenance and Repair
1992	645,769	393,831	156,455	93,335
1993	652,310	397,820	158,040	94,280
1994	682,469	416,213	165,347	98,639
1995	680,738	415,157	164,928	98,389
1996	714,067	435,483	173,002	103,206

Part B: Value of Construction Work by Sector and by Nature of Construction Activity in Millions of Constant 1992 Dollars: 1992-1996

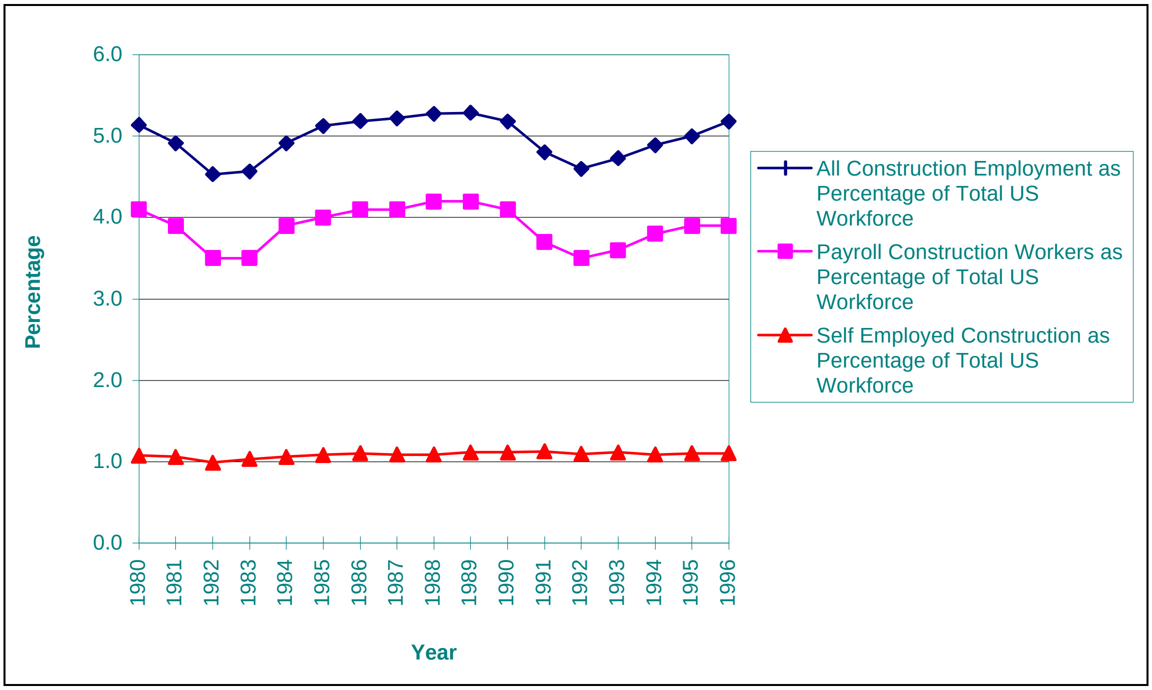
NEW CONSTRUCTION	All Sectors	Residential	Commercial/ Institutional	Industrial	Public Works
1992	393,831	133,658	122,960	30,902	106,311
1993	397,820	141,076	125,770	27,212	103,762
1994	416,213	156,576	128,116	28,161	103,360
1995	415,157	146,167	137,006	30,391	101,593
1996	435,483	157,846	149,445	29,219	98,973
DERIVED DATA - MAINTENANCE/ REPAIR					
1992	93,335	23,709	24,931	21,310	23,385
1993	94,280	23,949	25,183	21,526	23,622
1994	98,639	25,057	26,348	22,521	24,714
1995	98,389	24,993	26,281	22,464	24,651
1996	103,206	26,217	27,568	23,564	25,858
DERIVED DATA - ADDITIONS/ ALTERATIONS					
1992	156,455	37,204	67,904	21,632	29,715
1993	158,040	37,581	68,592	21,851	30,016
1994	165,347	39,319	71,764	22,861	31,404
1995	164,928	39,219	71,581	22,803	31,324
1996	173,002	41,139	75,086	23,919	32,858

A.3 Employment in Construction

Construction tends to be a cyclical activity that can have a significant impact on the national economy and even more so on various local economies. Construction activity has a significant impact on local employment due to secondary effects on construction supply and service industries.

Figure A-8 illustrates the cyclical nature of construction activity. Figure A-8 records employment in construction as a percent of overall employment in the US civilian workforce for the years 1980 through 1995. Because the construction workforce consists of a large number of self-employed workers, Figure A-8 also includes multi-year traces which divide the construction workforce into its two constituent parts. The first part records the percentage of the US civilian workforce associated with construction establishments with employees. The second part records the percentage of the US civilian workforce associated with self-employed construction workers.

Figure A-8. Construction Employment as a Proportion of the Total US Civilian Workforce



Source: Bureau of Labor Statistics, National Employment Data, and US Industrial Outlook

Figure A-8 shows the impact of recessions very clearly, as these are years when sharp declines in the construction workforce relative to the rest of the US civilian workforce occur. Notice that most of the declines and increases shown in Figure A-8 are due to construction establishments with employees. The percentage of self-employed workers hovers around one percent throughout the 15 year period. The relative increase in employment in the construction industry between 1992 and 1996 shown in Figure A-8 and its interaction with the rest of the economy can better be understood through reference to and comparison with Figure A-1. Reference to Figure A-1 shows strong increases in the value of new commercial/institutional construction put in place from 1994 through 1996. This upward trend was reinforced by a strong performance in 1996 for the residential sector.

Table A-5 provides detailed information for a single year, 1992. The data presented in Table A-5 are from the 1992 census of the construction industry. Table A-5 is organized around the three two-digit SIC codes and 26 four-digit SIC codes described earlier (see Table A-2). The table lists a specific segment or subsegment of the construction industry in the leftmost column. Immediately to the right is the corresponding two-digit or four-digit SIC code for the segment or subsegment of the construction industry. The four remaining columns record information on the number of establishments with payroll, the total number of employees in thousands, the value of construction work in millions of 1992 dollars, and value added in millions of 1992 dollars.[68] It is important to recognize that only construction establishments with employees are included in these figures. Consequently, the values shown in Table A-5 differ from those given in Section A.2 where data from the C30 report were used to compute the total value of construction work (see Figure A-2 for a comparison of the two sets of totals). Data from the 1992 census of the construction industry are used here because they provide the necessary level of detail to link employment and output information. For example, a key measure of productivity within the construction industry is value added per employee. The information in Table A-5 is very useful in characterizing employment and output in the construction industry. One such characterization is illustrated through a series of four pie charts and one bar chart.

Figure A-9 summarizes information on the number of establishments and the percentage of all construction establishments within each of the three two-digit SIC codes. Note that SIC code 17, special trade contractors, account for nearly two-thirds of all construction establishments. By contrast, heavy construction contractors, SIC code 16, are only six percent of the total number of construction establishments.

Figure A-10 summarizes information on the number of employees and the percentage of all construction employment within each of the three two-digit SIC codes. Note that the percentage of employment in SIC code 16, heavy construction contractors, amounts to 17 percent of the total, implying that establishments in this segment of the construction industry tend to be larger than for SIC codes 15 and 17.

[68] The process by which final goods and services are produced consists of many stages. Gross national product measures the value of all final goods and services produced in the economy during a given period. In practice, double counting is avoided by working with value added. At each stage, the value of the commodity sold minus the cost of the inputs equals value added. Therefore, the sum of value added at each stage equals the final value of the good or service.

Figure A-11 summarizes information on the value of construction work and the percentage of the total value (i.e., $528.1 billion) within each of the three two-digit SIC codes. Note that general building contractors, SIC code 15, and special trade contractors, SIC code 17, each account for 41 percent of the total.

Table A-5. Employment and Output Figures for the Construction Industry: 1992

Industry	SIC Code	Establishments with Payroll (1000's)	Total Employees (1000's)	Value of Construction Work (Million Dollars)	Value Added (Million Dollars)
All industries, total	(X)	572.9	4,668	528,106	234,618
General building contractors	**15**	**168.4**	**1,097**	**215,629**	**63,117**
Single-family houses	1521	107.5	404	48,633	17,183
Other residential buildings	1522	6.5	49	7,835	2,454
Operative builders	1531	17.0	114	44,588	15,289
Industrial buildings and warehouses	1541	7.7	123	20,586	6,438
Nonresidential buildings, n.e.c.	1542	29.7	407	93,987	21,754
Heavy construction contractors	**16**	**37.2**	**799**	**95,571**	**49,165**
Highway and street construction	1611	10.1	257	35,332	15,711
Bridge, tunnel, and elevated highway	1622	1.0	44	7,198	3,078
Water, sewer, and utility lines	1623	10.2	194	20,205	11,734
Heavy construction, n.e.c.	1629	15.8	304	32,837	18,642
Special trade contractors	**17**	**367.3**	**2,772**	**216,905**	**122,336**
Plumbing, heating, air-conditioning	1711	75.4	613	56,902	29,432
Painting and paperhanging	1721	32.0	163	8,690	5,855
Electrical work	1731	54.0	487	40,259	23,548
Masonry and other stonework	1741	22.6	148	8,458	5,146
Plastering, drywall, insulation	1742	18.6	207	14,056	8,143
Terrazzo, tile, marble, and mosaic work	1743	6.5	34	2,439	1,358
Carpentry	1751	38.2	178	12,852	6,760
Floorlaying and other floor work	1752	10.2	49	4,428	2,166
Roofing, siding, and sheet metal work	1761	27.6	216	16,788	8,906
Concrete work	1771	26.1	193	14,423	7,703
Water well drilling	1781	3.6	19	1,727	995
Structural steel erection	1791	3.8	58	4,952	3,021
Glass and glazing work	1793	4.6	32	2,724	1,424
Excavation work	1794	13.9	77	6,870	4,340
Wrecking and demolition work	1795	1.0	13	1,059	775
Installing building equipment, n.e.c.	1796	3.9	83	6,611	4,494
Special trade contractors, n.e.c.	1799	25.3	204	13,667	8,270

Figure A-9. Number of Establishments with Payroll by Two-Digit SIC Code: 1992

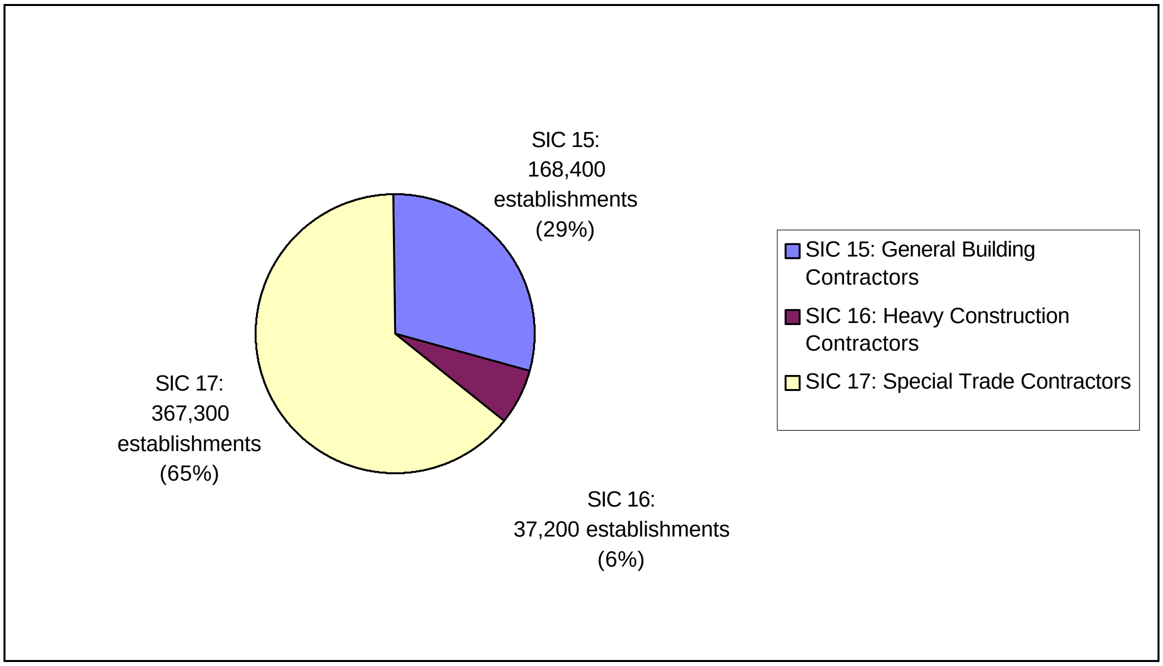


Figure A-10. Number of Employees for Establishments with Payroll by Two-Digit SIC Code: 1992

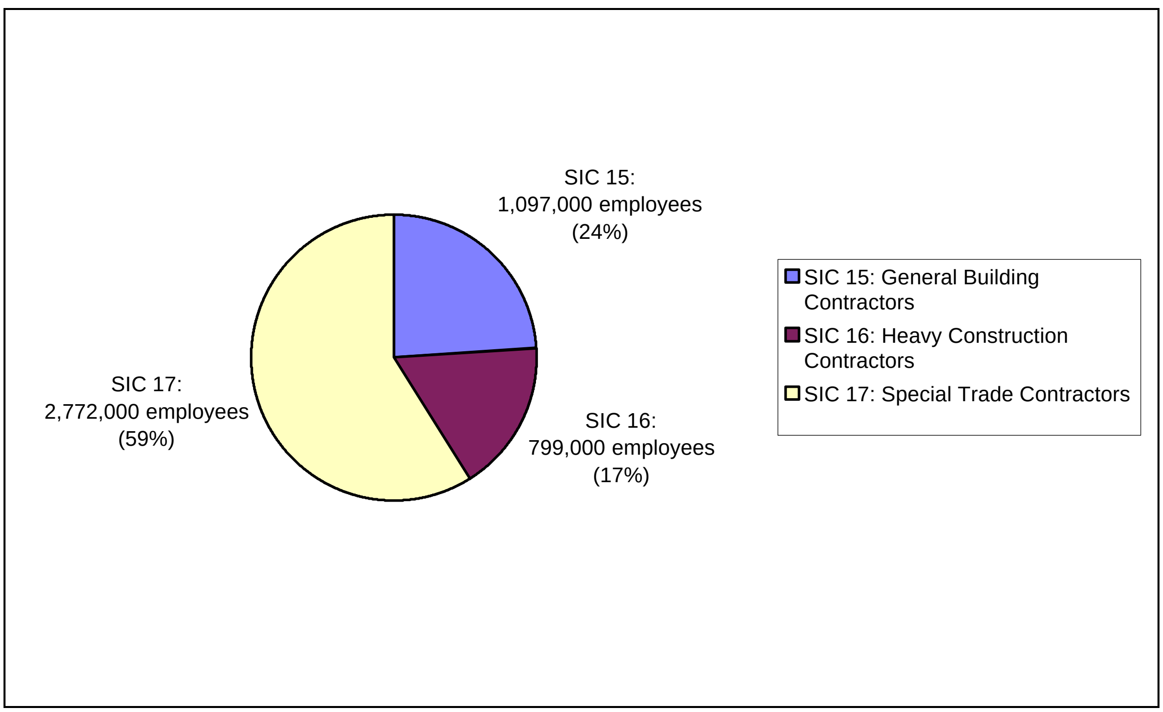


Figure A-11. Value of Construction Work for Establishments with Payroll by Two-Digit SIC Code: 1992

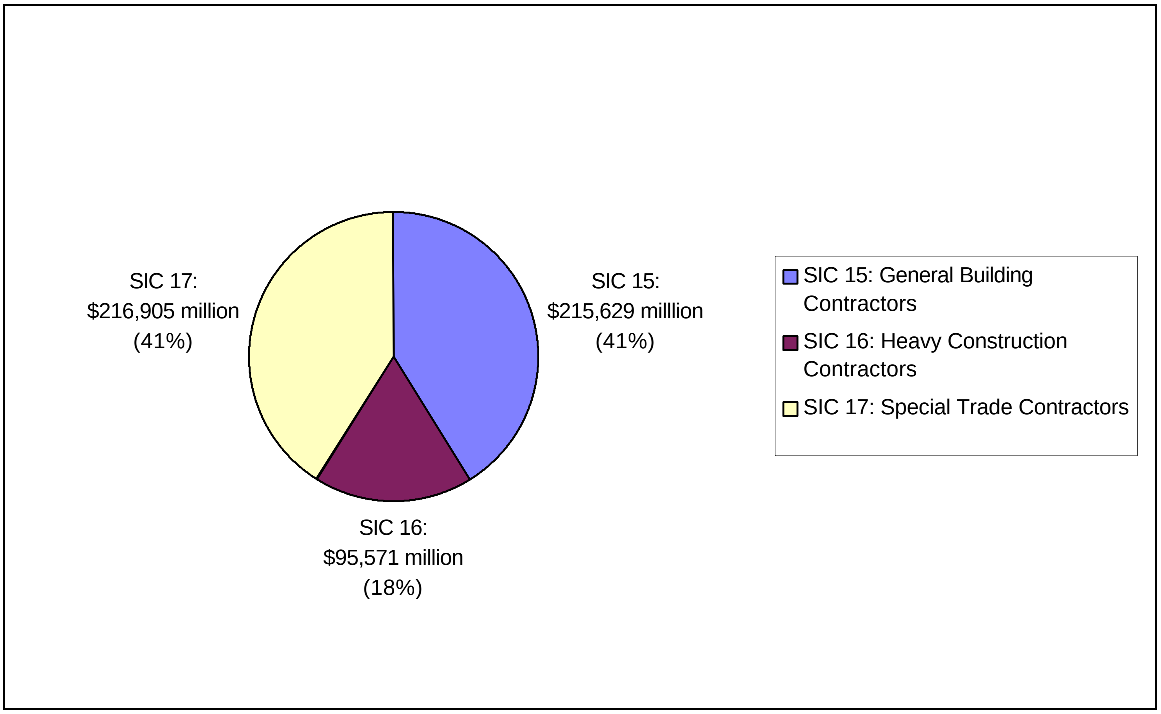


Figure A-12 summarizes information on value added and the percentage of the total value added (i.e., $234.6 billion) within each of the three two-digit SIC codes. Figure A-13 factors employment into the calculation; it records value added per employee in thousands of 1992 dollars.

Reference to Figure A-13 reveals that SIC code 16, heavy construction contractors, has the highest average value added per employee, $61.5 thousand, and SIC code 17, special trade contractors, has the lowest value added per employee, $44.1 thousand. That SIC code 16 is the highest should come as no surprise. Establishments within SIC code 16 tend to be larger on the average than for SIC codes 15 and 17 and accounted for a "relatively" larger percentage share of overall value added. For example, for SIC code 16, the percentage share of overall value added exceeded the percentage share of overall employment. While for SIC codes 15 and 17, their percentage shares of value added were either approximately equal or less than the percentage shares of overall employment.

Figure A-12. Value Added for Establishments with Payroll by Two Digit SIC Code: 1992

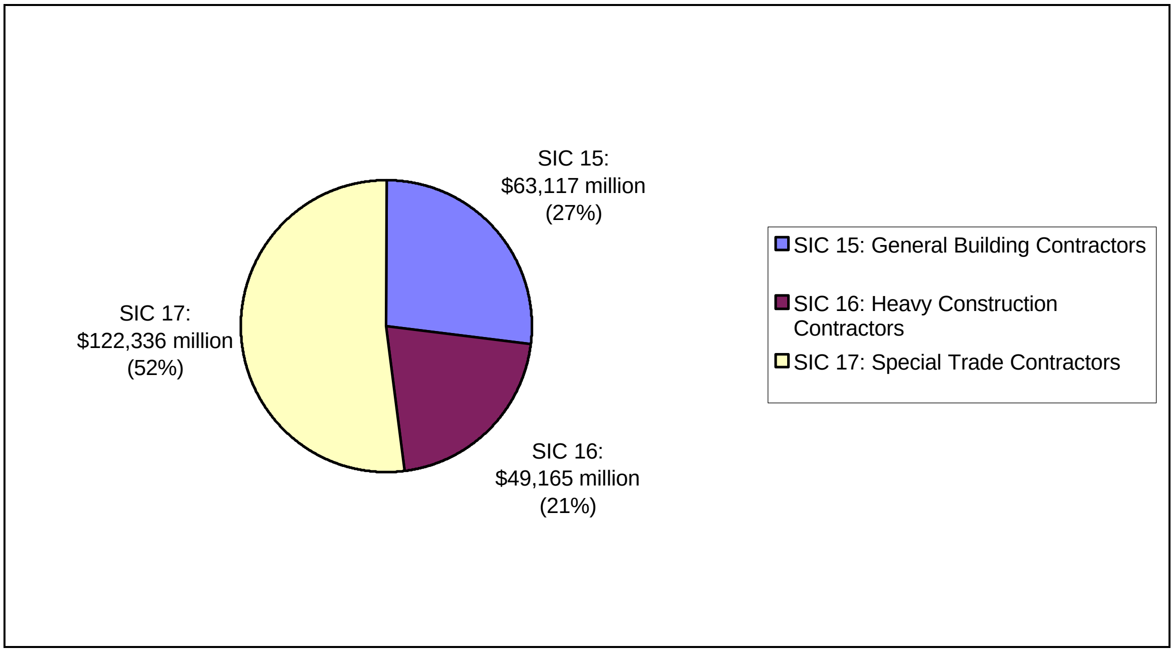
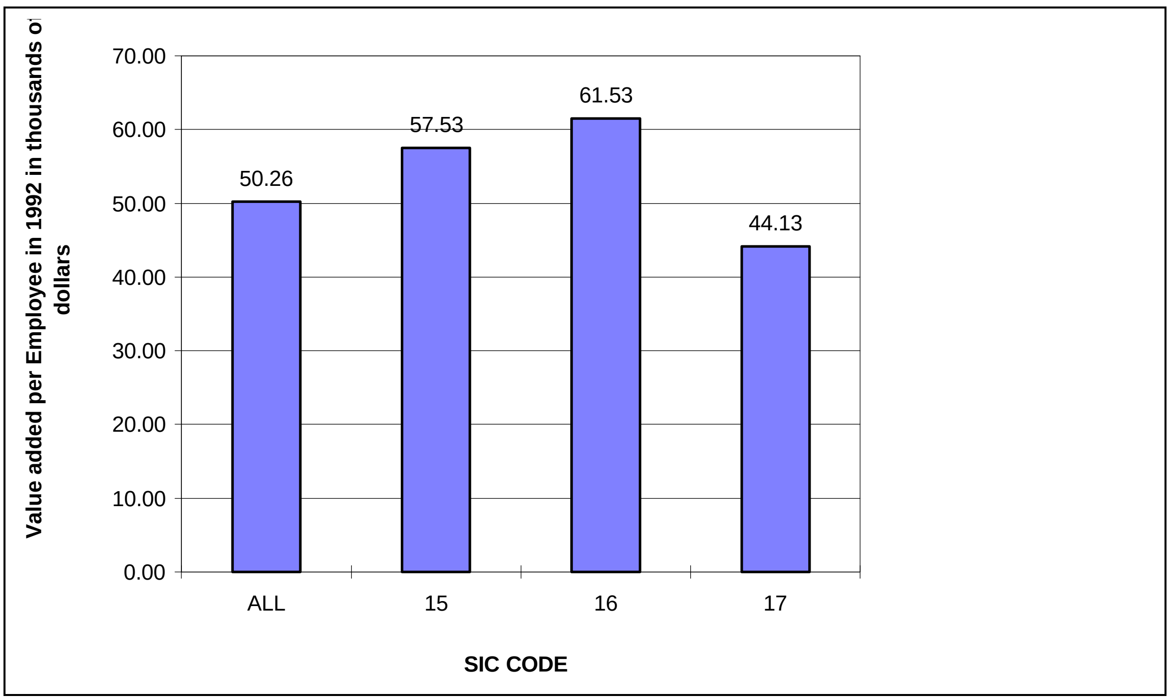


Figure A-13. Value Added per Employee for Establishments with Payroll: 1992



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