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Development and Assessment of the Tier II Work Force Strategy Implementation Index

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Development and Assessment of the Tier II Work Force Strategy Implementation Index

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Dedicated with love and appreciation

to my parents

and

my wife, Jeong-Yoon

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Development and Assessment of the Tier II Work Force Strategy Implementation Index

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The construction industry has been experiencing a major challenge in its work force, "the shortage of skilled craft workers." This problem has been caused by several factors such as the poor image of the construction industry, lack of training and education, unclear career path, declining wages, and changing work force demographics. A "step-change" approach called the "Two-Tier Work Force Strategy" has been proposed by the Center for Construction Industry Studies (CCIS) Work Force Research Team to deal with the work force related issues in a radical way. It is composed of two separate strategies, Tier I and II, and will provide a structure for long-term progress toward an improved work force.

This research characterizes the Tier II Work Force Strategy and develops its Implementation Index to measure the level of Tier II strategy implementation on projects. The Tier II strategy utilizes fewer, better-educated, and higher skilled

workers who perform some lower-management functions in addition to craft functions. They are paid more, but produce more through higher skills, stay on the job longer through multiskilling, and deliver improved project performance in safety, quality, schedule, and cost. The Tier II Work Force Strategy Implementation Index is composed of two major divisions: (1) Individual Worker Skills Index and (2) Tier II Project Index. The Individual Worker Skills Index assesses the skill level of an individual worker in both technical and management skills. The Tier II Project Index is divided into two parts: Project Workers Characteristics and Project Execution. The Project Workers Characteristics part assesses the skills of key crafts on a project regarding their technical and management skills. The Project Execution part assesses the effective use of skilled workers in executing the project and is divided into three categories: IT Utilization, Craft Utilization, and Organization.

Validation of the Tier II Work Force Strategy Implementation Index as a viable tool is a major focus of this research. For this purpose, five data sets collected in accordance with the Tier II metrics are presented and analyzed. It can be concluded from this research that the Tier II Strategy Implementation Index is a viable and easy-to-use tool for immediate use in the industry. Recommendations for future research and users of the index are provided. The Tier II Work Force Strategy has the potential to resolve the current work force problems and foster a better work force environment in the future.

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Chapter 1: Introduction

1.1 Problem Statement

The work force is perhaps the most valuable asset in the construction industry. Most of the construction tasks are completed by craft workers and labor cost comprises about 30% of the total project cost. Field labor is the most volatile element of a project and can significantly influence project cost, schedule, and quality. Safety of labor is also a critical factor for project success. However, there has been little emphasis on the importance of the work force and little effort has been exerted to attract, retain, manage, and develop human capital in the construction industry. As the result, the construction industry is now facing a major challenge, "the shortage of skilled craft workers."

This problem has been caused by several factors such as the poor image of the industry, lack of training and education, unclear career paths, declining real wages, changing work force demographics, and the changing economic and educational circumstances. These issues have been discussed since the late 1980s and many initiatives have been attempted to address the problem. However, those efforts were not enough to prevent the current work force problems. Since the industry did not know exactly what to do, the challenges of work force related issues still remain.

A "step-change" approach is needed to deal with work force related issues in a radical way. A strategy called the "Two-Tier Work Force Strategy" has been proposed by the Center for Construction Industry Studies (CCIS) Work Force

Research Team. It is composed of two separate strategies, Tier I and II, and if successful, should provide a structure for long-term progress toward an improved work force. The Tier I strategy uses less skilled and task trained craft workers, and has a larger administrative site management team than the Tier II strategy. The Tier II strategy utilizes fewer, better-educated, and higher skilled workers who perform some lower-management functions in addition to craft functions. They are paid more, but produce more through higher skills, stay on the job longer through multi-skilling, and deliver improved project performance in safety, quality, schedule, and cost. The Tier II strategy addresses the worker shortage issue through better retention and should facilitate recruitment.

This research focuses on the Tier II Work Force Strategy and its Implementation Index, and also provides a theoretical framework for both strategies. Considering that "what gets measured, gets improved," any attempt to improve requires measurement of outcomes as well as processes. There is no available measurement system to assess general management and utilization of the construction work force. This research addresses the metrics for such a system and validates the viability of the Tier II Work Force Strategy Implementation Index.

1.2 THE CENTER FOR CONSTRUCTION INDUSTRY STUDIES (CCIS)

CCIS is a research center in the Construction Engineering and Project Management (CEPM) Program at the University of Texas, Austin. The center was initiated with a multi-year grant from the Alfred P. Sloan Foundation and the

Construction Industry Institute (CII) in 1996. It is staffed by faculty and students from the college of engineering, college of business administration, and LBJ school of public affairs at the University of Texas. CCIS was created to perform multi-disciplinary, long-range studies addressing construction industry challenges in order to complement the traditionally short-term research process employed by the CII and others. It is dedicated to gaining a comprehensive understanding of the U.S. construction industry and to assuring its future competitiveness and advancement in a rapidly changing global environment. CCIS has a separate identity and organization from CII, yet it maintains a close relationship to gain ideas from CII members and to exploit CII resources and networking capabilities. CCIS has identified and initiated research in four thrust areas of pressing interest for the construction industry: (1) Owner/Contractor Work Structure, (2) Fully Integrated and Automated Project Processes (FIAPP), (3) Technology, and (4) Construction Work Force.

CCIS members have delivered more than 30 publications and 50 presentations to a wide variety of audiences. In addition, members of the CII Board of Advisors are regularly updated on CCIS findings. Less traceable, but certainly no less significant, is the incorporation of CCIS research results into academic curricula and industry practices. Several companies have reconsidered, and in some cases redirected corporate approaches as a result of CCIS research. The CII has also gained new and deeper insights into needs for further industry research, and new continuing education offerings will evolve as a result of CCIS research.

1.3 RESEARCH OBJECTIVES

The primary purpose of this research effort is to provide a radically different work force management approach to solve the current work force related issues. To achieve this, the objectives of this research are as follows:

1. Identify common characteristics of a Tier II Work Force Strategy and necessary elements for implementation.
2. Develop effective, simple, and easy-to-use metrics to measure the level of implementation for the Tier II Work Force Strategy.
3. Gather some preliminary data to assess current skill level of craft workers and status of the construction industry for Tier II strategy implementation.
4. Validate the viability and usefulness of the Tier II Strategy Implementation Index.

1.4 RESEARCH SCOPE

This research investigation is limited to the development of a Tier II Work Force Strategy and its Implementation Index, which is composed of assessment metrics to measure the level of implementation of the Tier II strategy. However, the concept of a Two-Tier Work Force Strategy including Tier I and Tier II is presented and a method of quantifying project success in construction phase is introduced.

The Tier II Work Force Strategy is a new concept proposed by CCIS to solve current work force related problems. The strategy is concentrated

exclusively on the construction phase of industrial projects because the other phases, such as engineering, procurement, and operation, are not directly related to the work force issues.

Identifying the relationship between the Tier II strategy implementation and project success is a multi-year, multi-project endeavor. CCIS will begin to solicit pilot projects to implement the strategy and several years of data collection will be needed to verify the effectiveness of the Tier II strategy.

This dissertation validates the viability and applicability of the Tier II Strategy Implementation Index with five data sets and provides process and methodology for an application of the Tier II Strategy Implementation Index on a real construction project.

1.5 DISSERTATION ORGANIZATION

This dissertation is divided into seven chapters. Chapter 1 describes the existing work force problems, research objectives, scope, and hypothesis. Chapter 2 contains background information and a literature review regarding the construction industry, detailed work force problems, and previous work force initiatives. The research methodology is presented in Chapter 3, including the approach of CCIS sponsored research, the process of Tier II strategy development, and the procedures for application of the Tier II strategy. Chapter 4 presents the concepts of the Two-Tier Work Force Strategy, the introduction of project success in the construction phase, and the theoretical Tier II strategy research model. Chapter 5 provides detailed descriptions of the Tier II Work

Force Strategy Implementation Index development process, the metrics developed, weighting of five categories using Analytical Hierarchy Process (AHP), and how to compute the index. Chapter 6 discusses the validation of the Tier II Strategy Implementation Index as a viable tool. Five data sets are collected including workshop attendees' self-evaluation, questionnaire, and applications of pilot projects. The results of the data analyses are also presented in detail. Finally, Chapter 7 concludes the research of the Tier II Work Force Strategy with its Implementation Index and offers several recommendations for users and for future research. Discussion about the contribution of this research in academia and the industry is also included.

Chapter 2: Background and Literature Review

Many organizations, including the Business Roundtable (BRT), the National Center for Construction Education and Research (NCCER), and the Construction Industry Institute (CII), have recognized recent work force challenges in the U.S. construction industry. The Sloan Center for Construction Industry Studies (CCIS) has extensively researched work force issues since 1997, including an interim assessment of key work force challenges in construction, multi-skilling, U.S. construction labor productivity trends, return on investment of training and education in construction, the effects of computers on foremen, and impact of the Internet on recruitment of skilled labor.

In the future, the industry may be able to reduce the number of workers needed to build a project as is required today through use of advanced technology, multi-skilled workers, productivity improvement, better training, and better work force utilization. The construction industry could improve the recruiting and retention of workers with higher wages, more work hours per year, better benefits, clear career path, and improved working conditions.

The following sections describe the current work force issues, causes for the work force problems, previous work force initiatives to address the problems, and some related research. All of these have formed the basis for the development of the Tier II Work Force Strategy.

2.1 U.S. CONSTRUCTION INDUSTRY

The construction industry comprises a significant portion of the entire U.S. economy. The annual value of new construction is more than $800 billion and represents approximately 8% of the Gross Domestic Product, which is the total of all goods and services produced in the U.S. (FMI 1999, U.S. Census Bureau 2001). The industry consists of about 630,000 companies, 82% of which have fewer than 10 employees. The large companies, having 100 or more employees, total less than 1% of construction establishments (Center to Protect Workers' Rights 1998). This fragmentation in the industry has prevented developing industry standards and investing in training.

There are approximately 8.6 million workers in the U.S. construction industry including wage-and-salary workers and self-employed workers, which are 6.4% of the total U.S. labor force (CPWR 1998). This number increases to more than 10 million when design, new construction, renovation, equipment and materials manufacturing, and supply are included (Bernstein and Lemer 1996). The design and construction industry together comprises the nation's largest manufacturing industry.

2.2 SHORTAGE OF SKILLED CONSTRUCTION WORKERS

The biggest challenge facing the construction industry is its shortage of skilled craft workers. There have been many predictions of a potential shortage of skilled workers in the construction industry. According to the results of the Business Roundtable survey in 1996, over 60% of the respondents indicated they

had encountered a shortage of skilled craft workers, and 75% reported the trend had increased over the past five years (BRT 1997).

This problem is a combination of worker shortage in addition to deficient skill levels of craft workers caused by insufficient or outdated training. This problem could result in increased project costs and schedule delays. The schedule delays often cause dramatic cost increase. The productivity of workers can be lowered and the quality of project can be degraded. The projects of recent years are more sophisticated than ever before and demand craft workers with more knowledge, ability, and skills. The company that cannot perform quality work will eventually lose its business in construction.

Craft worker shortages were most frequently reported among electricians, pipe fitters, and welders. The Southwest and Southeast Gulf Coast areas have encountered shortages of workers most frequently (BRT 1997). The construction work force is getting older and fewer young people are being employed in construction (Gaylor 1997). As shown in Table 2.1, the construction industry is among the top seven industries with rapidly growing employment. To fill new worker opportunities and replace workers as they retire or leave, the industry has to recruit 8% of all new work force entrants (CII 1992) which totals between 200,000 and 250,000 new craft workers each year (BRT 1997). The influx of Hispanic workers into the construction industry cannot be the ultimate solution even though it can increase the number of workers for a short term. In addition to attracting new workers to the industry, retaining skilled workers is also important. If the industry were better able to retain more of its trained workers, it would

significantly relieve the burden of recruitment. The shortage of skilled workers remains a threat and will be much worse in the near future if the industry does not do something immediately.

Table 2.1 Industries with the Largest Employment Growth (1998 – 2008)

Industry Description	Jobs (000s)		Change	Avg. annual rate of change
	1998	2008		
Computer / DP services	1,599.3	3,471.6	1,872.3	8.1
Health services	1,209.1	2,018.3	809.2	5.3
Residential care	746.7	1,171.0	424.3	4.6
Management and public relations	1,033.9	1,500.0	466.1	3.8
Nursing and personal care facilities	1,762.0	2,212.9	450.9	2.3
Hospitals	3,926.1	4,336.9	410.8	1.0
Construction	5,984.8	6,535.0	550.2	0.9

Sources:Bureau of Labor Statistics (Workforce 2000)

2.2.1 Poor Image of Construction Industry

One of the major reasons for the shortage of skilled workers is the poor image of the construction industry. The image of the construction industry has degraded for several decades and the unfavorable image has hindered the efforts of recruiting new craft workers into the industry. The image problem in construction comes from many different perceptions. A career in the construction industry has meant a lifetime of hard, dangerous, seasonal, and dirty work with

too few holidays and not enough money. Young people view the construction trades as non-technical and unprofessional. The necessity to travel and relocate is also a major contributor for the poor image. This unfavorable image of construction exists not only in the U.S., but worldwide.

The construction industry could tolerate this in the past because there were always enough people willing to take on the challenges of new construction projects. However, the U.S. construction industry cannot continue business as usual due to several changes in the markets. The work force in the U.S. has decreased, so it is difficult for the construction industry to meet its work force needs when other industries are also competing for employees in the same decreasing work force pool. A career in construction ranked 244th in a survey out of 250 possible career choices based on criteria such as income, environment, outlook, physical demands, security, and stress (Krantz 2000). Physical, outdoor work is no longer viewed as rewarding by young people. In addition, the compensation for the construction worker is relatively low compared to the effort required.

The image problems must be addressed extensively. The industry must change young people's perception of construction as a career by emphasizing more of the positive opportunities, accomplishments, and importance of the construction industry, the nation's largest industry. Everyone in the industry, including owners, contractors, contractor associations, labor organizations, and academia, have to cooperate to improve the current poor image.

2.2.2 Unclear Career Path

There has been no distinctive career path in construction and an unclear career path has been another problem for recruitment and retention of workers. Promotional growth opportunities for craft workers are limited in construction and there is little advancement to management positions. A career in construction is inherently unstable and uncertain.

More than half of craft workers usually work in the industry for less than ten years and typical craft workers leave the job at age 36. The desire for a permanent and stable job is one of the primary reasons for leaving the construction industry (CII 1992, 2000). This indicates the loss of good workers with experience and skills.

A promotional career path has to be developed and given to the workers according to their skill and ability levels. It would serve as an incentive to stay and advance in construction. Necessary training and education should also be provided.

2.2.3 Lack of Training and Education

Craft training and education have received a tremendous amount of focus in recent years as a basic driving force to solve the current work force problems. In addition to training and education, testing and certification of the trained skills have been recognized as another important issue related to work force. Currently, there is no unified standard training and certification program in the construction

industry. The shortage of skilled workers is often attributed to the lack of training and education opportunities.

Clear differences exist in training philosophies between industry sectors. The union sector has broadly scoped, formal, and well-developed apprenticeship-based training, which represents a high level of investment with a long-term view. Nearly two-thirds of all registered American apprentices belong to construction trades. Part of this concentration of apprentices is attributed to the Davis-Bacon Act of 1931. Under the Davis-Bacon Act, contractors performing work in the public sector must pay prevailing wage rate (the full journeyman wage rate prevailing in the local labor market) to their workers unless the workers are registered apprentices. These provisions offer a unique incentive for employers to register their apprentices. Construction apprentices receive broad training and develop skills regarding all aspects of a particular trade through rotations lasting between three to five years accompanied by supplemental classroom instruction (CCIS Report No.3 1999).

Although apprenticeship training in the union sector is well-established and funded through collective bargaining agreements, the number of apprentices now being trained is substantially reduced as the union sector has experienced the effects of decreasing market share and the image problems of choosing construction as a career.

The open shop sector has been slow to develop training programs despite the advantages demonstrated by union apprenticeship. Some open shop employers have focused on narrow task training, which represents a low investment with a

short-term payoff. Large general contractors started training divisions in their own companies in the 1970s and contractor associations organized various programs including "Wheels of Learning", which is now a standard form of training sponsored by NCCER. The open shop sector began an initiative to standardize training curriculum on a national basis for the first time through establishment of the National Center for Construction Education and Research (NCCER) in 1995 (CCIS Report No.3 1999). Unity and support among contractors and associations are essential for the open shop sector to be successful in meeting the skilled worker needs of the future. Even though the open shop sector is the primary focus for NCCER, the entire industry can benefit from its research and education activities. The NCCER has made tremendous advances to involve numerous parties to support the training efforts and improve the industry as a whole. However, the NCCER does not have branches that actually provide the training and the standardized curriculum alone does not produce skilled workers. The challenge remains to implement that training through local initiatives. The open shop sector, as a whole, has not supported formal craft training to the extent necessary to systematically produce skilled craft workers.

The Business Roundtable recommended training as the most important mechanism to assure the successful performance of the industry and to confront the skilled work force shortage. However, contractors have hesitated to train because of the expense. In addition to the training cost, the investment in training and education is lost when a trained worker moves to a competitor and the benefits of training are difficult to measure. The unique characteristics of

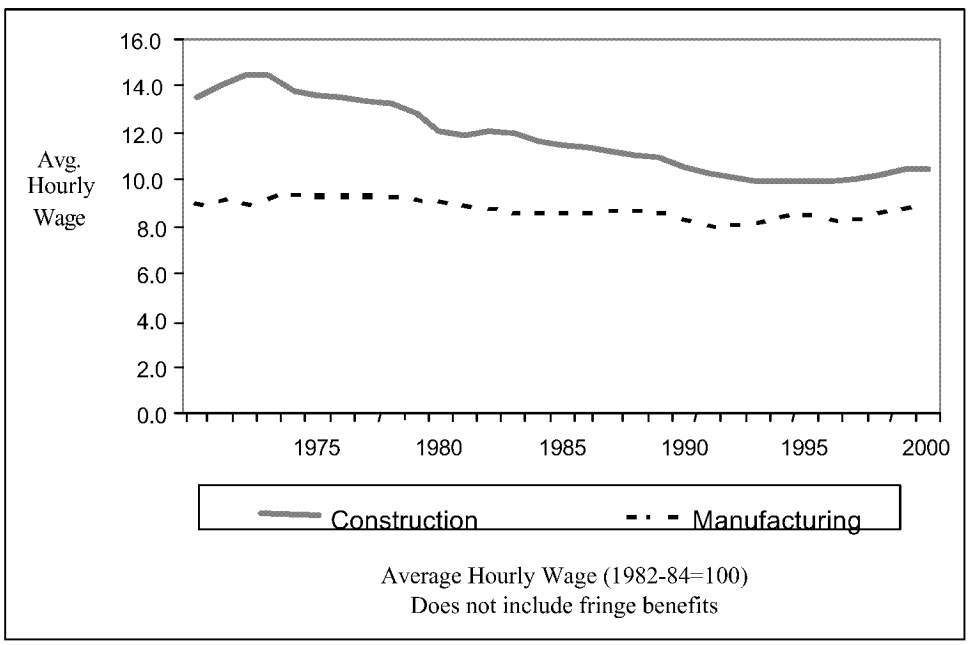
construction make it difficult to measure the return on investment (ROI) of training efficiently (BRT 1997).

Training is a critical issue for both union and open shop sectors. The industry must address this issue in order to maintain a skilled work force and to provide cost-effective construction. It is important that the industry make an attempt to unite and combine its forces to accomplish a common goal benefiting the whole industry. Owners should support work force training and limit their business relationships to contractors who invest in training and maintain the skills of workers (BRT 1997). Training should be imposed as a requirement like safety was, and then it should become a driving force for new environments of the construction industry. In addition to training and education, certification of skills is an important issue. If the industry can provide standardized certification to workers, it will provide huge benefits to workers, contractors, and owners. There is no consensus for certification even though union workers are certified as journeymen after spending three to five years as apprentices.

2.2.4 Declining Wages

Real wages in construction have dropped faster over the past 30 years than those in other industries. This can be partially attributed to the decline in the union force, which was estimated at 70% during the 1970s and has dropped to an estimated 20% in the 1990s (CPWR 1998). The real wages for construction workers have declined about 25% over the last 25 years (Hirsch and MacPherson 1997).

Figure 2.1 shows the comparison of average hourly wages in construction and manufacturing from 1970 to 1999. The average wage in the construction industry was 50% higher than manufacturing during the early 1970s. However, it declined continuously thereafter and now does not have an advantage over manufacturing. Fringe benefits are not included in the values for real wages.



Sources: Business Statistics of the United States, Fifth Edition (1999).
Original sources: U.S. Department of Labor, Bureau of Labor Statistics

Figure 2.1 Wages Comparison in Construction and Manufacturing 1970-2000 (Non-supervisory workers)

Several factors contributing to the declining wages in construction have been identified (Oppendahl 2000). First, uneven regional economic growth may have lowered relative wages in construction because wages tended to be lower in the higher growth regions such as the South and West during the last two decades.

Second, there has been a trend that the increase of wage premiums has been associated with higher levels of education and such increases in the returns to education have had the effect of lowering the relative wages of construction workers. Third, de-skilling due to advances in construction processes, methods, and pre-fabrication has reduced the need for high-wage skilled workers. Fourth, improved safety has lessened the wage premium related to the riskier nature of construction. Finally, the influence of unions has diminished in construction over the past three decades. The average hourly earnings in construction have declined as more non-union workers were hired at lower wage rates.

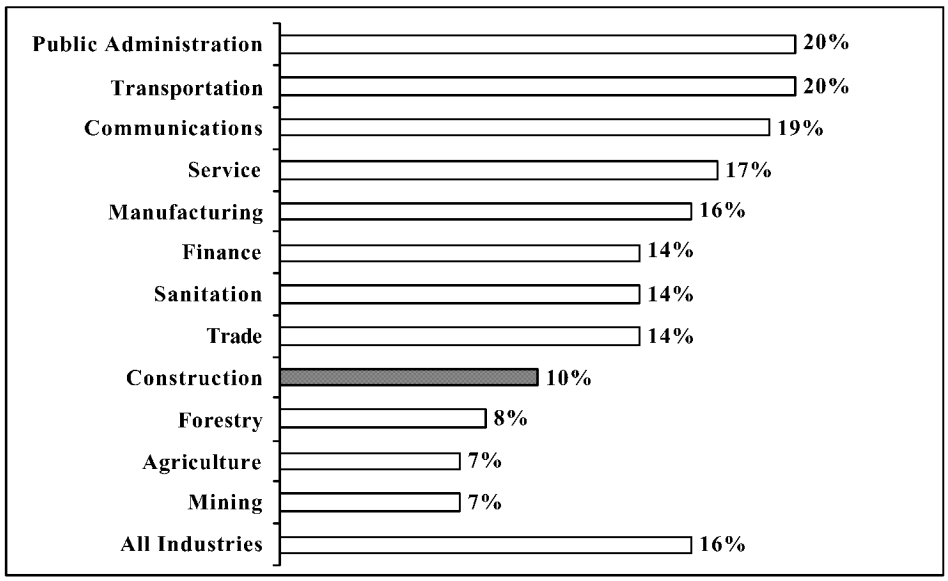
2.2.5 Changing Work Force Demographics

There have been significant changes in the demographics of the construction work force. It is necessary to understand the changes in recent years and the difficulties of contractors who are tackling the shortage of skilled workers.

The traditional construction workers in the U.S. have been white, American, non-Hispanic men who were 76% of construction production workers in 1996 (CPWR 1998). However, non-traditional workers such as minorities, immigrants, and women have increased their portion in the industry continuously. The industry has had to employ more diverse people to fill vacancies and these groups are essential for the future of the construction industry.

Minorities are all racial groups except white including black, American Indian, Aleut, Eskimo, Asian, Pacific Islander, and others. The percentage of

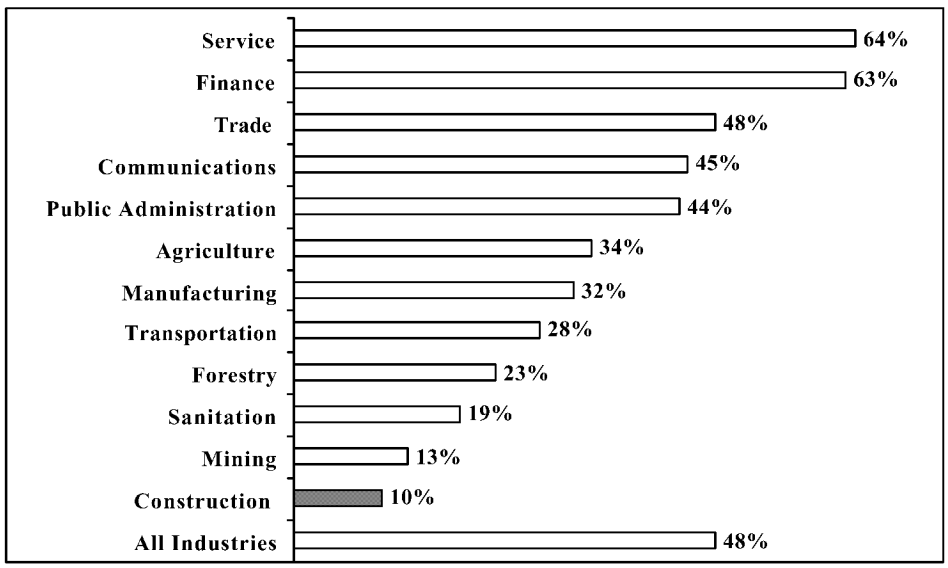
minority employees is lower in construction than in the other industries. According to the data from the Bureau of Labor Statistics in 1996, racial minorities accounted for 10.2% of the construction work force, while the average of all industries was 15.9% (CPWR 1998). These numbers are based on production workers only and production workers are defined as all workers except managerial and administrative-support staff, but including the self-employed. Figure 2.2 illustrates the percentage of minorities in construction and other industries.



Source: CPWR 1998, Bureau of Labor Statistics 1996

Figure 2.2 Employees in Racial Minorities as a Percentage of Each Industry (wage-and-salary workers)

Female construction workers are a small but growing percentage of the construction work force. Ten percent of total construction employees are women and more than 80% of them are employed in primarily clerical, managerial, and administrative positions. Only 2.5% of the production work force in construction is composed of female workers and most of the female production workers are employed as painters or laborers (CPWR 1998). Figure 2.3 shows the percentage of female employees in several industries and illustrates that the construction industry employs the least percentage of women. The physical demands have made it difficult for women to execute tough work on site, but an increasing number of tasks can be performed by women recently due to advances in technology and equipment.



Source: CPWR 1998, Bureau of Labor Statistics 1996

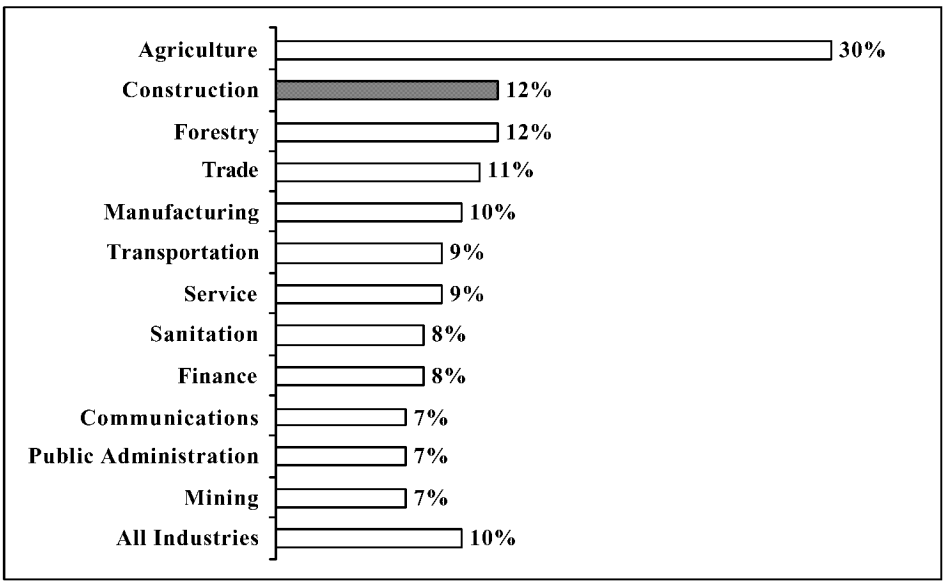
Figure 2.3 Female Employees as a Percentage of Each Industry (wage-and-salary workers)

The most important component of the U.S. construction work force currently is Hispanics and immigrant workers. Hispanic is defined separately from race and includes people who identify themselves as Mexican American, Chicano, Mexican, Puerto Rican, Cuban, Central or South American, or other Hispanic origin. Because of racial diversity in the Hispanic population, they are included in the white and black groups as well as other population groups and thus, there is overlapped data between the racial minorities and Hispanics. In addition, there could be many Hispanic people working illegally in the U.S. The numbers presented in several papers may lead to figures less than actual sum.

Hispanic workers are the fastest growing proportion of the construction work force. Workers of Hispanic origin represented 8.9% of wage-and-salary production work force in 1985 and have increased to 14.6% in 1995 (CPWR 1998). Figure 2.4 shows the percentage of total Hispanic employees in several industries and illustrates that the construction industry is second only to agriculture.

Immigrant workers, including racial minorities and Hispanics, have played an important role in the construction industry in recent years and the industry cannot survive without them. However, the introduction of immigrant and minority workers has contributed to the decline of wages because they are generally less skilled and more willing to accept low wages (Oppendahl 2000). The immigrant workers may increase the general number of construction workers for the present time, but the problems of lack of skills and declining wages are not disappearing and could become even more severe in the future. If the construction

industry treats the immigrant and minority workers the same in the future as it does today, they may leave for other industry sectors after they acquire adequate language skills. The industry should adapt to the changing demographics and cope with them.



Source: CPWR 1998, Bureau of Labor Statistics 1996

Figure 2.4 Hispanic Employees as a Percentage of Each Industry (wage-and-salary workers)

2.3 WORK FORCE INITIATIVES

The shortage of skilled workers has been recognized as a major challenge in construction for several years. Many initiatives have been undertaken and research has been performed to solve work force related problems. Most of the

efforts have resulted in limited success in the short-term. This section summarizes some of these initiatives to date.

2.3.1 Multi-Skilling

With a dwindling work force, the construction industry needs to get more out of its existing work force. Multi-skilling is a labor utilization strategy where workers develop a range of skills appropriate for more than one trade through extensive training. Multi-skilled workers can be used more flexibly on a project or within an organization. The use of multi-skilled workers in which construction personnel are trained in more than one trade has been estimated using data from the CII Model Plant Project. Results of the analysis showed a 35% reduction in the required project work force and a 24% reduction in labor costs as well as a 9% increase in average individual employment duration (Burlesson 1997). Multi-skilled workers could therefore increase their wages and annual earnings.

Impediments to effective multi-skilling include limits on human skill retention, complexity of maintaining a multi-skilled workforce, owner bid requirements, project management infrastructure, resistance to change, pride of craft association, and licensing requirements. Barriers between trades and organized labor have also prevented full utilization of the available work force. Nevertheless, some construction companies are already using some forms of multi-skilling as their business strategy.

Results from a simulation revealed that the benefits of multi-skilling became marginal when the percentage of multi-skilling was increased beyond a

certain point. Benefits in terms of reduction of total workforce to peak workforce ratio are observed to diminish after approximately 10% of the workforce becomes multi-skilled, as shown in Figure 2.5 (CCIS Report No.13 2000).

Figure 2.5 Diminishing Benefits of Multi-skilling

In a survey of more than 1,100 union and non-union craft workers, approximately 70% have worked outside of their primary trades, 79% are interested in learning more skills in their primary trades, and 57% are interested in learning skills in other trades. In addition, workers feel that multi-skilling will positively affect their work by allowing them to work more, stay on projects longer, receive better pay, create more mentally challenging jobs, and stay with the same company longer. The survey results also indicate that multi-skilling allows merit and open shop workers to work more weeks per year and to achieve better incomes (CCIS Report No.4 1999). Figure 2.6 shows the relationship between the number of skills a worker possesses and average weeks worked per

year. The more workers possess different trade skills, the more weeks they can work per year (CCIS Report No.13 2000).

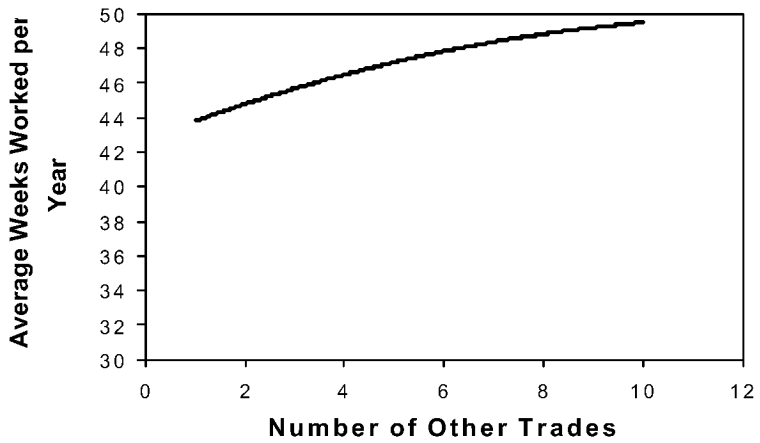


Figure 2.6 Effect of Multi-skilling on Employment

2.3.2 Impact of Technology on Construction Work Force

New technology is continuously allowing the construction work force to work more efficiently, safely, and less expensively, even though the construction industry has been slow and resistant to adopt new technology. Technology advances in construction have been accelerating in the past few years and the changes are challenging the ways construction is executed and work forces are utilized.

The use of computers has advanced the way projects are managed, controlled, and constructed. The computer was initially viewed as a tool for computations and technical or scientific applications; however, it has changed the way construction is executed more than any other technology (Oberlender 2000).

Technological progress has led to new construction processes, methods, materials, and techniques, many of which reduce the need to hire more skilled workers. The new equipment and better knowledge of overcoming nature have also reduced the impact of the seasonal cycles of construction (Oppendahl 2000). In a study of construction productivity, it was discovered that technology has had an impact on productivity gains of construction workers although there is little consensus concerning even the direction of construction productivity trends over the last 30 years (CCIS Report No.7 1999, Allmon et al. 2000).

Use of computers has improved the ease and level of communication through the Internet and e-mail, which allows information to flow without delay among all project participants - owner, architect, general contractor, and workers on site. Project schedule and cost could be improved significantly by reducing delays in receiving proper information. Computers are also used to track materials, equipment, labor, and project progress. Project reports regarding schedule, cost, safety, and quality could be filed electronically, reducing paperwork and time and also allowing for easy reference later. Front-line workers could have much more information, responsibility, and authority using the information technology, provided that enough training and education are given.

In research on the impact of computers on foremen, the foremen employed by six companies utilizing foremen-level task automation were surveyed. Among the 179 foremen who responded, 57% used computers at work. Of the foremen who used computers at work, 77% reported that they were comfortable with computers. A computer-using foreman spends 7% more time supervising his crew

than does a non-computer-using counterpart, and he also spends less time completing non-supervisory tasks, as shown in Figure 2.7. It is generally accepted in the industry that time spent supervising rather than doing paperwork is directly productive and improves the productivity of the crew (CCIS Report No.9 2000).

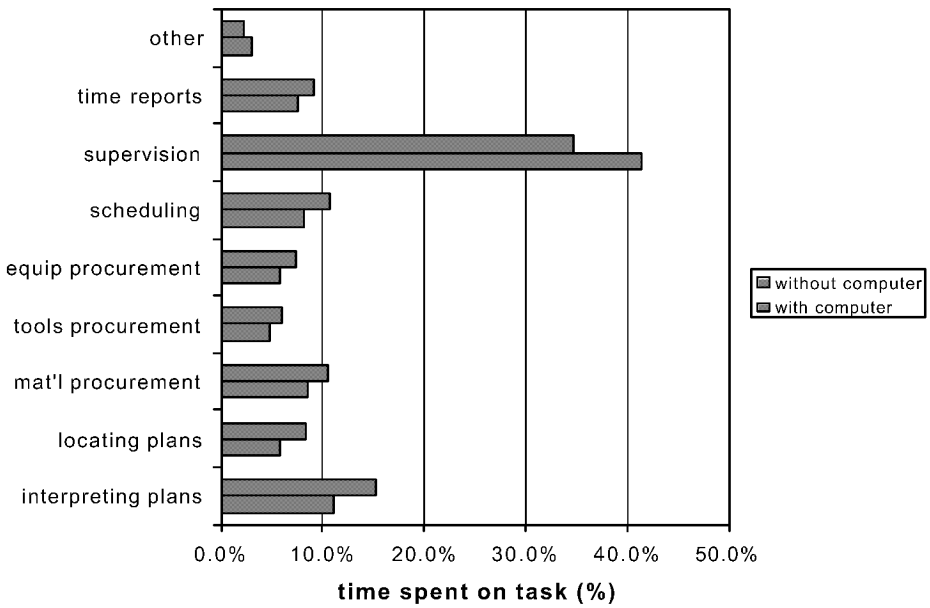


Figure 2.7 Foremen Activity With and Without Computers

2.3.3 High Performance Work System and Organization

A high performance work system has been proposed not specifically for the construction industry but for general organization in industry. The concept is very promising for the future of the construction industry. The characteristics of the high performance system have formed the basis for the Tier II Work Force Strategy.

The importance of change to a high performance system from a mass production system was emphasized by Ray Marshall (1996, 2000). With the globalization of national economies, global competition cannot be avoided by countries, companies, and people if they want to thrive. Because of global competition, they can compete in only two ways: reduce wages and incomes, or increase value added (i.e. productivity and quality). The only way for those following the low-wage option to improve total incomes is to work more, a reality that clearly limits economic progress. The high-wage, high productivity option, by contrast, could create very steep learning and earning curves, and therefore holds greater promise for personal, organizational, and national advancement. National strategies are necessary to create environments that discourage the low-wage alternative and encourage companies to organize for high performance.

The characteristics of high performance organization according to Ray Marshall (1996, 2000) are as follows: (1) Productivity, Flexibility, and Quality, (2) Worker Participation and Lean Management Systems, (3) High-Order Thinking Skills, (4) Development and Use of Leading-Edge Technology, (5) Positive Incentive Systems, and (6) Workers' Independent Sources of Power.

The construction industry has traditionally followed the low wage option, which is dependent on low skilled labor and resources instead of ideas, skills, and knowledge. The low wage option is not productive, not quality-driven and limits improvements in incomes to hard work and the use of more physical resources, which is inherently self-limiting. Under the low wage option, workers' skill training is limited to specific, minimal tasks and workers have less flexibility

among jobs on site. The construction industry may look at the high performance system to revive in the future.

2.3.4 SELF-MANAGED WORK TEAM

Poor management has often been blamed for inhibiting the productivity of workers due to considerable delay time on site, including rework for design errors, and waiting for materials, tools, equipment, and information. A past study found that poor management was responsible for more than half of the time wasted on a job site (BRT 1983). Management has also been credited with blocking free discussion and exchanges of ideas, partially due to the hierarchical nature of construction. The work on site will be more efficient and delays can be reduced significantly if the workers perform some of the management functions and make decisions by themselves.

The self-managed work team (SMWT) is a part of the Tier II Work Force Strategy under the category of Organization. The SMWT consists of employees who are responsible for managing and performing technical tasks resulting in a product being delivered. Team members are typically responsible for managing most aspects of the work and performing all the technical tasks involved. Technical tasks are typically rotated among team members, as are management responsibilities, such as monitoring the team's productivity and quality. The team members of SMWT have the authority, as a team, to make decisions about the work and to handle internal processes as they see fit to generate a specific team product, service, or decision. With the given authority, they should have enough

knowledge, skill, and ability to perform any given work. Interpersonal processes within and between teams are also important in SMWT including communication, coordination, cooperation, conflict, cohesion, and trust (Yeatts 1998).

The term SMWT is used interchangeably with high performance work team (HPWT). Even though the meaning of the terms would depend on the party who uses it, the concepts of SMWT and HPWT are the same most of the time.

A field study about the high performance work team was performed in 1998 (CII Special Publication 98-12). HPWT was defined in the study as a group of craft persons who are collectively highly motivated, technically competent in a craft, success- and goal-driven, and willing to work in a team environment. The advantages of high performance work teams are summarized as follows:

1. Employees know best how to perform their jobs.
2. Employees want to "own" their work and make contributions to their organizations.
3. Work teams provide growth opportunities for employees.

The important factors for the success of HPWT are recognized as follows: safety, training and development, planning and coordination, recognition and reward, materials, tools, and equipment, openness, teamwork, employee involvement, foreman and management effectiveness, client focus, clear goals and direction, and performance assessment.

This field study project achieved less conflict, improved communications, team member ownership, scheduled milestone dates, good productivity, and

satisfied clients. The HPWT approach was also proven to have great benefits in project performance, including safety, cost, schedule, and quality.

Another study for identifying success factors for high performance project teams was performed by CII (Dukerich and Ammeter 1998, CII Research Summary 134-1 1999). High performance was defined as 10% (or better) improvement over the cost, schedule, safety, and quality target, where the targets were aggressively set. Common characteristics of high performance project teams in the construction industry were identified as follows:

1. Effective Leader Behaviors – communicating project goals, setting high standards and expectations, supporting team decisions.
2. Team Member Characteristics – commitment and dedication to the project, sense of ownership of the project, the right qualifications to meet the team's needs.
3. Team-Building Type Behaviors – participation in formal and informal team building, recognizing and celebrating success.

Among these three characteristics, leader behavior showed the strongest association with project performance, especially with reduced cost growth. Team-building type behaviors did not show a strong relationship with performance of project teams. Given the strong relationship between performance and leader behavior, it is possible that team building in the absence of effective and consistent project leadership behaviors may not be as effective as generally thought. There was a strong relationship between team building and leader behaviors, suggesting that good project leaders naturally use team-building types

of activities. The research also found that the use of best practices was positively associated with the project's cost and schedule performance.

HPWT is a very promising approach because fewer workers, increased competition, and fast track projects require employees to provide solutions to typical problems on their own. Construction companies are concerned about availability of skilled trade people to meet their needs and HPWT can be part of a solution for that problem. All the characteristics of HPWT are included in the category of Organization under the Tier II Work Force Strategy.

2.3.5 Communication

Effective team communication is one of the critical factors for the success of a project. It is necessary to identify, compile, and accurately disseminate relevant information among team members throughout the entire life cycle of a project. Project performance can be enhanced through effective project communications and conversely, a project can fail if hindered by poor communication. Communication problems are apparent and would be worsened if they exist on the project and information does not flow smoothly (Thomas 1996).

Thomas (1996) performed research showing strong and positive correlation between effective communication and project success. Six categories were identified which measure the perceptions of communication effectiveness. Table 2.2 shows those six categories with relative importance indicated by weights (Thomas 1996).

Table 2.2 Communications Categories and Weights

Category	Description	Weight (%)
Accuracy	The accuracy of information received as indicated by the frequency of conflicting instructions, poor communications, and lack of coordination.	21
Procedures	The existence, use and effectiveness of formally defined procedures outlining scope, methods, etc.	19
Barriers	The presence of barriers (interpersonal, accessibility, logistic or other) interfering with communications between supervisors or other groups.	18
Understanding	An understanding of information expectations with supervisors and other groups.	16
Timeliness	The timeliness of information received including design and schedule changes.	14
Completeness	The amount of relevant information received.	12
		SUM = 100 (%)

Language is probably the most common barrier to effective communication (Sigband and Bell 1989). A large portion of U.S. work force has been replaced with Mexican workers in recent years and the resulting language problem is a significant concern at construction sites. Poor organizational structure with many layers may result in inadequate information flow. From a study about communication, workers at the lowest levels of the organization were shown to receive as little as 20% of the information disseminated. Even at the upper levels, vice presidents, second in the hierarchy, only received 63 percent (Gibson and Hodgetts 1990).

Recent construction projects have become more complicated than before and are composed of many teams representing various organizations. The competing interests of people among the teams as well as within a team could serve to complicate communications.

2.3.6 Enhancement of Construction Industry Image

The poor image of construction was discussed in the Section 2.2.1 as a major cause for the shortage of workers. As an effort to address the poor image of construction and discuss solutions for it, the National Center for Construction Education and Research (NCCER) held the National Construction Image Summit in 2000 with 150 industry leaders from construction companies, owners, labor, associations, manufacturers, and academia. The strategic plan developed by the conference attendees led to the formation of the Image Steering Committee in 2001 to lead this initiative. The committee has been charged with a mission to develop a path forward that can be used by the entire construction industry.

The National Construction Image Steering Committee includes seven subcommittees in addition to a governing body to determine the major issues affecting the poor image, find viable solutions, and resolve the problems of recruitment and retention. The seven committees will be tackling issues such as work force diversity, wages and benefits, employee relations, awards and recognition criteria, media and public relations, education/school to career, and an industry web site. The vision of the effort is to make construction the career of choice (Bennet 2001).

2.4 SUMMARY

The background research and literature review revealed that the construction industry has been suffering from a shortage of skilled workers, which was caused by the poor image of construction, unclear career paths, lack of training and education, declining wages, and changing work force demographics. Each of these causes was investigated through an extensive literature review.

Many initiatives and studies to solve the work force related problems have been performed, including but not limited to multi-skilling, the impact of technology on the construction work force, high performance work teams (HPWT), and communication. Most of the efforts have resulted in limited success in the short-term.

A strong need to develop a revolutionary approach has been identified and the literature review has formed the basis for the development of the Tier II Work Force Strategy.

Chapter 3: Research Methodology

This chapter explains the procedures employed in the development of the Two-Tier Work Force Strategy, mainly focusing on the Tier II Work Force Strategy and its application. An overview of the various stages of this research process is provided in Figure 3.1. The CCIS work force research effort is intended to be perpetual and long-term results oriented. This characteristic assigns additional challenges to the CCIS Work Force Research Team and the Steering Committee.

The research for the Two-Tier Work Force Strategy was initiated by the CCIS work force research team at The University of Texas at Austin. The research team established the basis of the strategy and proposed the idea to the CCIS work force steering committee. After the committee reviewed the basic concepts and approved further research, the team at The University of Texas performed considerable research, including a literature review and team discussions, and clarified concepts about the Two-Tier Strategy. Preliminary Tier II strategy implementation metrics had been developed and they were revised through steering committee meetings and workshops until they were finalized.

Weightings of the elements were determined by debate among the steering committee members. Finalizing the elements of the Tier II Work Force Strategy Implementation Index, classifying those elements into five categories, and then weighting each elements required inputs from a broad range of construction industry experts representing owners, general contractors, research associations,

and academia. Analytical Hierarchy Process (AHP) was used to determine weightings of the five categories. The developed metrics were presented in workshops and CII conferences.

The Individual Worker Skills Index assessing the technical and management skills of workers has been tested by attendees of the second CCIS workshop to evaluate the current level of workers and to verify the applicability. The Tier II Work Force Strategy Implementation Index has been applied to pilot projects and they provided insightful results.

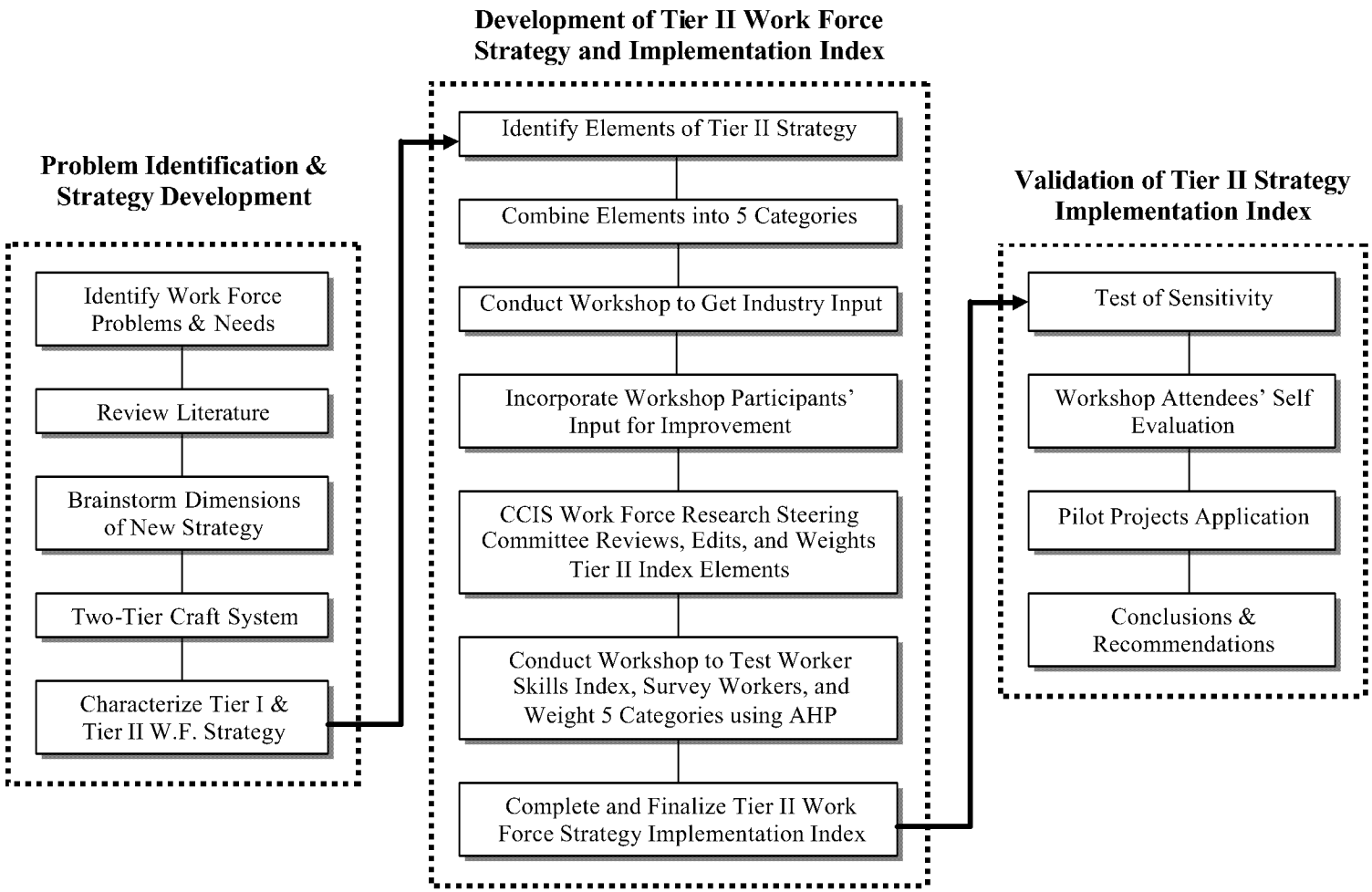


Figure 3.1 Research Methodology Flow Diagram

3.1 APPROACH OF CCIS-SPONSORED RESEARCH

The executive advisory panel, comprised of senior executives from major owners, contractor companies, and associations, has provided overall guidance to assure the research is focused on the most pressing issues facing the construction industry. High-quality research into capital projects requires tight linkages with industry. CCIS research activities have involved and relied upon an immense amount of industry input. The previous CCIS studies have acquired data from more than 300 organizations.

There are currently four thrust areas in CCIS: (1) Fully Integrated and Automated Project Process (FIAPP), (2) Owner/Contractor Work Structure, (3) Technology, and (4) Construction Work Force Issues. For each of these thrust area, there is a steering committee which determines the direction of research.

Professors and graduate research assistants conduct research projects with guidance and support from the steering committee. The working relationship between the academic and the industry members is a joint effort and very important for the success of the research. Discussions among the academic and industry members often result in modification of research questions, approach, and data collection. Industry members are especially helpful in acquiring data. They also assist in interpretations arising from data analysis, and in devising strategies for improving industry practices as a consequence of the research findings.

The CCIS Work Force Steering Committee is composed of thirteen industry leaders, including the president of the United Brotherhood of Carpenters

and Joiners of America, the chairman of a multibillion dollar merit shop contractor, the director of the National Center for Construction Education and Research, and director-level representatives from leading owner and constructor firms from around the nation. The list of the CCIS Work Force Steering Committee is included in Appendix A. The committee members have met several times in Austin, Texas to provide guidance, valuable reviews, and recommendations on the Tier II strategy and metrics, which were developed by the graduate research assistants and faculty at The University of Texas at Austin. The committee members were very knowledgeable about real industry problems currently being experienced in their companies.

3.2 PROBLEM IDENTIFICATION AND STRATEGY DEVELOPMENT

The first stage of this research was to identify current work force problems and develop the concept of a new step change approach. To identify current work force problems, tremendous amounts of literature were studied and discussed among CCIS work force research team members at weekly meetings. After identifying problems, new strategies that could give long-term solutions in construction were brainstormed among team members, and finally the concept of a Two-Tier Work Force Strategy was developed.

The Two-Tier strategy, which is composed of Tier I and Tier II strategies, was developed to address the shortage of skilled workers through a formalized structure of the work force. This strategy provides the industry with a new work force structure where construction companies can choose one of the two Tiers

depending on their situations. Each of the Tier I and Tier II strategies was characterized distinctively and proposed to the steering committee. It was agreed that the strategy could revive the construction industry if successfully implemented in real projects, and therefore the committee approved a continuation of the research effort.

Three research areas have been identified as Tier I, Tier II, and construction success. It was decided that three different research teams would perform research in each of these areas. CCIS has conducted research about the Tier II Work Force Strategy, which is the most important and innovative approach. Research about the Tier I Work Force Strategy and construction success has been performed by the CII RT 182 and the CII BM&M team, respectively. Each of these teams decided to develop appropriate metrics. This dissertation is about the Tier II Work Force Strategy and its Implementation Index.

3.3 DEVELOPMENT OF TIER II WORK FORCE STRATEGY AND ITS IMPLEMENTATION INDEX

The concept of the Tier II work force strategy was new and many industry practitioners did not know much about this approach. It was essential to identify necessary elements of the Tier II strategy first with the consensus of industry. Elements of the Tier II strategy were identified from a year-long research effort and the elements were combined initially into six categories: Craft Training and Certification, Craft Management Training, IT Utilization/Impact, Necessary Metrics, Craft Utilization, and Work Structure. Literature, including books,

journal articles, magazines, theses and dissertations, were reviewed to identify the necessary elements for each category of the Tier II strategy.

The first workshop to obtain the industry perceptions and feedback for the Tier II strategy was held in Austin, Texas on February 12 and 13, 2001, with 31 executives representing 25 construction and owner companies, 4 directors of research organization, and 4 faculty members and 10 graduate students from The University of Texas at Austin. The list of the first workshop attendees is attached in Appendix B. There was consensus among attendees that the industry should provide new ways of treating the work force in order to revive the industry in the future. The initial set of elements, categories, and metrics was revised and necessary steps were recommended by the participants' inputs. The 40 attendees at this workshop were greatly helpful in developing the final metrics presented in this document.

After the first workshop, the steering committee and CCIS work force research team reviewed and revised the elements again, and decided five essential categories characterizing the Tier II Work Force Strategy as follows: (1) Craft Technical Skills, (2) Craft Management Skills, (3) IT Utilization, (4) Craft Utilization, and (5) Organization. The former elements were arranged according to these five categories. The steering committee members determined the weights of the elements according to relative importance in hours of debate. They also filled out blank matrix forms for the Analytical Hierarchy Process (AHP), which was used to determine weights of the five categories. Some people may argue that the weights of elements are subjective and do not have scientific significance;

however, the author and research team felt that they are good enough as initial weights. The steering committee members are the experts in construction with significant experience, about 30 years for each person, and they know the industry better than anybody. The weights will be adjusted as data are gathered and new results are revealed.

The second workshop involving craft workers was again held in Austin, Texas on July 12 and 13, 2001. Twenty-one experienced quality craft workers were invited to share the idea of the Tier II Work Force Strategy and obtain some feedback from them. The list of the second workshop attendees is attached in Appendix B. The attendees had a chance to evaluate their own status in regard to the Individual Worker Skills metrics and questionnaires were distributed for the same workers to observe several aspects of the current work force in construction.

Based on the feedback from attendees and the analysis of their self-evaluation, some of the elements and the metric scores were adjusted. Their responses were valuable in adjusting and further developing the Tier II strategy. The attendees also filled out the blank AHP matrix forms for weighting the five categories and these results were combined with the input from the CCIS steering committee meeting.

After the second workshop, the Tier II Work Force Strategy Implementation Index was finalized. Elements having the highest impact and most applicability have been selected at the current stage; however, these elements and metric scores, as well as their weights, are not fixed. They may be

updated as more project data are gathered and analyses show enough evidence for change.

The Tier II Work Force Strategy and its Implementation Index, along with the Tier I concept, were presented in the 2001 CII annual conference at San Francisco, California, and the CII Construction Project Improvement (CPI) conference at Austin, Texas. Responses from the attendees were positive and valuable. Pilot projects for actual implementation of the Tier II strategy were solicited and the research team acquired several pilot projects. The CII conferences were very effective in informing the construction industry of the Two-Tier Work Force Strategy.

3.4 VALIDATION OF TIER II WORK FORCE STRATEGY IMPLEMENTATION INDEX

After developing the Tier II Implementation Index, validation of the index as a viable tool is necessary for immediate use in the construction industry. This validation is the most important process in this dissertation. Five data sets were gathered and used for this validation of viability.

The sensitivity and robustness of the Tier II Implementation Index were tested using CII Model Plant Project. The index turned out to be insensitive regardless of the different judgments of the evaluators. Most of the assessment was within the range of Mean ± Standard Deviation (SD).

The self-evaluations of the second workshop attendees were analyzed and gave meaningful results about the current skill level of quality workers in the construction industry. The questionnaire answers also yielded valuable

information regarding current craft workers' backgrounds and their perception about the Tier II strategy.

The Tier II Implementation Index has been applied to two pilot projects to validate its applicability and viability. The index turned out to be easily applicable to real industry projects and the metrics were easy to measure. The process and methodology used for the pilot projects can be repeated for future project applications.

The pilot projects did not exhibit a high degree of implementation of the Tier II elements at the time of data collection. The research team made recommendations for improvement in critical elements. However, the initial results gave a general idea about the current implementation level of the Tier II strategy in the construction industry. The current skill level of workers in the project was also identified through the Individual Worker Skills Index.

The effectiveness of the Tier II Work Force Strategy and its Implementation Index cannot be fully validated at this time because there are not enough project data to show the relationship between the level of Tier II strategy implementation and construction success. The process of data gathering will continue as a perpetual effort in the CCIS work force research team and hopefully the industry will be convinced with the results, resulting in rapid adoption of the strategy. Complete explanations with analytical results are provided in detail in Chapter 6.

3.5 SUMMARY

This chapter outlined the procedures and methodologies employed in this study. There were three progressive stages in this study as follows: (1) Problem Identification and Strategy Development, (2) Development of the Tier II Work Force Strategy and its Implementation Index, (3) Validation of the Tier II Work Force Strategy Implementation Index. Several techniques such as the Analytical Hierarchy Process (AHP) and the regression analysis were used to determine weights and perform data analysis. The next chapter presents the detailed process of developing the Two-Tier Work Force Strategy and characteristics of the Tier I and Tier II strategy.

Chapter 4: Development of Two-Tier Work Force Strategy

This chapter provides the concept of the Two-Tier Work Force Strategy, which is composed of two distinct strategies, the Tier I and Tier II strategies. These two strategies are compared and characteristics of each strategy are explained. The research model of the Tier II Implementation Index, which is the main focus of this research, is illustrated in graphical form with a brief explanation. Finally, project success in the construction phase is mentioned, although it is outside the scope of this research effort.

4.1 Causes, Effects, and Solutions

Several work force problems in construction have been discussed in Chapter 2. Figure 4.1 shows the causes, effects, and solutions of work force issues in a simplistic way. More money should be invested in the industry for better training and higher compensation of workers. Foreigners, minorities, and women could relieve some burden of the shortage of workers. Technology and automation could reduce the need for skilled construction workers. However, none of these alone can provide the ultimate solution for the work force issues and there should be a "step change" approach including all of these partial solutions.

To continue its major role in the U.S. economy and to revive its workforce in the future, the construction industry must find ways to remain competitive with other industries. The construction industry must develop new strategies to attract,

retain, maintain, and utilize workers and provide incentives for workers to continue their construction careers.

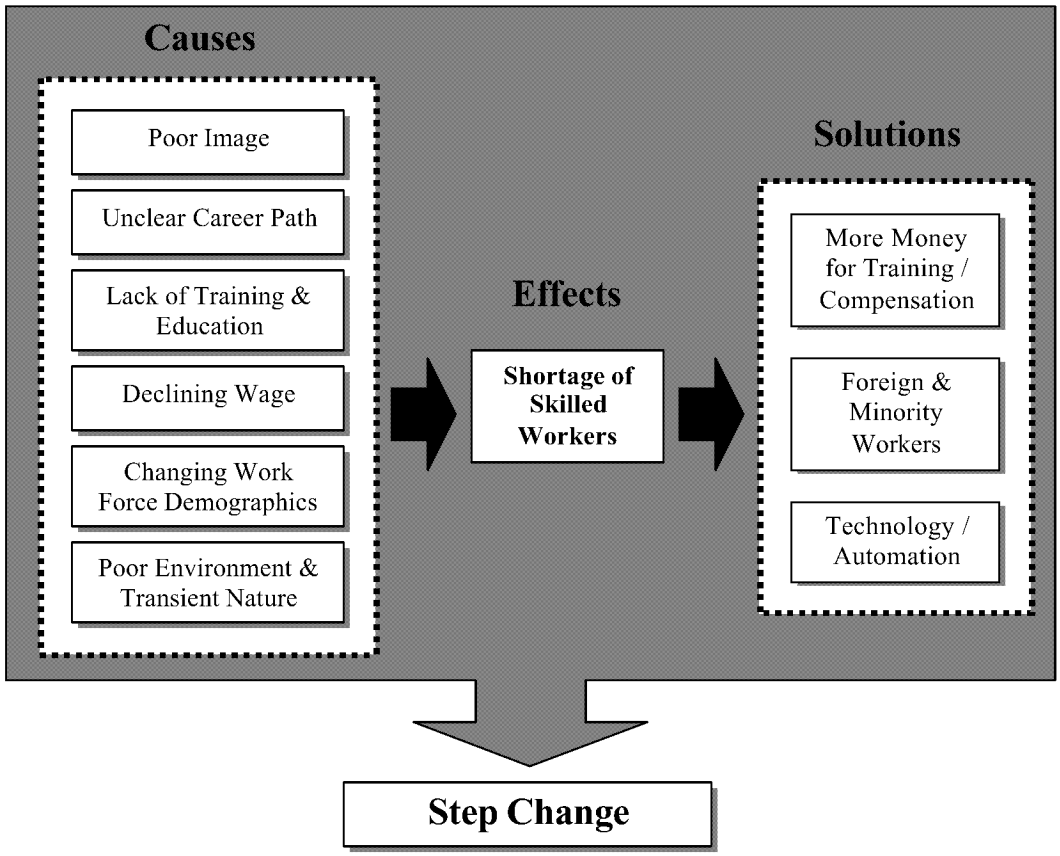


Figure 4.1 Causes, Effects & Solutions of Work Force Issues

4.2 TWO-TIER WORK FORCE STRATEGY

Many initiatives including multi-skilling, technology usage, high performance work team, and enhancement of the industry image have been undertaken to address the problem of the shortage of skilled workers. Since most

of the efforts have only resulted in limited short-term improvements, the CCIS work force research team identified the strong need to develop an innovative work force approach in construction and proposed a new concept called a Two-Tier Work Force Strategy.

The concept of the Two-Tier Work Force Strategy has evolved over a number of years, with considerable input from many industry experts and organizations, and based upon numerous earlier research studies, conferences, and initiatives. It is a step-change approach to overcome current work force problems in the construction industry such as the lack of a clear career path, poor industry image, and declining wages, and seeks to address the shortage of skilled workers through a more formalized structuring of the work force.

The Two-Tier approach is composed of two distinct work force strategies, Tier I and Tier II. In this dissertation, a project utilizing the Tier I strategy is called a Tier I project, and a project utilizing the Tier II strategy is called a Tier II project. Workers on a Tier I project are called Tier I workers, and those on a Tier II project are called Tier II workers.

The construction industry has historically been more dependent on low-skilled labor and resources than on new ideas, skills, and knowledge. Recently, the industry has not been productive and quality driven. Widespread use of overtime is the most common method for workers to increase their income, which is inherently self-limiting. Workers' skill training is typically limited to specific, minimal tasks and workers have little flexibility to perform different jobs on site.

Construction companies do not retain workers for a long time and promotion opportunities for workers are limited.

The Tier I Work Force Strategy is similar to the current typical approach of the construction industry as explained above; however, it is different from what the industry uses today in that it has a more formalized structure. The Tier I strategy uses less-skilled and task-trained craft workers, and has a larger administrative site management team than the Tier II strategy. In contrast, the Tier II strategy utilizes fewer, better-educated and higher-skilled workers who also perform some management functions in addition to craft functions. As a result, they receive higher compensation, while delivering projects with improved safety, quality, schedule, and cost performance. Detailed explanations of each strategy are given in the following sections. The comparison of Tier I and Tier II workers is summarized in Table 4.1.

Table 4.1 Two-Tier Workers Comparison

Element	**Worker Profile**	
	Tier I	**Tier II**
Workers' Technical Skills	Average	Above Average
Workers' Management Skills	N/A	Selected
Career Path	N/A	Planned
Training	Task Oriented	Multi-skilled
Management Supervision	High	Moderate
Crew Flexibility	Reduced	High

There is no comprehensive strategy of work force management currently in the construction industry. There is only an unstructured work force with some Tier I type workers. However, this will be changed as the new Two-Tier craft system is phased in over time due to the introduction of the Tier I and II strategy as shown in Figure 4.2. It is hoped that the Tier II workers will comprise most of the construction work force while Tier I workers occupy a small portion of it. The Tier I strategy would be mostly used to accommodate the cyclic nature of construction while maintaining a stable number of Tier II workers. Fewer construction workers would be required due to the higher quality of the Tier II work force. If the Two-Tier Work Force Strategy were successful, it would provide a structure for the long-term development of an improved work force.

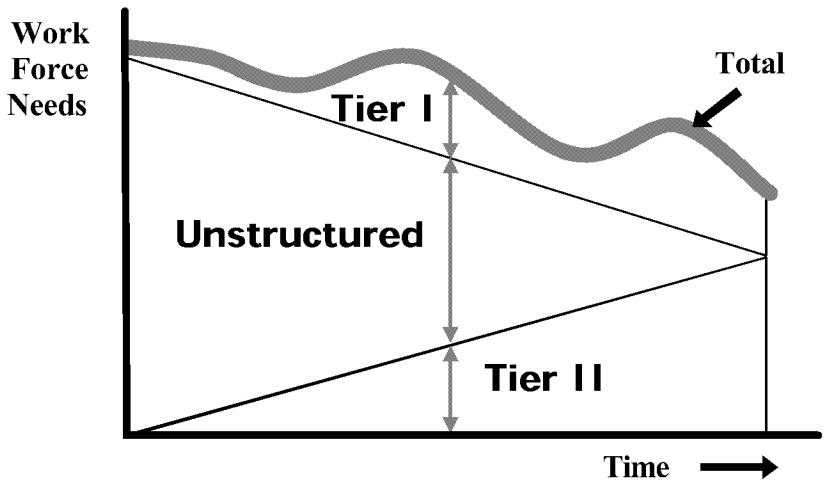


Figure 4.2 Two-Tier Craft System

The hypothetical relationship between the implementation of the Tier I and Tier II strategies and construction success is illustrated in Figure 4.3. Both

Tier I and Tier II strategies have the potential for great construction success if the strategy is chosen and implemented properly. The decision of whether to implement the Tier I or Tier II strategy would be very project specific and governed by many factors including project type, size, location, number of workers on the project, and local labor availability.

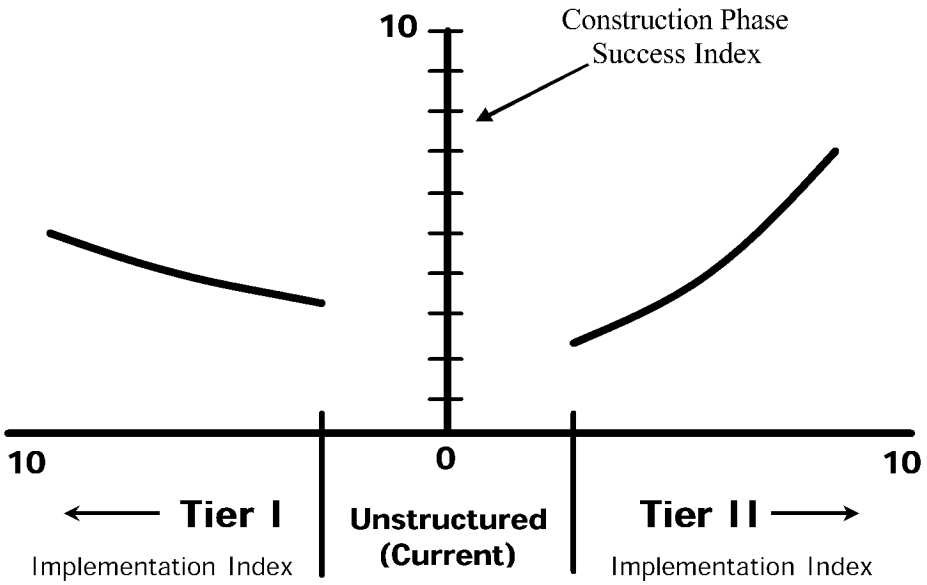


Figure 4.3 Hypothetical Relationship between Level of a Two-Tier Work Force Strategy Implementation and Project Success in Construction Phase

The overall Two-Tier strategy is wide-ranging and requires considerable development. An overriding requirement would be the development of metrics, for measuring the level of implementation of both Tier I and Tier II strategies and also the project success in the construction phase. All three indices would range from 0 to 10 and give a simplified measure of implementation and success on each axis as shown in Figure 4.3.

Three different research groups are addressing these three indices and other details. A common construction phase success index will be developed for use with both the Tier I and Tier II strategies and is under development by the Productivity Measurements initiative of the CII Benchmarking and Metrics (CII BM&M) Team. The Tier I strategy is under development by the CII Research Team 182 and the Tier II strategy with implementation metrics was developed by the CCIS Work Force Research Team. The research teams work closely together to assure consistent metrics. The goal of all research efforts is to provide new work force strategies that can be used by construction companies on any project. This dissertation provides details of the development of the Tier II Work Force Strategy and its Implementation Index.

4.2.1 Tier I Work Force Strategy

The Tier I Work Force Strategy will be presented in a separate document, so only basic concepts about it are provided in this dissertation. The Tier I strategy is based on a relatively less skilled construction work force. The Tier I workers would, on average, have limited technical skills and experience and they would be paid less than the Tier II workers consistent with their skill levels. Because the Tier I strategy will utilize workers with limited skills and minimal experience, a more detailed management system is essential to employ the workers effectively. Administrative personnel will perform most of the cost management, planning, purchasing, estimating, and scheduling. More training must be provided to overcome limited skills and so, training is most likely limited

to project-specific tasks. Entry-level workers are eligible to be Tier I workers and so their loyalty to their company, the project, and the industry is minimal. As a result they can easily move into other industry sectors. However, they also have the opportunity to become Tier II workers. Even with all these features, it should be possible to realize highly successful Tier I projects. Table 4.2 summarizes the characteristics of the Tier I strategy.

Table 4.2 Characteristics of Tier I Work Force Strategy

Skills training at today's level (or less) (limited to specific, minimal task)	More detailed supervision (high ratio of supervisor versus craft)
More task training	"White collar" administration (planning, purchasing, scheduling, etc.)
More (less skilled) workers needed	Outside inspection
Relatively low journeyman wages	Entry-level workers & wages
Limited craft flexibility	Minimal worker loyalty to company / project / industry
Shorter retention time (more turnover)	Limited promotion opportunities

The Tier I Work Force Strategy may be applicable to projects in developing countries or U.S. projects that have a high proportion of immigrant or resident alien workers who are low skilled or have English language difficulties, and also on projects where owners cannot be convinced of the merits of the Tier II strategy. It is probable that the Tier I strategy could provide an immediate short-

term solution for the shortage of skilled work force. However, the industry should eventually phase into the Tier II strategy to revive.

4.2.2 Tier II Work Force Strategy

The Tier II strategy is based on Tier II workers who have superior technical skills, including multi-skilling, achieved through extensive training and considerable experience. In addition to technical skills, Tier II workers possess some management skills such as administrative, computer, planning, and job management skills. The essence of the Tier II strategy is in the training and certification of craft workers with support and cooperation from management. The requirements for training and certification give craft workers challenges and once they become certified, they have a better opportunity to advance and continue a career in construction. Workers will be able to progress from apprentices/helpers and journeymen to Tier II workers through an increased emphasis in training and certification.

The Tier II project will require fewer, but better-skilled workers who are expected to produce improved safety, quality, schedule, and cost results compared to current practice. Not all workers on a Tier II project will be Tier II workers. The Tier II workers will receive higher compensation and other benefits corresponding to their skill levels and will experience greater longevity on the project. The peak work force and average number of workers on a Tier II project site will be less than that of today's projects because of the high productivity of

the Tier II workers and the resulting reduced turnover. The characteristics of the Tier II strategy are summarized in Table 4.3.

Table 4.3 Characteristics of Tier II Work Force Strategy

Higher compensation for workers (wages & duration on site)	Less supervision / Higher worker autonomy
Fewer workers on site (less peak and turnover)	Higher worker loyalty to company / project / industry
Different journeyman/helper mix	Career path opportunities / Longer tenure
Higher worker craft skills (certified)	Appropriate management approach (certified)
Multi-skilled workers (certified)	More craft flexibility
Administration-skilled workers (certified in computers, planning, scheduling, controls, etc)	

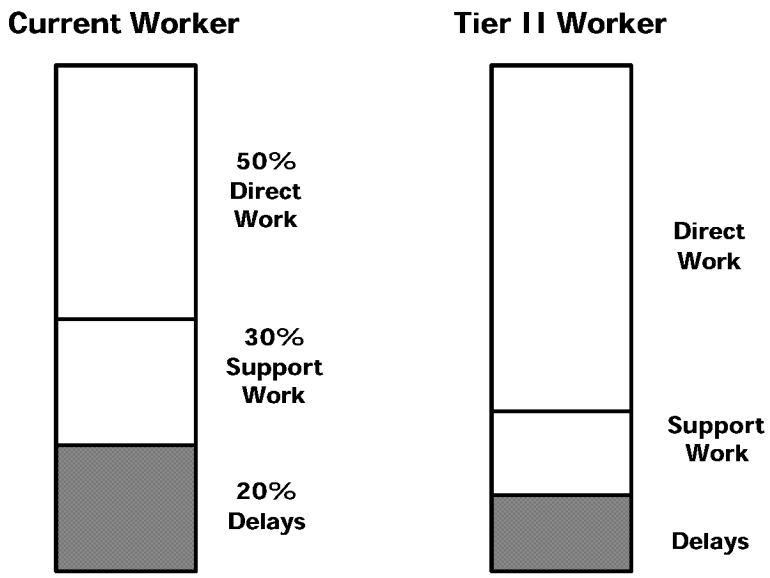
A Tier II project will be organized and executed to exploit those advanced Tier II worker skills through information technology, craft worker utilization, and a high performance organization. The organizational structure changes into a flat system giving more responsibility and autonomy in decision-making to the lower levels of the work force because the Tier II workers can handle complicated situations with their additional knowledge and skills. The number of management personnel can be reduced significantly and the crews function as self-managed work teams. As a result of improved compensation and increased duration of employment, workers will develop loyalties to both the project and the company, and furthermore to the industry.

The Tier II Work Force Strategy is a "step-change" approach in the way the construction industry presently organizes for and executes projects. The present efforts surrounding the Tier II strategy are focused exclusively on the construction phase of projects because the strategy is all about improving and then better utilizing the craft work force.

Successful implementation of the Tier II Work Force Strategy will achieve the following objectives at the project level:

- Comparable or better project costs.
- Better quality – less rework because of better-skilled workers and improved planning.
- Better safety – due to better workers and increased tenure on a project.
- Better schedule – resulting from less rework and improved productivity.
- Better productivity – due to better-skilled workers, improved planning and scheduling, less rework, better materials management, and improved communication.
- More predictability/less chaos – because of better planning and scheduling at the crew level.
- Less administration/supervision – reduction in field administrative personnel because more tasks are handled at crew and craft level.
- Fewer workers/less turnover on a project – increased use of multi-skilled workers who are able to stay on the project longer and achieve increased performance.

Less attrition of workers as a result of an available career path will benefit the companies and the whole industry as well. Figure 4.4 shows the comparison of activity between a typical current worker and the Tier II worker. Current workers perform about 50% of total work activity as direct work and about 30% of total work as support work such as transportation of tools and materials, traveling with empty hands, planning, and instructions. About 20% of total work is related to delays including waiting for materials, instructions, crew delay, and personal time. In comparison, the Tier II workers increase direct work by reducing delays because they have the ability to solve problems by themselves. Helpers perform most of the support work.



Source: Tucker, CII AC 2001

Figure 4.4 Typical Worker Activity

There are necessary steps which must be addressed by industry in order to achieve the Tier II Work Force Strategy. These include but are not limited to the following:

1. Phase in over time - There should be continuous support from industry including owner, general contractor, and labor associations in order that the Tier II Work Force Strategy can be phases in over the whole industry and become the new standard form of work force management.
2. Establish criteria/agencies for training and certification – As mentioned before, training and certification is the foundation for the success of the Tier II strategy. There are several different agencies performing training and those agencies could be merged into one or provide standardized curricula together. Union and non-union sectors should work together to achieve this purpose. It would be greatly beneficial for the industry if the workers could have unified standard certifications, which could be used nationwide.
3. Assessment and continuous monitoring of projects – There should be concrete evidence about the effectiveness of the Tier II strategy in order to have the whole industry believe and adopt it. Therefore, it is necessary to assess and monitor actual projects and then find the relationship between the level of implementation and project success.

The basic assumption of the Tier II strategy is that better workers, properly utilized, will produce a more successful construction effort. That

assumption is illustrated in the right side of Figure 4.3 in Section 4.2 above. This step change in the management of the construction work force from unstructured to Tier II is possible and necessary. The Tier II strategy has great promise to address the shortage of skilled workers by introducing incentives for workers to learn skills and to stay in the construction industry in the long run, and hopefully revive the construction industry in the future.

4.2.3 Other Considerations in Tier II Work Force Strategy

Two subjects such as compensation and training with certification are not directly addressed in this dissertation. For the compensation issue including incentives and benefits of Tier II workers, the marketplace will naturally allow the issue to be appropriately addressed in order to gain acceptance. For the training and certification issue, the Tier II strategy does not provide "how to accomplish training and certification" but assumes that both will be necessary and provided. For some elements of a worker's technical skills, excellent training programs are currently available at project, company and national levels. For other elements, such programs must be developed. Hopefully, the diversified training and certification programs will be combined into one standardized program.

The construction companies should have a standard to choose between the Tier I and the Tier II strategy. A suitability index will be developed through future research after enough data have been analyzed to determine the difference between the two strategies. The suitability index will assess the characteristics of a construction project through adjustment factors such as domestic or

international project, geographic project location, industry sector, project type, project size, contract type, local/regional labor availability, number of workers on project, and open shop versus union. It will provide guidance for the decision whether the project is better suited for the Tier I or Tier II strategy.

There are also environmental factors that can possibly impact the performance of Tier II Work Force strategy, and they are divided into factors within the organization and outside the organization. The environmental factors existing within the organization include the reward, training and certification systems, performance assessment system, and organization culture. The environmental factors outside the organization include new technologies, the economic climate, and competitors. Table 4.4 summarizes the environmental factors within and outside the organization.

Table 4.4 Environmental Factors affecting Tier II Work Force Strategy

Within Organization	**Outside Organization**
• Organization Philosophy, Culture	• Economy
• Goal Clarity and Challenge	• Technology
• Reward and Recognition System	• Political-Legal Situation
• Training and Education Systems	• Demographics
• Performance Assessment System	• Competitors
• Management Support and Control	• Social Culture
• Inter-Group Relations	• Resources Available
• Task Assignments	• Owner, Union Support

4.3 TIER II STRATEGY IMPLEMENTATION INDEX RESEARCH MODEL

The critical success factor in the Tier II Work Force Strategy is the development of metrics to measure the level of implementation, which is the major output of this research. The metrics are combined together to make a Tier II Implementation Index. It is intended that the index itself will not only measure the level of implementation but also provide a guide to implementation of the Tier II strategy.

The research model of the Tier II Work Force Strategy Implementation Index is illustrated in Figure 4.6. At first, individual workers are assessed in their technical and management skills, and then the assessment is used to determine the overall project craft workers' skill levels. After identifying current skill levels of project workers, it is necessary to measure how well the project is executed using the skilled workers in terms of Information Technology Utilization, Craft Utilization, and finally Organizational Changes. A detailed explanation for each of these categories is given in Chapter 5.

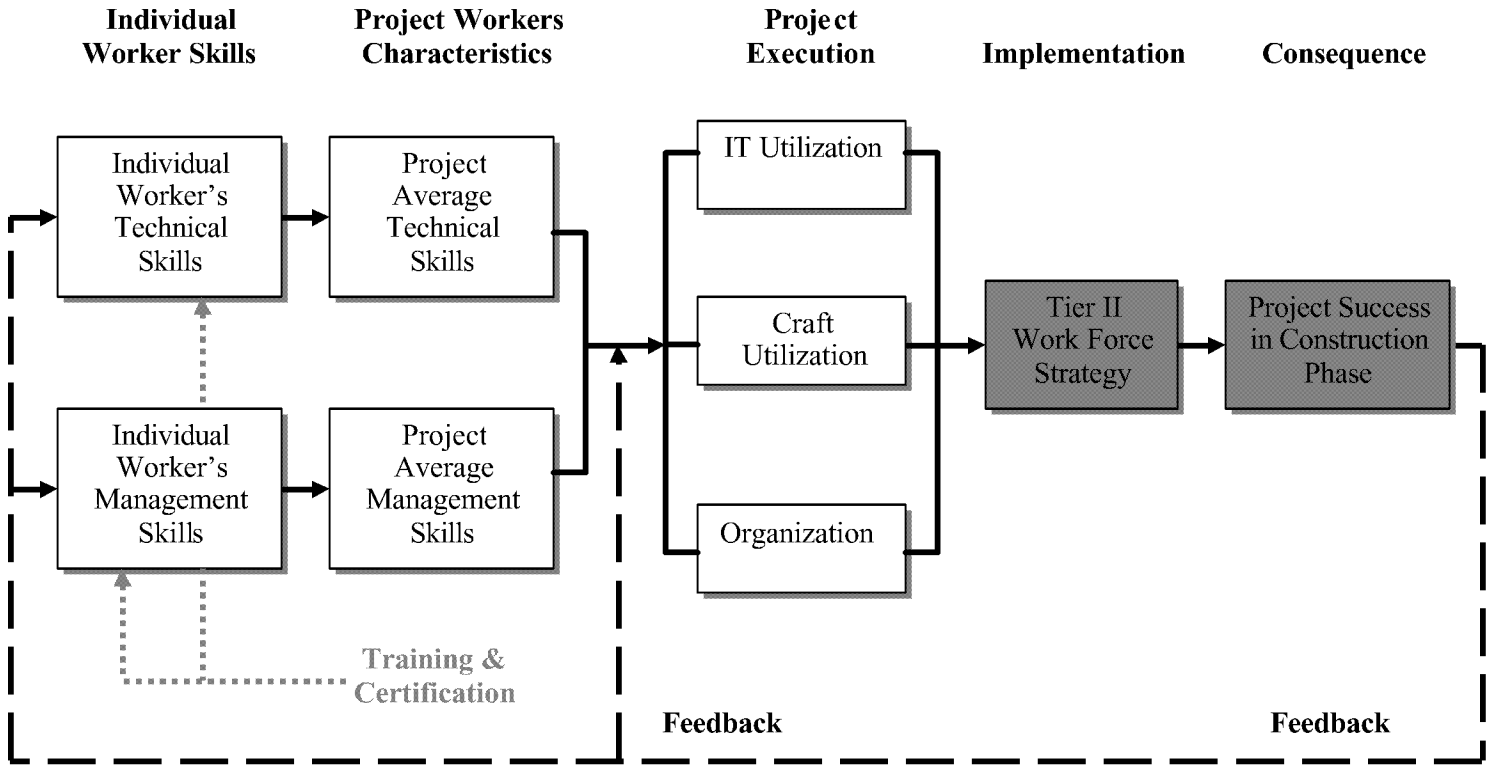


Figure 4.5 Research Model of Tier II Strategy Implementation Index

4.4 PROJECT SUCCESS IN CONSTRUCTION PHASE

Project success has been the focus of many studies. Many factors contributing to construction project success have been identified. The research has focused on all aspects of a project including engineering, procurement, and construction. However, the project success corresponding to the Tier II Work Force Strategy will focus on the construction phase because innovative work force management can only impact the construction phase of a project.

The metrics used to measure the project success in the construction phase are very important to eventually verify the effectiveness of the Tier II strategy. However, the research into measuring construction success is outside the scope of this research. The CII BM&M research team will address this issue through research that is currently in progress.

Simple measurements of construction success are generated and used when Tier II Work Force Strategy is applied on the pilot projects. This simplified measurement of construction success is attached in Appendix J.

4.5 SUMMARY

This chapter outlined the concept of a Two-Tier Work Force Strategy. The characteristics of the Tier I and Tier II strategies were explained. The benefits of the Tier II strategy were emphasized. Considerations for the Tier II strategy were discussed and a research model for the Tier II Strategy Implementation Index was illustrated. Lastly, project success in construction phase was mentioned briefly.

Chapter 5: Tier II Work Force Strategy Implementation Index

The Tier II Work Force Strategy Implementation Index is the essence of this research and is explained in detail in this chapter. Categories and elements with evaluation criteria are given and extensively explained. The weighting process using AHP and the results are explained. The finalized Tier II Work Force Strategy Implementation Index and instructions on how to use it are also presented in this chapter.

5.1 Purpose of Metrics

Consistent with the supposition, "What gets measured, gets done and improved", there should be reliable metrics to measure, assess, and monitor the implementation and effectiveness of the Tier II Work Force Strategy during a project's construction phase. Not only do the metrics simply measure how well the strategy is implemented on a project, but the metrics themselves also provide guidance on implementation of the Tier II strategy at the beginning of the project and throughout the construction. The companies implementing the Tier II strategy check their current status at the beginning of a project, and evaluate again at the middle and end of a project to see how well they implemented necessary elements.

5.2 CRITERIA FOR METRICS

The seven attributes characterizing a good metric are as follows (U.S. Air Force 1995):

1. It is meaningful in terms of customer requirements.
2. It tells how well organizational goals and objectives are being met through processes and tasks.
3. It is simple, understandable, logical, and repeatable.
4. It shows a trend over time.
5. It is unambiguously defined.
6. Its data are economical to collect.
7. It is timely.

The metrics in the Tier II Work Force Strategy Implementation Index were attempted to adhere to these seven criteria as shown above.

5.3 COMPOSITION OF TIER II STRATEGY IMPLEMENTATION INDEX

The Tier II Work Force Strategy Implementation Index is divided into two major divisions: (1) Individual Worker Skills Index and (2) Tier II Project Index. The Individual Worker Skills Index assesses the skill level of an individual worker and is composed of two categories: Individual Worker Technical Skills and Management Skills.

The Tier II Project Index evaluates overall implementation of the Tier II strategy on a project and is divided into two parts: Project Worker Characteristics and Project Execution. The Project Worker Characteristics part assesses the

quality of entire workers on a project through two categories: Project Craft Technical Skills and Management Skills. The Project Execution part is concerned with the effective use of highly skilled workers in executing the project and is divided into three categories: IT Utilization, Craft Utilization, and Organization.

A concentrated effort has been made to identify evaluation criteria for each element in those categories of the Tier II Work Force Strategy Implementation Index, which should be simple to assess, and to eliminate the necessity of collecting massive amounts of data. Many studies have revealed the importance of the elements chosen in the metrics, which are essential for a better work force environment in the future construction industry. The major divisions and categories are summarized in Table 5.1 below.

Table 5.1 Composition of Tier II Strategy Implementation Index

DIVISION I: INDIVIDUAL WORKER SKILLS INDEX
1. Individual Worker Technical Skills
2. Individual Worker Management Skills
DIVISION II: TIER II PROJECT INDEX
A. PROJECT WORKERS CHARACTERISTICS (capabilities)
1. Project Craft Technical Skills
2. Project Craft Management Skills
B. PROJECT EXECUTION (use of craft workers)
1. Information Technology Utilization
2. Craft Utilization
3. Organization

Once again, the basis for the Tier II strategy is high quality workers, and then utilizing them in an optimal fashion. Division I describes the necessary worker attributes and provides a means of individual worker assessment. Division II assesses the average worker's characteristics in the project, and then the project execution to utilize the highly skilled workers. A more detailed explanation is given in the following sections.

5.4 SCORE FOR EACH ELEMENT

Evaluation criteria for each element were decided through research and discussion among research team members and steering committee members. For each element, only three possible scores - 0, 5, 10 - are provided according to detailed evaluation criteria. Judgment must be made for interpolation between these values. A score of '10' represents an ideal, probably future, state. A score of '5' represents a currently good state, and a score of '0' represents an unacceptable worst state for that element as shown in Table 5.2. The scoring system is consistent for all the elements.

Table 5.2 Scoring Value for Each Element

ELEMENT VALUE	CHARACTERIZATION OF SCORING VALUE
10	Ideal, future state
5	Currently good state
0	Unacceptable, worst state

5.5 INDIVIDUAL WORKER SKILLS INDEX

A Tier II worker must have both superior technical and management skills. The inclusion of management skills is, in itself, a "step-change" in worker expectations and represents a potential career path for ambitious workers.

The Individual Worker Skills Index includes both technical and management skills categories. Each element is measured on a scale of 0 to 10, and weighted such that a maximum score of 100 points is possible for each skills metric. The scores representing individual worker technical skills and management skills will be combined to determine a worker's skill level. The combined score has a maximum value of 200 points. A combined score of 150 points has been decided by discussion among research team members as the minimum score to be qualified as a Tier II worker. Thus, to qualify as a Tier II worker, it is necessary to have both technical and management skills to a significant degree.

5.5.1 Individual Worker Technical Skills Metric

Craft workers' technical skills are considered to be of critical importance for a Tier II project. The individual worker technical skills metric is composed of three elements as follows:

1. Craft certification, including multi-skilling
2. Technical experience
3. Continuous training and education

Craft workers must possess outstanding technical skills to be qualified as a Tier II worker. The first element of the technical skills is craft certification. The Tier II workers are expected to have different craft skills in addition to their primary craft. They would be certified in three different crafts in the ideal future. It is more likely that the workers will be flexible on a project if they can perform various tasks. Turnover ratio as well as peak work force will then be minimized because the workers can stay longer on a project. A standardized training and certification program is necessary to provide and prove the technical skill level of workers.

The second element is technical experience after getting certification in a certain craft. Even though workers are certified in a certain craft, the actual depth of craft workers' skills can be different. Actual work experience in the craft after certification is the real indication of a craft worker's competency and skills.

The third element is continuous training and education. The technical skills of construction workers are easily outdated; therefore, continuous skill updating through training and education is essential to keep the workers productive. This research does not address the standardized training and certification program. The effort of developing that program is another agency's role; however, it is certain that a standardized program is the mechanism to evaluate skills of craft workers and produce qualified workers and brings the success of the Tier II strategy. The union and non-union sectors should work together for this matter.

Specific details for the evaluation of the individual worker's technical skills are shown in Figure 5.1. Each element is measured by evaluation criteria on a scale from 0 to 10 and interpolation should be used for intermediate values. The maximum possible score is 100 points. The weights of elements presented in the following metric were decided through long discussion among CCIS Work Force Steering Committee members. They will not be changed until strong evidence is revealed in future data collected from real applications of the Tier II strategy.

Elements	Weights	Evaluation Criteria	Score	Max Score = 10 x Weight
Craft Certification	4.0	Certified in 3 crafts	10	40
		Certified in 2 crafts	5	
		No certification	0	
Technical Experience	4.0	More than 10 years of experience at the certified craft level	10	40
		5 years of experience at the certified craft level	5	
		Less than 1 year of experience at the certified craft level	0	
Continuous Training and Education	2.0	More than 200 hours of training and skill updating in the last 3 years	10	20
		100 hours of training and skill updating in the last 3 years	5	
		No training or skills updating since first craft certification	0	
	10.0			Total = 100

Figure 5.1 Individual Worker Technical Skills Metric

5.5.2 Individual Worker Management Skills Metric

Traditionally construction craft workers are not involved in management functions. Even the foreman just performed a few basic management functions such as general supervision, material allocation, layout, task planning, and some scheduling (Borcherding 1976, Lemna et al. 1986, Laufer 1989).

However, the Tier II workers will possess necessary management skills allowing them to manage day-to-day operations without consulting with management personnel; therefore, the Tier II project will reduce the number of management personnel on site and give more autonomy with responsibility to the Tier II workers. They will have administrative skills, computer skills, planning ability, and job management skills through extensive training and those skills will eventually be certified. Also, they are required to have superior personal work records in several aspects from previous projects to assure quality of their work.

The individual worker management skills metric is composed of five elements as follows:

1. Administrative Skills
2. Computer Skills
3. Planning Skills
4. Job Management Skills
5. Work Record

Planning skills and work record turned out to be most important elements in individual worker management skills through discussion among the CCIS work

force steering committee members. Each of them obtained the weight value of three out of total weight of ten.

Planning skills include the timely request and management of materials, equipment, tools, and information, which are usually recognized as the major source of delays in the field. Short-term planning and scheduling of work activities are also included in planning skills. It brings great benefits to the project in saving money and time if the workers can plan properly by themselves.

A personal work record includes safety performance, attendance/truancy records, quality and productivity of previous work performed, and personal initiative of workers. This element was not initially included in individual worker management skills; however, the CCIS steering committee members strongly felt these records are more important than any other elements in this category and a good indication of workers' management skills. They agreed that the workers' management skills and quality of work performed usually are better if the workers have a good personal work record.

Job management includes crew/team coordination, inter- and intra- craft coordination, selection of work means/methods, and leadership. This is the third important element among the five elements. This element shares some common functions with the planning skills, but more emphasis is placed on the work activity-level coordination and management.

Computer skills include e-mail/Internet, word processing, spreadsheets, scheduling, estimating, CAD, and material management. The computer skills are not the main element of management skills at this time, but they will play a major

role in the near future for communication and management functions when all the workers have handheld computers on site.

Administrative skills include cost management, scheduling, material management, request for information (RFI), and estimating. Making reports and keeping documents are also major functions belonging to this element. These skills are not recognized as critical elements because workers do not currently perform many of these functions; however Tier II workers are required to have administrative skills to advance in their career path.

A similar set of criteria, and scoring, are used to complete an individual worker management skills metric as shown in Figure 5.2. The five elements are weighted to give a maximum individual worker's management skills score of 100 points, as for the individual worker's technical skills score.

Elements	Weights	Evaluation Criteria	Score	Max Score = 10 x Weight
Administrative (***cost management, scheduling, material management, RFI, and estimating***)	1.0	Certified in at least 4 administrative skills	10	10
		Certified in 2 administrative skills	5	
		No certified administrative skills	0	
Computer (***e-mail / internet, word processing, spreadsheet, scheduling, estimating, CAD, and material management***)	1.0	Certified in at least 5 computer skills	10	10
		Certified in 3 computer skills	5	
		No certified computer skills	0	
Planning (***material, equipment, tools and information request, short-term planning, and scheduling***)	3.0	Certified in planning skills	10	30
		160 hours of training but not certified in planning skills	5	
		No training and certification	0	
Job Management (***crew coordination, inter- and intra-craft coordination, selection of work means and methods, and leadership***)	2.0	Certified in job management functions	10	20
		160 hours of training but not certified in job management functions	5	
		No training and certification	0	
Work Record (***safety, attendance / truancy, quality, productivity, and initiative***)	3.0	Superior in all categories	10	30
		Superior in some, modest in others	5	
		Weak in most categories	0	
	10.0			Total = 100

Figure 5.2 Individual Worker Management Skills Metric

5.6 TIER II PROJECT INDEX

The level of implementation of the Tier II Work Force Strategy on a project is measured through the Tier II Project Index. A Tier II project, inherently, must have an adequate number of Tier II workers and their high skills and capabilities must be effectively utilized during the project execution. The organization and management should support the Tier II workers in order to achieve the results expected from them.

The index is divided into two parts measuring project worker characteristics and project execution. The project worker characteristics part assesses the skills of workers on a project by craft technical skills and management skills. These two categories are evaluated using the average score from the individual worker skills index. The project execution part evaluates whether the Tier II workers are used effectively with the three categories of IT utilization, craft utilization, and organization.

Each of the five categories has a maximum value of 100. Each category value is multiplied by a weight determined through the Analytical Hierarchy Process (AHP) and then the values of the five categories are summed. Finally, the sum is divided by 10 to give a maximum Tier II Project Index value of 10.0. An illustrative example of this index calculation is given in the last section of this chapter.

5.6.1 Project Workers Characteristics

The first two categories of a Tier II Project Index are project craft technical skills and management skills, which characterize the workers on a project and determine the depth and breadth of the skill levels of key crafts. The scores of these two categories are derived from the scores of the individual worker technical and management skills. Only the workers in the project's key crafts are included in the evaluation of skills. Site management determines the key crafts for a given project.

5.6.1.1 Project Craft Technical Skills Metric

A major element of the project craft technical skills metric is the average value of the individual worker technical skills obtained from the key crafts of a project. The other element is the percentage of Tier II workers in the key crafts. This element is only included in the project craft technical skills metric even though it is also related to the project craft management skills metric.

Currently the average value of the individual worker technical skills would be higher than that of management skills, and the weights from AHP also suggest that the project craft technical skills metric is presently more important than the management skills metric. These justify including the percentage of Tier II workers only in the project craft technical skills index. Detailed evaluation criteria are given in Figure 5.3.

5.6.1.2 Project Craft Management Skills Metric

The project craft management skills metric is based on the average of individual worker management skills scores for the workers in the key crafts and is shown in Figure 5.4.

Elements	Weights	Evaluation Criteria	Score	Max Score = 10 x Weight
Average Score from Individual Evaluation on Technical Skills *	7.0	Greater than 75 points	10	70
		50 points	5	
		Less than 25 points	0	
Percentage of Tier II Workers *	3.0	40% or more of journeymen are certified as Tier II workers	10	30
		20% of journeymen are certified as Tier II workers	5	
		Less than 10 % of journeymen are certified as Tier II workers	0	
	10.0			Total = 100

**** for project's key crafts***

Figure 5.3 Project Craft Technical Skills Metric

Elements	Weights	Evaluation Criteria	Score	Max Score = 10 x Weight
Average Score from Individual Evaluation on Management Skills *	10.0	Greater than 75 points 50 points Less than 25 points	10 5 0	100
	10.0			Total = 100

**** for project's key crafts***

Figure 5.4 Project Craft Management Skills Metric

5.6.2 Project Execution

After workers are qualified as Tier II workers with outstanding technical and management skills, the project team should effectively utilize those resources. The next three categories belong to the execution component of the Tier II Project Index. There are three categories such as Information Technology (IT) Utilization, Craft Utilization, and Organization, and each of these is described in the following sections.

5.6.2.1 Information Technology Utilization Metric

IT has great potential to positively influence the construction project in many efficient ways. This category tries to measure IT capabilities on a project and the use of those capabilities. The IT utilization metric assumes that the Tier II workers are computer knowledgeable. It is presented in Figure 5.5 and consists of two elements.

The first element assesses the ease of direct access for Tier II workers to necessary project information including the exchange of information and the degree of data integration. The information includes schedule, cost, materials and equipment management, safety, drawings, and worker skills. The second element assesses the use of resources through modern hardware. The Tier II workers should have appropriate hardware such as a Personal Data Assistant (PDA) and perhaps a wearable computer in the near future to access the necessary project information any time.

Elements	Weights	Evaluation Criteria	Score	Max Score = 10 x Weight
Integrated Information Access	6.0	All information* is stored, integrated, continuously updated, and accessed by Tier II workers electronically	10	60
		3 types of information* are stored, integrated, continuously updated, and accessed by Tier II workers electronically	5	
		Information* is not directly accessed by Tier II workers	0	
Hardware	4.0	Tier II workers have wireless, wearable computers	10	40
		Hardware is nearby and shared among crews	5	
		No hardware is available to Tier II workers	0	
	10.0			Total = 100

* Information includes schedule, costs, materials and equipment management, safety, drawings, and worker skills

Figure 5.5 Information Technology Utilization Metric

5.6.2.2 Craft Utilization Metric

Effective utilization of the work force on a Tier II project is very important for construction success. The construction industry should fully utilize the current work force available. The craft utilization metric is presented in Figure 5.6 and consists of three elements. The first element is crew mix, which is measured by the percentage of Tier II workers in key craft crews. The second element is the use of multi-skilled workers, which is the percentage of multi-skilled workers in key craft crews. These two elements essentially measure the distribution of advanced worker skills within the key crafts on a project.

The final element is the worker turnover on a project and is defined as total hires divided by peak workforce. The current best possible value for this metric is decided to be three and a score of less than two represents the ideal future state. The Tier II workers can perform different crafts and their productivity is higher than usual. As a result, the total number of workers needed would be reduced considerably.

It is a good indication of effective craft utilization if the project has some appropriate Tier II workers with multi-skilling and low turnover ratio.

Elements	Weights	Evaluation Criteria	Score	Max Score = 10 x Weight
Crew Mix	4.0	Key crafts' crews (on avg.) have at least 40% of Tier II workers	10	40
		Key crafts' crews (on avg.) have at least 20% of Tier II workers	5	
		Less than 50% of key crafts' crews have Tier II workers	0	
Use of Multiskilled Workers	2.0	Key crafts' crews (on avg.) have at least 40% multiskilled workers	10	20
		Key crafts' crews (on avg.) have at least 20% multiskilled workers	5	
		Less than 50% of key crafts' crews have multiskilled workers	0	
Worker Turnover (Total Hires / Peak Workforce)	4.0	Less than 2	10	40
		Equal to 3	5	
		Greater than 4	0	
	10.0			Total = 100

Figure 5.6 Craft Utilization Metric

5.6.2.3 Organization Metric

Organizational changes on a Tier II project are inevitable because today's construction projects are somewhat bureaucratic and workers are not involved in the management. The current organizational system has to be changed into a high performance organization to accommodate the Tier II strategy.

This final category of the Tier II Project Index, organization metric, consists of two elements as shown in Figure 5.7. The first element is communications, which stresses the importance of effective communications in an organization for a successful project. This identifies the level of proactive information flow, formal and informal communication, open access of workers to management, and information sharing on the projects. The level of information to be shared with workers should be determined by the management of the projects.

Construction projects have recently become more complicated than before and are composed of many teams representing various competing interests among the teams as well as within a team, which could make it difficult to communicate. Research shows a strong and positive correlation between effective communications and project success (Thomas 1996).

The second element is the High Performance Work Place, which reflects the necessity of utilizing the management skills of the Tier II workers. The High Performance Work Place includes self-managed work teams, which empower workers with appropriate authority and accountability. Decision-making will be delegated to the craft worker level. However, a clear definition of authority, responsibility, and expectations should be given to each team and team members.

A fair performance measurement system with positive rewards would motivate workers. All the training of workers will be given through a high performance work team approach. This high performance work place is possible and promising because the Tier II workers have superior skills in technical and management skills.

Presumably, higher performing work teams will result in a reduction in the construction time and/or a reduction in overall project cost. The Tier II strategy focuses its impact on the construction phase of a project and the benefits of high performance work teams in the construction phase will be great. It has been proven in several studies that the high performance work place, including a self-managed work team, is positively related to project success (see Section 2.3.3 and 2.3.4).

Elements	Weights	Evaluation Criteria	Score	Max Score = 10 x Weight
Communications	6.0	Proactive information flow to and from workers about the project, established formal & informal channels, open access to management, frequent meetings with workers, all workers are familiar with all aspects of the project	10	60
		Informal communication channels, regular meetings with workers, workers can receive project information requested, open door policy	5	
		Rigid hierarchical structure for communication, only information that management deems necessary to workers is provided.	0	
High Performance Work Place	4.0	Delegation of appropriate authority and accountability to High Performance Work Teams (HPWT). Clear definition of authority, accountability and expectations to each team. Training of all teams in HPWT approach. Expected utilization by crews of management skills and IT information available thru Tier II workers	10	40
		Hierarchical structure, but with 2-way information & idea flow between crews and management	5	
		Rigid hierarchical structure	0	
	10.0			Total = 100

Figure 5.7 Organization Metric

5.7 WEIGHTING OF CATEGORIES USING ANALYTICAL HIERARCHY PROCESS (AHP)

The weights of the five categories were assumed to be equal initially while the weights of elements in each of the five categories were determined through literature review, previous study, and long debate among CCIS Work Force Steering Committee members. However, the relative importance of the five categories is obviously different and the Analytical Hierarchy Process (AHP) was used to determine the weights of categories. The AHP blank matrices were distributed through the steering committee meeting and the second workshop.

The weights shown in this dissertation are based on input from industry experts and experienced craft workers. More accurate and statistically significant weights can be determined in the future after enough project data are gathered. The participants in this weighting process had enough experience and knowledge in the construction industry to give their insight with judgments, and the AHP was the best approach available at the current stage of the research to decide weights.

5.7.1 Introduction of AHP

The Analytical Hierarchy Process (AHP) was developed by Saaty (1982) and has been used in many complex decision-making processes such as planning, conflict resolution, resource allocation, analyzing the impact of policy, and cost/benefit analysis (Golden et al. 1989). The AHP is a flexible model that allows individuals or groups to shape ideas and define problems by making their own assumptions and deriving the desired solution from them. It incorporates

judgments and personal values in a logical way, depending on imagination, experience, and knowledge to structure the hierarchy of a problem and on logic, intuition, and experience to provide judgments. To determine a complex problem and to develop sound judgments, the AHP must be progressively repeated over time. Another feature of the AHP is that it provides a framework for group participation in decision-making or problem solving (Saaty 1982).

The first step of the AHP is to structure a hierarchy of the factors, which contribute to the final objective. The hierarchical structure for the Tier II Work Force Strategy is shown in Figure 5.8. By comparing these factors in a pairwise matrix format, a priority vector can be derived through mathematical procedures. The coefficients of the priority vector represent the weights that should be assigned to each factor. AHP has been proven in many studies to be effective as a decision making process. A mathematical process for checking the consistency of these weights also has been provided.

In many cases, researchers have intuitively assigned subjective weights to factors directly, which are difficult to justify. The AHP resolves the argument of subjective weights and reaches an objective distribution of priority through a mathematical evaluation process. Even though the priorities are given based on the experts' judgments, the AHP incorporates judgments and personal values in a logical way and effectively presents non-quantitative factors in a systematic way.

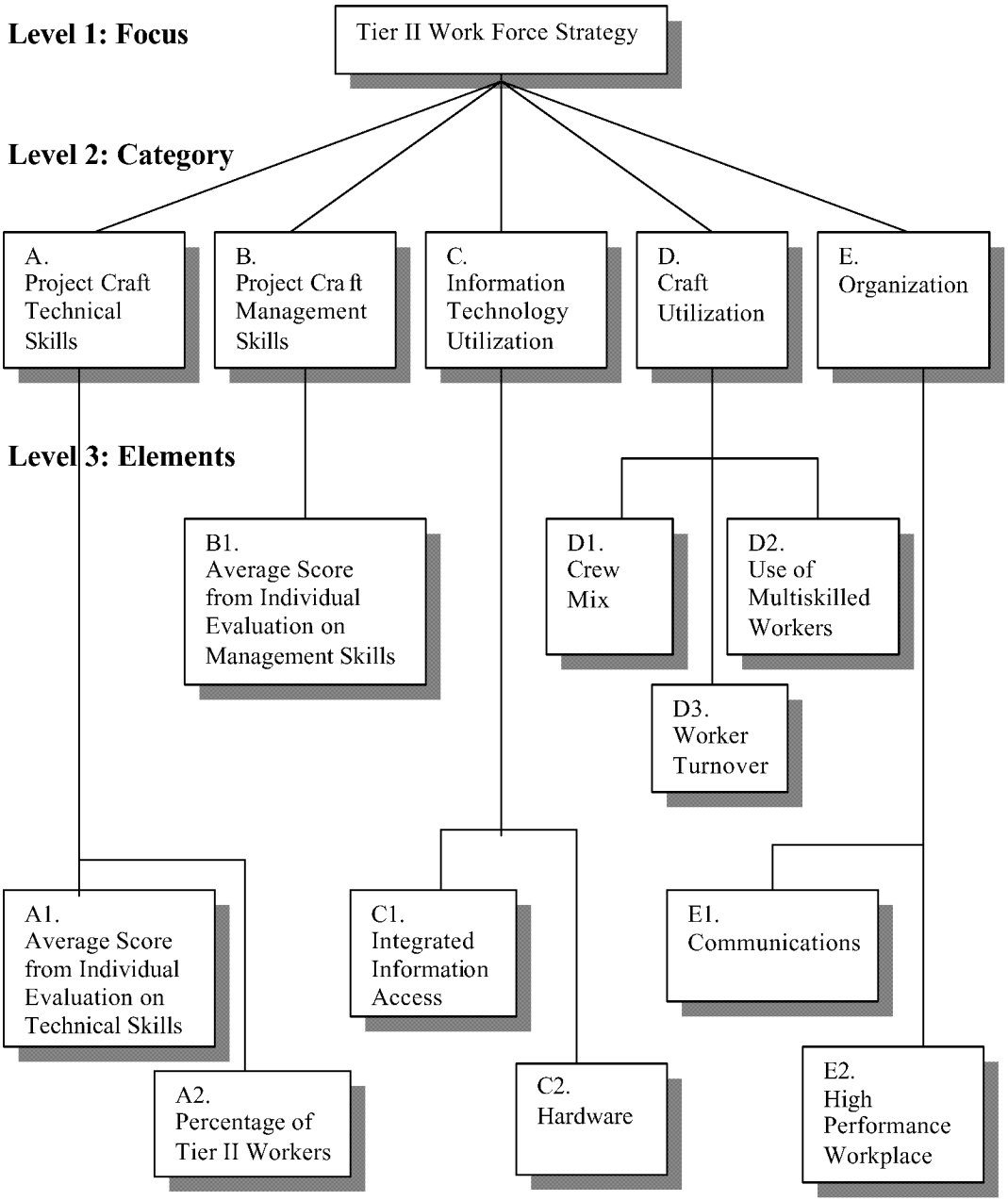


Figure 5.8 Hierarchy for Tier II Work Force Strategy

The basic procedure involved in AHP is described as follows (Guo 1993):

1. Develop a hierarchical structure of factors contributing to the final objective.
2. Put these factors as headings of both rows and columns in the pairwise comparison matrix. The matrix has a value of 1 in all the diagonal cells.
3. Compare these factors in pairs using a scale from 1 to 9 (fractions can be used) and fill in the upper half of the matrix. The element in the left-hand column of the matrix is always compared with the element in the top row. If it is regarded less favorably, the judgment is a fraction. The relative importance of one element over another is defined in Table 5.3.

Table 5.3 Pairwise Comparison Scale

Level of Importance	**Definition**
1	Equal importance
3	Weak importance of one over another
5	Essential or strong importance of one over another
7	Very strong or demonstrated importance of one over another
9	Absolute importance of one over another
2, 4, 6, 8	Intermediate values between adjacent scale values

4. Put the reciprocal of each cell to the symmetric cell of the lower half of the matrix.
5. Calculate Row $\text{Sum}_j = \sum_{i=1}^{n} \frac{cell\ \ value_{ij}}{column\ \ sum_i}$ (i=1 to n, column; j=1 to n, row) for each factor.

6. Normalize row sums to obtain a priority vector. The coefficients of the priority vector are the final weights for the factors.

The next part of the AHP after determining the weights of the factors is to combine them with the priority vector of each alternative based on different factors. The combined weights produce the overall priorities among the several different alternatives. There were no alternatives to choose for the Tier II application so part of the AHP, choosing among several alternatives, was not used in this research. The AHP was only used to obtain the weight of each Tier II strategy factor. However, if several Tier II strategy application alternatives are available, the AHP can be used to decide which alternative to choose.

5.7.2 Weights Distribution

Blank pairwise matrix forms were distributed to the industry experts, researchers, and experienced quality workers to get appropriate weights for five categories. The questionnaire is attached in Appendix C as a reference.

This section explains the basic procedures for weights calculation with an example. This example was collected and proven to be valid. The element that appears in the left-hand column is always compared with the element appearing in the top row, and the value is given to the element in the column as it is compared with the element in the row. If it is regarded less favorably, the judgment is a fraction.

Tier II Strategy	Technical Skills	Management Skills	IT Utilization	Craft Utilization	Organization
Technical Skills	1	5	9	9	1
Management Skills		1	7	7	1
IT Utilization			1	1	1/7
Craft Utilization				1	1/9
Organization					1

In this example, technical skills are strongly more important than management skills, absolutely more important than IT utilization or craft utilization, and equally important with organization. Organization is very strongly more important than IT utilization (note that the fraction 1/7 is entered in the third row of organization column, see Table 5.3 for reference of scale).

Once the comparison scales are determined, the reciprocal of each cell is put into the lower half of the matrix, and the column total is calculated. Then, the row sum is calculated as $\sum_{i=1}^{n} \frac{cell\ \ value_{ij}}{column\ \ sum_i}$ (i=1 to n; column, j=1 to n; row) as follows:

Tier II Strategy	Technical Skills	Management Skills	IT Utilization	Craft Utilization	Organization	Row Sum
Technical Skills	1	5	9	9	1	2.10
Management Skills	1/5	1	7	7	1	1.07
IT Utilization	1/9	1/7	1	1	1/7	0.19
Craft Utilization	1/9	1/7	1	1	1/9	0.18
Organization	1	1	7	9	1	1.47
Column Sum	2.42	7.29	25.00	27.00	3.25	5.00

Finally, normalize the row sum vector to obtain the priority vector:

$$\begin{vmatrix} 2.10 \\ 1.07 \\ 0.19 \\ 0.18 \\ 1.47 \\ \hline 5.00 \end{vmatrix} = \begin{vmatrix} 0.42 \\ 0.21 \\ 0.04 \\ 0.04 \\ 0.29 \\ \hline 1.00 \end{vmatrix}$$

This priority vector is valid only if it shows enough consistency. The next section explains how to determine consistency.

5.7.3 Consistency Check

In decision-making problems it is important to know the consistency of the matrix because the decision should be based on judgments that have high

consistency. It is common for people to be inconsistent while filling the matrix by comparing several factors pair-wisely. In other words, each column of the matrix will represent a different weight distribution for the factors. However, if the inconsistency is high enough to ruin the comparison logic (e.g., if apples are preferred to oranges, and oranges are preferred to bananas, then apples must be preferred to bananas in a perfectly consistent relationship), the comparison scales become invalid and revision is needed.

An Eigenvalue method has been used to check the consistency of the comparison scales in the matrix (Saaty 1982, Harker 1989). The maximum Eigenvalue, λ_{max}, is always greater than the matrix size N for a reciprocal and positive matrix. For a perfectly consistent matrix (i.e., the weight derived from each column of the matrix is identical), the maximum Eigenvalue (λ_{max}) will be equal to the size of the matrix. Thus, (λ_{max} – N) provides a useful measure of the degree of inconsistency. Normalizing this measure by the size of the matrix, the Consistency Index (CI) is defined as follows and reflects the deviation of the inconsistency:

$$\mathrm{CI} = \frac{\lambda_{max} - N}{N - 1}$$

A Random Consistency Index (RCI) derived from 500 random matrices is used to compare with the CI and is shown in Table 5.4. Finally, the Consistency Ratio (CR) is defined as follows.

$$\mathrm{CR} = \frac{CI}{RCI}$$

A CR of 10% or less is suggested as acceptable. If the CR is greater than 10%, the judgments may be somewhat random and the scales should be revised.

The procedures for checking the consistency of the comparison matrix are described below.

First, multiply the comparison matrix with the priority vector:

$$\begin{vmatrix} 1 & 5 & 9 & 9 & 1 \\ 1/5 & 1 & 7 & 7 & 1 \\ 1/9 & 1/7 & 1 & 1 & 1/7 \\ 1/9 & 1/7 & 1 & 1 & 1/9 \\ 1 & 1 & 7 & 9 & 1 \end{vmatrix} \times \begin{vmatrix} 0.42 \\ 0.21 \\ 0.04 \\ 0.04 \\ 0.29 \end{vmatrix} = \begin{vmatrix} 2.43 \\ 1.10 \\ 0.19 \\ 0.18 \\ 1.51 \end{vmatrix}$$

Then, divide the result by the priority vector to get the consistency vector:

$$\begin{vmatrix} 2.43 \\ 1.10 \\ 0.19 \\ 0.18 \\ 1.51 \end{vmatrix} \div \begin{vmatrix} 0.42 \\ 0.21 \\ 0.04 \\ 0.04 \\ 0.29 \end{vmatrix} = \begin{vmatrix} 5.80 \\ 5.16 \\ 5.14 \\ 5.16 \\ 5.12 \end{vmatrix}$$

The maximum Eigenvalue λ_{max} is obtained by averaging the value of the entries in the consistency vector:

$$\lambda_{max} = (5.80 + 5.16 + 5.14 + 5.16 + 5.12) / 5 = 5.28$$

Then, CI is calculated as:

$$CI = \frac{\lambda_{max} - N}{N - 1} = \frac{5.28 - 5}{5 - 1} = 0.07$$

Compare the CI with the RCI in the Table 5.4 below and the CR can be obtained as follows.

$$CR = \frac{CI}{RCI} = \frac{0.07}{1.12} = 0.06 = 6\ \%$$

Table 5.4 Random Consistency Index (RCI) by Matrix Size

N	1	2	3	4	5	6	7	8	9	10
RCI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

The CR is less than 10%, indicating that the consistency of the matrix is good enough to accept. The same procedures for checking consistency were applied to all the responses and only the responses that passed the criteria of CR ≤ 10% were used in the final weights calculation.

5.7.4 Rationale of AHP

People intuitively select one factor as the base with a certain weight when several factors need to be weighted, and then compare the other factors with this base and sum up to 100%. Using the approach of directly assigning a subjective weight to each factor will cause judgment error. The AHP, through the requirement of asking N(N-1)/2 comparisons, can avoid this problem.

The AHP is the only decision-aiding methodology that deals formally with consistency and it has a simple yet elegant theoretical foundation. The AHP does not require the decision-maker to be consistent, but it provides a measure of inconsistency. Formally dealing with errors that occur in many aspects is the philosophy underlying the AHP. It is a process of "systematic rationality" and

enables us to consider a problem as a whole and to study the simultaneous interaction of its components within a hierarchy (Harker 1989, Saaty 1982).

5.7.5 Final Weights of Five Categories

Following the mathematical procedures listed above, the weights of five categories in the Tier II Project Index have been determined. Two rounds of questionnaire collection have been performed in the CCIS Work Force Steering Committee Meeting and the second CCIS Workshop. Only responses with CR ≤ 10% were regarded as valid and included in the final calculation of average weights for each category.

A total of 38 responses were gathered - 12 from the CCIS steering committee meeting and 26 from the second CCIS workshop. Out of 38 responses, 19 turned out to be valid based on the consistency criteria of CR ≤ 10%, which include the responses of 3 professors, 5 graduate research assistants, and experienced workers and researchers. The valid answers and average weights from the two data sets are included in Appendix D.

The average weights from the second workshop and the steering committee meeting are quite close. This means that there is some consensus between the two data sets. However, the results from the second workshop may be biased because most of the attendees were workers at the craft or foreman level and so they may have put more emphasis on their own strengths.

The average weights were calculated with the 19 valid responses and then, adjusted for the convenience of calculation as shown in Table 5.5.

Table 5.5 Weights of Categories

	Average Weights (%)	**Adjusted Weights (%)**
Craft Technical Skills	38	**40**
Craft Management Skills	22	**20**
IT Utilization	10	**10**
Craft Utilization	15	**15**
Organization	15	**15**
Sum	100	100

These weights will be compared with the weights obtained from statistical analysis after enough data from Tier II projects are gathered in future research.

5.8 CALCULATION OF TIER II STRATEGY IMPLEMENTATION INDEX

The Tier II Work Force Strategy Implementation Index is the combined scores of the five categories: Project Craft Technical Skills, Project Craft Management Skills, Information Technology Utilization, Craft Utilization, and Organization. Each element in the five categories is assessed by the evaluation criteria and assigned a score from 0 to 10 as shown in the previous metric tables. For the assessment of Project Craft Technical Skills and Management Skills categories, the Individual Worker Skills Index must be obtained first. The average scores from individual worker evaluations in technical and management skills and percentage of the Tier II workers should be calculated in advance.

Each of the five categories can have a maximum score of 100 points. To reach the final Tier II Strategy Implementation Index value, the score of each

category is multiplied by the weight determined through the AHP, and then the sum of the five categories is divided by 10. The Tier II Index ranges from 0 to a possible maximum value of 10. The weights and evaluation criteria could be changed continuously as the research progresses and more evidence is revealed. Table 5.6 summarizes the calculation of the Tier II Project Index Value.

Table 5.6 Scoring System of Tier II Project Index

	CATEGORY	WEIGHT	MAX. CATEGORY METRIC VALUE	POSSIBLE MAX. SCORE
Project Workers Characteristics	Project Average Technical Skills	0.40	100	40
	Project Average Management Skills	0.20	100	20
Project Execution	Information Technology Utilization	0.10	100	10
	Craft Utilization	0.15	100	15
	Organization	0.15	100	15
	Sum:	1.00		100
Tier II Project Index = (Weight * Category Metric Value) / 10 = Max 10.0				

The Tier II Strategy Implementation Index is computed using the following equation as shown in Figure 5.9 and will have a maximum value of 10.

Tier II Strategy Implementation Index (T2SII)

$$= \frac{1}{10}\{\sum_{i=1}^{5} \text{Category Weight}_i \sum_{j=1}^{n} (\text{Element Weight}_{ij} \text{ x Evaluation Criteria Score}_{ij})\}$$

$$= \frac{1}{10}\{0.40 \text{ *Project Craft Technical Skills} + 0.20 \text{ *Project Craft Management Skills} + 0.10 \text{ *IT Utilization} + 0.15 \text{ *Craft Utilization} + 0.15 \text{ *Organization}\}$$

where n is the number of elements for each category.

Figure 5.9 Equation of Tier II Strategy Implementation Index

The actual calculation of the Tier II Strategy Implementation Index after it is applied to the pilot project is provided in the Chapter 6, along with a detailed explanation of the application process.

5.9 SUMMARY

This chapter outlined the formation of the Tier II Work Force Strategy Implementation Index, which is the main focus of this dissertation. The purpose of these metrics was explained. The complete metrics for each category were presented with elements, weights, and evaluation criteria. The Analytical Hierarchy Process was used to determine the weights of five categories and the procedures were explained in detail. Finally, the Tier II Implementation Index was given with a scoring system for immediate application of the Tier II strategy. The next chapter presents the actual application of the Tier II strategy to a pilot project and the computation of the Tier II Project Index.

Chapter 6: Validation of Tier II Strategy Implementation Index

This chapter discusses the process employed in obtaining the data sets and results of the data analysis to validate the usefulness and viability of the Tier II Work Force Strategy Implementation Index as a practical tool, which can be used immediately on actual projects.

Five data sets were presented in this chapter as follows:

1. Sensitivity test of the Tier II Strategy Implementation Index.
2. Questionnaire answers of the second CCIS workshop attendees.
3. Self-evaluations of the second CCIS workshop attendees.
4. First application of the Tier II Strategy Implementation Index on No.1 Pilot Project (a power plant project).
5. Second application of the Tier II Strategy Implementation Index on No.2 Pilot Project (an environmental project).

The first data set is from a test of sensitivity of the Tier II Strategy Implementation Index regardless of different judgments of evaluators. The second data set is general questions about the craft workers' characteristics and their perception about the Tier II concept. The third data set is the workshop attendees' self-evaluations to measure the current skill levels of craft workers. The fourth and fifth data sets are applications of the Tier II Strategy Implementation Index on pilot projects to gather preliminary baseline data for current industry status in terms of the elements of the Tier II Index. Each of the five data sets is explained thoroughly in the following sections with results of the data analysis.

There is no project fully employing all elements of the Tier II Strategy Implementation Index currently because it is a new concept, even though several construction companies claim that they already utilize some of the elements. Preliminary baseline data from two pilot projects are presented in detail to show the procedures and methodology of the analysis. More investigations will be performed in the future on numerous projects implementing the entire elements of the Tier II Index to observe the potential impact of the Tier II implementation on construction success.

6.1 SENSITIVITY OF TIER II STRATEGY IMPLEMENTATION INDEX

As with any new index, there was concern that the Tier II Strategy Implementation Index value could be sensitive to the evaluator's subjective judgment. Therefore, the Tier II Index was tested to observe its sensitivity and robustness. The evaluation criteria for the elements of Individual Worker Skills Index and the Tier II Project Index were given for judgment based on the CII Model Plant data. Twenty-one students, including 9 CCIS graduate research assistants and an additional 12 graduate students, filled out the Tier II Strategy Implementation Index forms using the CII Model Plant information. This information and blank metrics are attached in Appendix E.

The CII Model Plant is a theoretical project developed to provide baseline productivity data for previous CII research. The Model Plant represents a petrochemical process plant that costs in the range of $75-85 million to construct. Contractors and owners, based on actual experience, have estimated the amount

of construction labor that would be required to build the Model Plant and these estimates formed baseline data for productivity measurement. In addition to its use as a standard for productivity measurement, the CII Model Plant is intended to provide a point of reference for other construction research activities. The Model Plant can be used as a demonstration example for new concepts or ideas as used in this research (CII Source Document 23 1986).

The evaluation results of the Individual Worker Skills Index are shown in Table 6.1 and Figure 6.1. The individual worker technical skills score ranges from 40 to 52 with a mean of 46.1 and a standard deviation (SD) of 3.4. The individual worker management skills score ranges from 26 to 51 with a mean of 35.0 and a SD of 6.0. The variation of management skills score is larger than that of technical skills score.

The combined Individual Worker Skills Index ranges from 66 to 99 with a mean of 81.1 and a standard deviation of 8.0. Out of 21 responses, 14 (67%) are within a range of Mean ± SD and 20 (95%) are within a range of Mean ± 2 SD as shown in Figure 6.1, which means the difference among the evaluators is acceptable and not significant.

Table 6.1 Statistical Values of Individual Worker Skills Index

	Ind. Worker Technical Skills (Max 100)	Ind. Worker Mgmt. Skills (Max 100)	Combined Ind. Worker Skills Index (Max 200)
Mean	46.1	35.0	81.1
Median	46	35	80
Mode	44	35	79
S.D.	3.4	6.0	8.0
Range	12	25	33
Minimum	40	26	66
Maximum	52	51	99

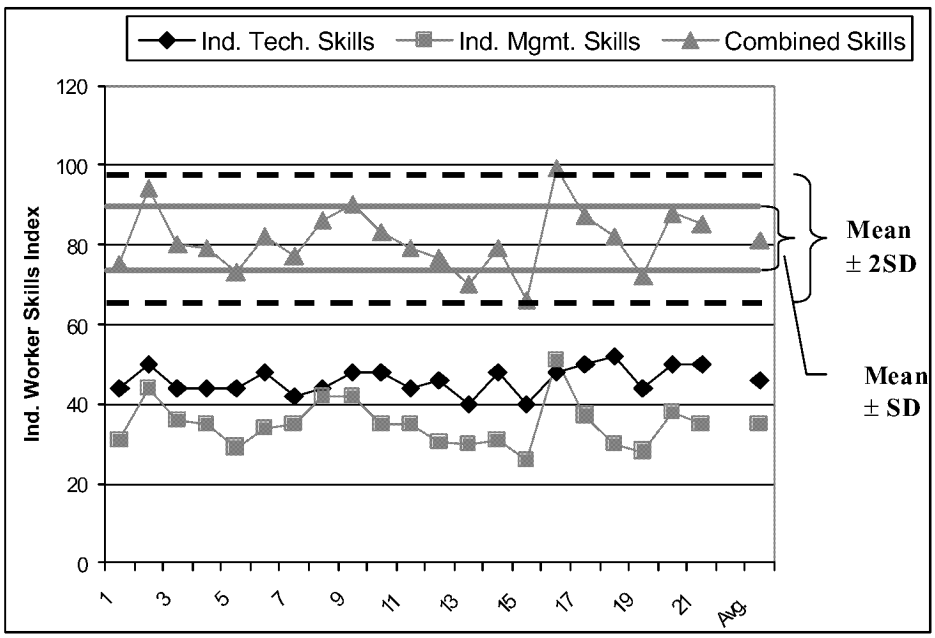


Figure 6.1 Individual Worker Skills Evaluation

The evaluation scores for the five categories of the Tier II Project Index are shown in Table 6.2 and Figure 6.2. The values were calculated using the weighted score for each category. The organization category shows somewhat wide range of scores compared to other categories considering the maximum score for this category is 15.

Table 6.2 Statistical Values of Tier II Project Index

	Proj. Craft Technical Skills (Max 40)	Proj. Craft Mgmt. Skills (Max 20)	IT Utilization (Max 10)	Craft Utilization (Max 15)	Organization (Max 15)	Combined Tier II Project Index (Max 100)
Mean	12.6	5.1	2.2	4.8	7.0	31.8
Median	13.6	6.0	2.3	4.8	7.2	32.4
Mode	13.6	6.0	2.8	4.8	7.2	30.7
S.D.	1.9	1.2	0.6	0.8	1.2	3.3
Range	6.8	4.2	2.0	3.2	4.8	11.8
Minimum	9.6	3.8	1.2	3.6	4.5	26.0
Maximum	16.4	8.0	3.2	6.8	9.3	37.8

The combined Tier II Strategy Implementation Index ranges from 26.0 to 37.8 with a mean of 31.8 and a standard deviation of 3.3. The maximum possible score is 100. Out of 21 responses, 14 (67%) are within a range of Mean ± SD and all responses (100%) are within a range of Mean ± 2 SD as shown in Figure 6.3. As the case with the Individual Worker Skills Index, the difference among the evaluators is acceptable and not significant.

It was concluded that the metrics are not very sensitive to the judgments of evaluators based on the range of scores. Therefore, the Tier II Strategy

Implementation Index can be used in the industry immediately after giving some basic instructions about how to score the metrics.

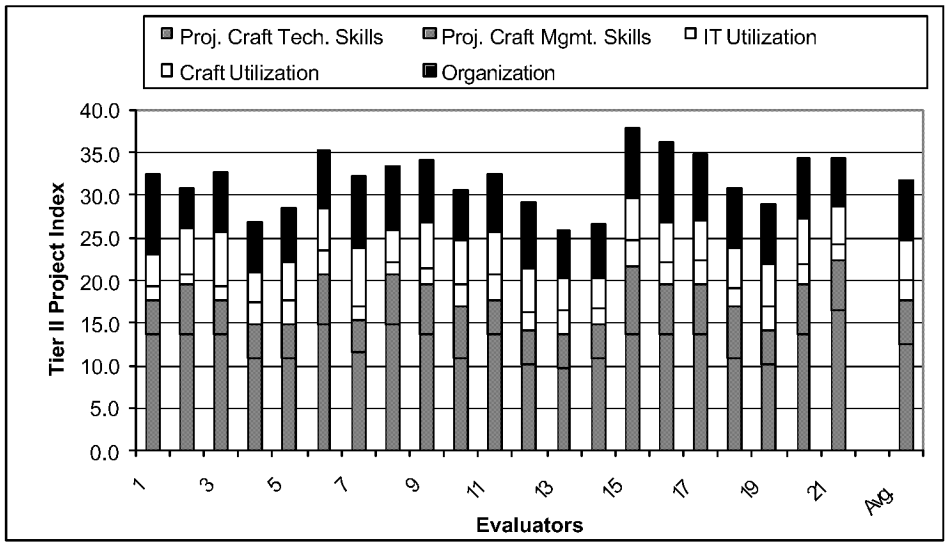


Figure 6.2 Scores for Five Categories of Tier II Project Index

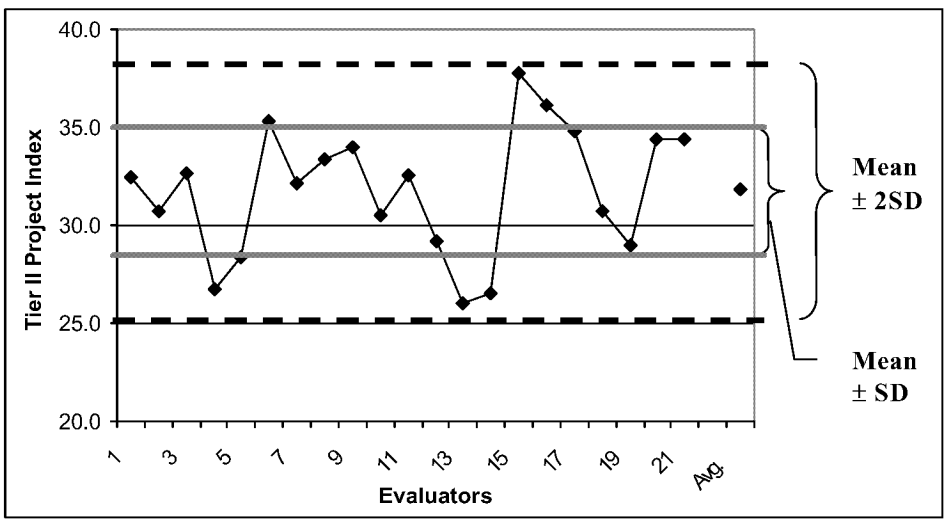


Figure 6.3 Tier II Project Implementation Evaluation

6.2 WORKSHOP

The second Tier II workshop with 21 experienced craft workers was held in July 2001 in Austin, Texas. Most of the attendees were above journeymen level and highly qualified workers with considerable work experience. Two different sets of data were gathered through the second workshop. The first data set is the attendees' self-evaluation of their own skill levels according to the Tier II Individual Worker Skills Index. They also evaluated the skill levels of the average workers working with them. The other data set is the questionnaire answers, which obtained some information about the Tier II strategy related characteristics of current work force. These results were used to refine the Tier II Strategy Implementation Index. Detailed explanations with analytical results are given in the next sections.

6.2.1 Evaluation of Skills for Workshop Attendees and Average Workers

During the second Tier II workshop with craft workers, the attendees conducted a self-assessment of their own skills using the Tier II Individual Worker Skills Index. They also performed the assessment for the "average worker" on the project where they have been participating at that moment or the most recent project they had worked on. Out of 21 attendees, 14 workers submitted the filled-out metrics.

Based on the workshop attendees' self-evaluation, 4 of 14 respondents (29%) were qualified as Tier II workers, which means those workers scored at

least 150 out of a maximum possible score of 200 points. This result is shown in Figure 6.4.

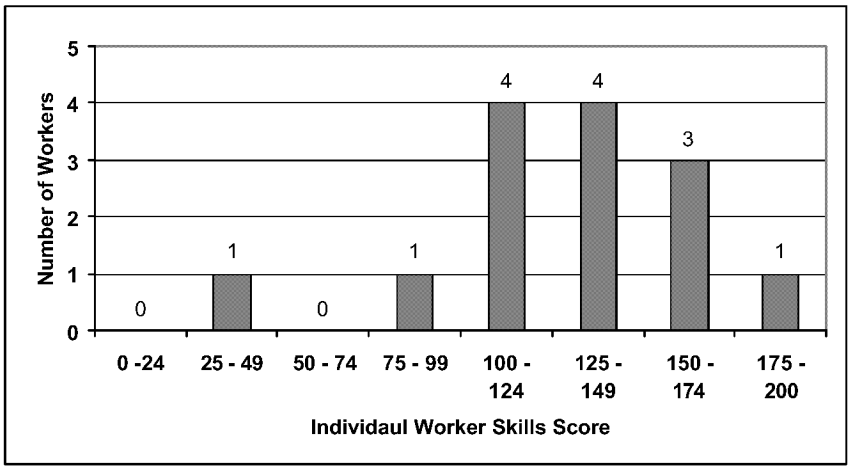


Figure 6.4 Attendees' Self-Evaluation

The responses indicated that none of the average workers on their projects would yield a score high enough to be qualified as a Tier II level worker. Figure 6.5 shows the summarized result.

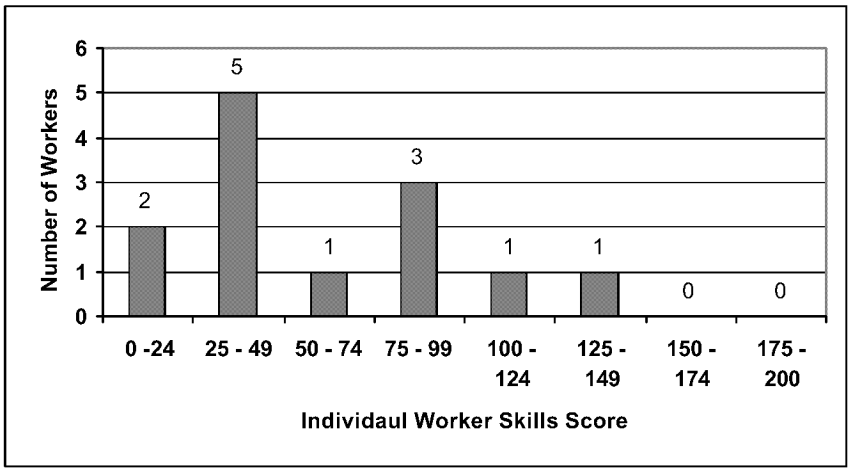


Figure 6.5 Attendees' Evaluation of Average Workers

The average scores of technical skills and management skills for each craft are shown in Table 6.3. The average scores of all respondents resulted very close for technical and management skills, which were **63.9** and **65.3** respectively. The scores are higher than the currently good state and the average management skills score is unexpectedly higher than the average technical skills score. These results could be explained by the fact that most of the respondents were foremen or superintendents. They have had considerable work experiences and performed some management functions.

Table 6.3 Average Skills Scores of the Workshop Respondents

	No. of Workers	**Avg. Tech. Skills Score**	**Avg. Mgmt. Skills Score**	**Combined Worker Skills Score**	Range	No. of Tier II Workers
Boilermaker	1	60.0	60.0	120.0	120	0
Carpenter	3	83.3	71.7	155.0	120 - 180	2
Electrician	4	64.0	65.5	129.5	105 - 148	0
Millwright	1	0.0	40.0	40.0	40	0
Pipefitter	4	65.0	66.5	131.5	90 - 165	2
Plumber	1	68.0	71.0	139.0	139	0
Total Average:	14	**63.9**	**65.3**	**129.1**		4

Five out of 14 respondents evaluated their management skills scores as greater than 75 out of a possible 100 points. Also, 7 of them assessed their technical skills scores as greater than 75 out of possible 100 points as shown in Figure 6.6. One respondent evaluated his technical skill level as the maximum 100 points. The four workers who were qualified as Tier II workers showed an exceptional skill level.

Half of the respondents obtained a higher score in management skills than technical skills. This is not surprising given that most of the attendees are highly qualified workers in the level of a foreman or a superintendent, and they have performed management functions.

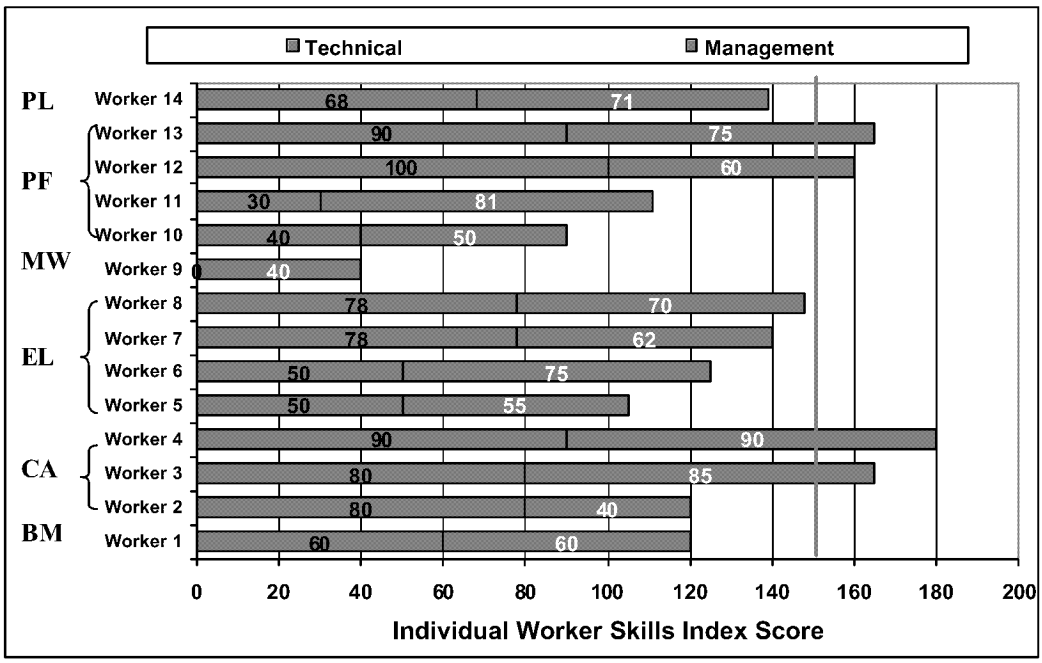


Figure 6.6 Management and Technical Skills from Attendees' Self-Evaluation

One consistent problem was identified in completing the evaluation form of the Individual Worker Skills Index. Only 3 possible choices were provided for each element of the metrics (0, 5, 10) and the interpolation between these numbers was recommended based on personal judgment whenever necessary; however, only a few people interpolated. Instructions on how to fill out the form with interpolation should be emphasized in the future project applications.

The application of the Individual Worker Skills Index is very easy and practical. Although the result from the attendees' self-assessment showed that only four people evaluated themselves at a Tier II level, it is reasonable to assume that almost all the attendees could be qualified as Tier II workers after specific targeted training was provided. It is also probable that some of the current average workers could be Tier II workers if necessary training and support were provided.

6.2.2 Questionnaire

During the second Tier II workshop, questionnaires were distributed to get the Tier II implementation-related characteristics of the workers and their conception of the Tier II Work Force Strategy. The 14 attendees who performed a self-evaluation also answered the questionnaires. The results of the questionnaire analysis are illustrated in this section. Some of the results are quite descriptive of the workers themselves and others are closely related to the elements of the Tier II Strategy Implementation Index. The results were accommodated in refining the Tier II Strategy Implementation Index. The complete package of questionnaire is attached in Appendix F.

Figure 6.7 shows the respondents' current job title. Most of the respondents were foremen or craftsmen. Some of the respondents were in the management level, however, they had significant experience as craftsmen or foremen.

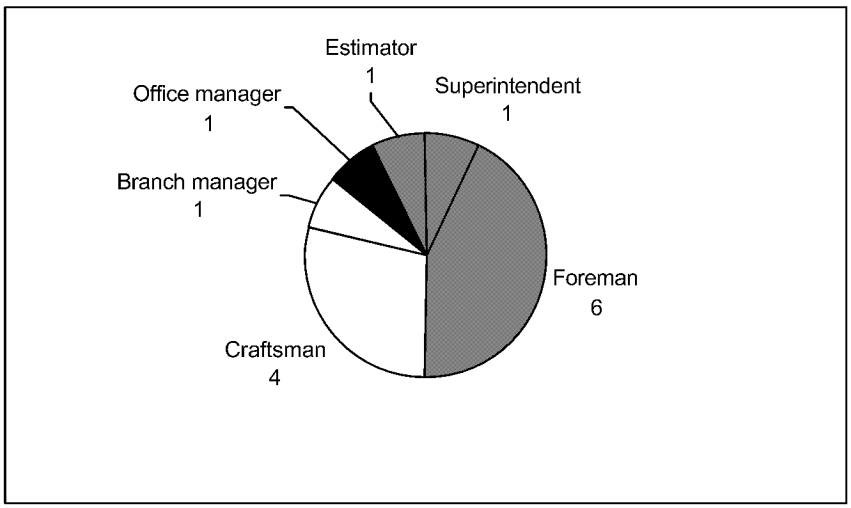


Figure 6.7 Job Title of Respondents

The respondents' years of work experience in construction are shown in Figure 6.8. They had an average 13 years of experience as journeymen and average 6 years as foremen.

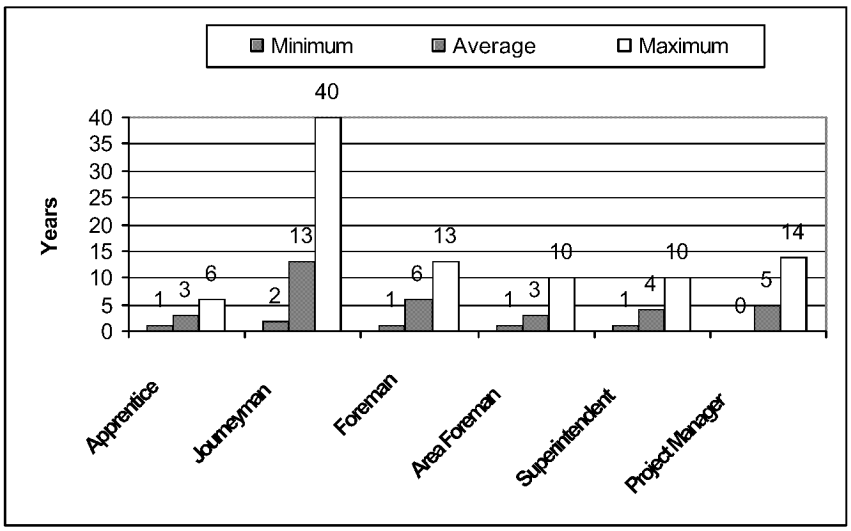


Figure 6.8 Years of Experience in each Job Title

The average number of years with their present company was 12.5 years and the average number of years of longest employment with one company was 11.1 years. These show that the workers who attended the workshop are some of the best workers in their companies. The respondents also answered that they were employed by an average of 7.5 different companies while in construction.

With respect to the possibly effective multi-crafting, the most frequent combination of crafts was carpenter and concrete finisher as shown in Figure 6.9. The combination of pipefitter and welder; crane operator and rigger; and carpenter, concrete finisher, and reinforcing rodman recorded the next highest frequency.

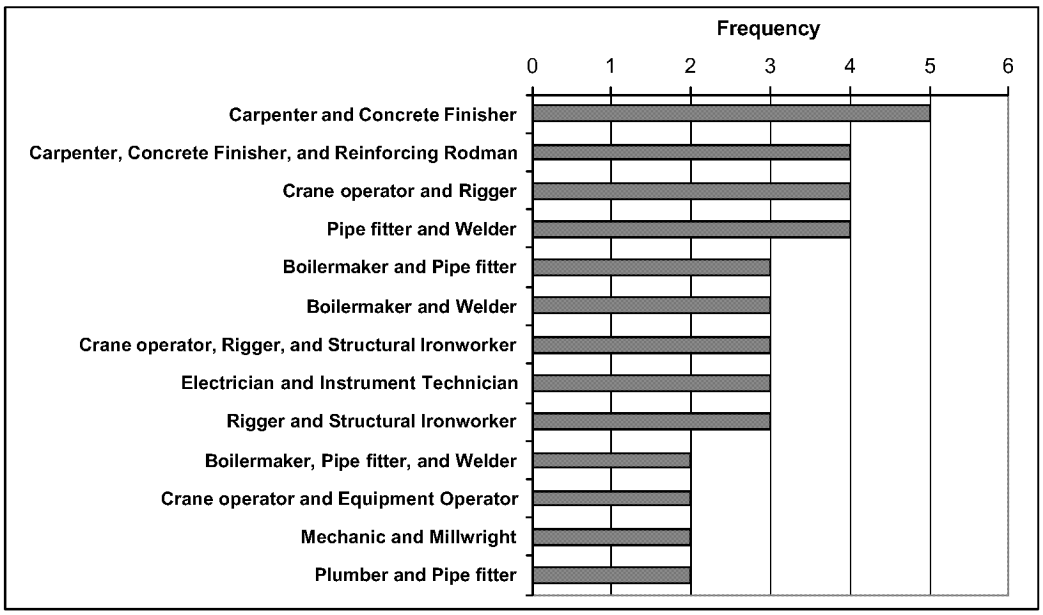


Figure 6.9 Possible Combinations of Multi-Craft Workers

Training is an important factor to keep and increase skilled workers. The benefits and needs of training are emphasized in this study and training is the main driving force for the success of the Tier II Strategy.

According to the results of the questions asking about training experience in the past three years as shown in Figure 6.10, safety training was the most common and skills training in a primary craft recorded the second highest frequency. However, the skills training in a second craft was not common. Training on communication skills and new technology recorded the next highest frequencies. Some workers answered that they receive computer training in scheduling, estimating, word processing, spreadsheet, email/internet, and CAD; however, the frequency was not high and more computer training should be provided as hand-held computers are being used more on sites.

The total hours of training received in the past three years are shown in Figure 6.11. The number of training hours for primary craft skills and safety were significantly high. Notably, the workers also got significant training in new technologies. They also got some training for communication skills, management, and cost estimating.

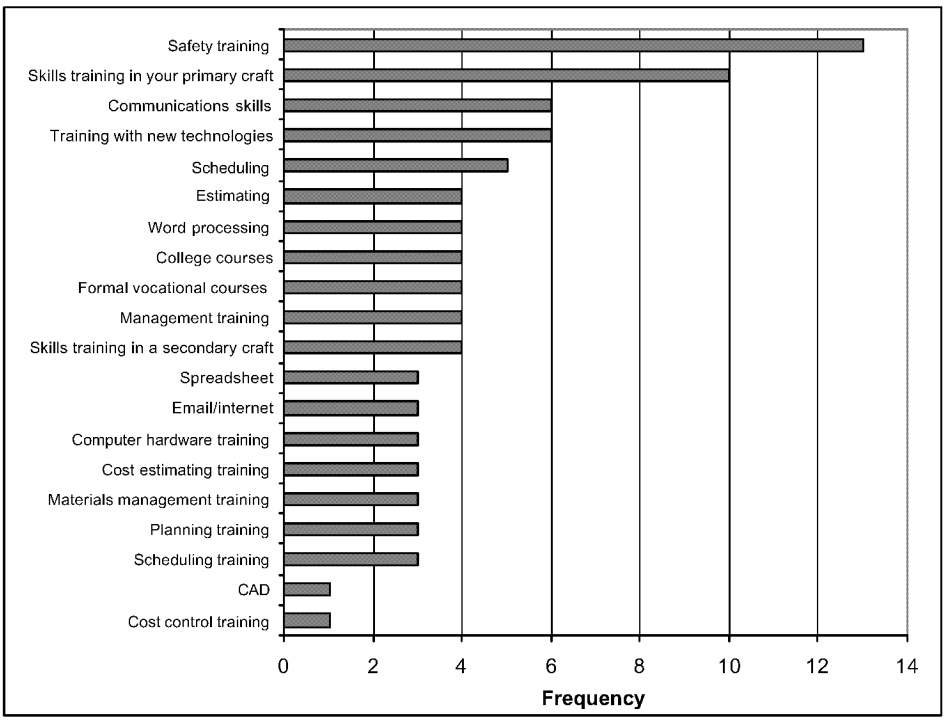


Figure 6.10 Training in Past Three Years

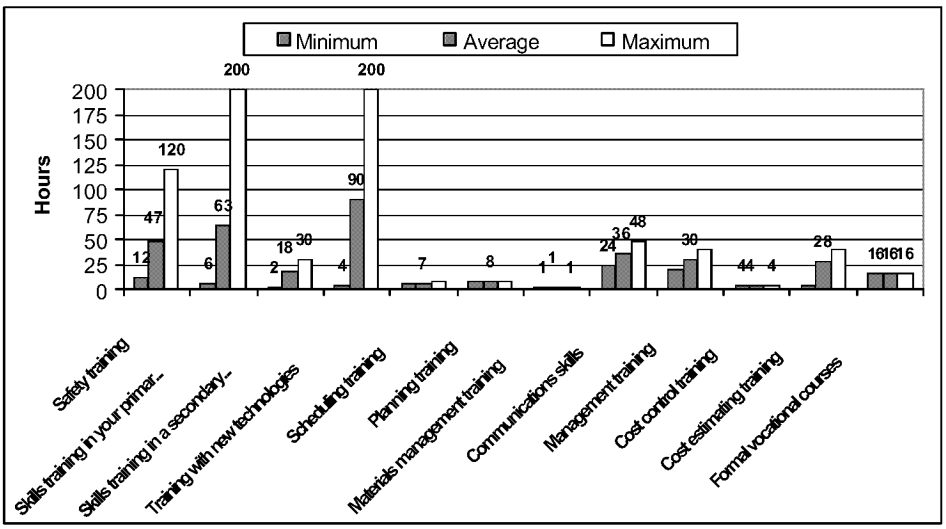


Figure 6.11 Training Hours in Past Three Years

Number of hours worked in the last year and the current year are shown in Figure 6.12. The respondents worked an average of 1,729 hours and an average of 614 premium hours last year. They expected to work more this year.

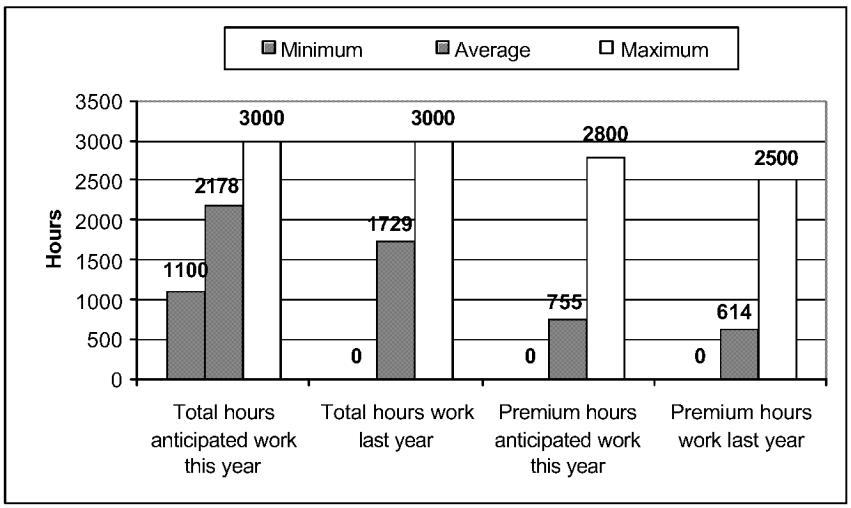


Figure 6.12 Annual Work Hours

The work history of respondents in the previous year is shown in Figure 6.13. The respondents worked an average of 39 weeks, averaging 40 hours per week and 14 days of vacation. The average number of weeks worked last year was somewhat lower than expected, considering the attendees of the workshop were high quality workers and they must have been needed on many projects. This may show the tendency of construction workers to work hard and then relax in the remaining time.

Out of 14 respondents, 6 worked in other industries before they started working in construction and 3 have worked outside of construction since they started working in construction.

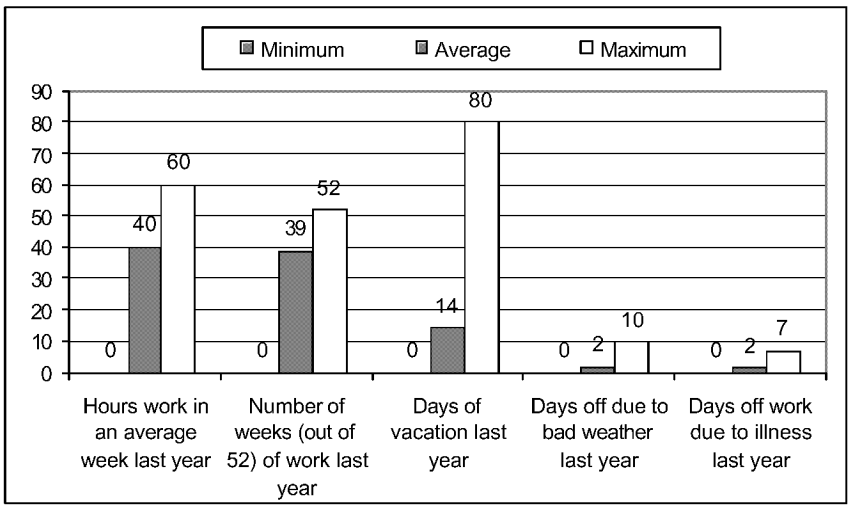


Figure 6.13 Work History of Previous Year

Most of the respondents (11 of 14) are paid overtime and 9 of 14 are paid overtime by the week.

According to the questionnaire answers shown in Figure 6.14, the construction companies prefer to give recognition rather than monetary bonuses for higher productivity, quality, and early completion. The companies tend to give cash bonuses for good safety performance more than for other factors.

Figure 6.15 shows the management functions by workers. The respondents perform considerable management functions including short-term planning, inter-craft coordination, crew coordination, tool and material procurement, and request for information (RFI). However, not many workers perform cost related functions such as cost management and cost estimating, and the usage of computers is limited to performing management functions.

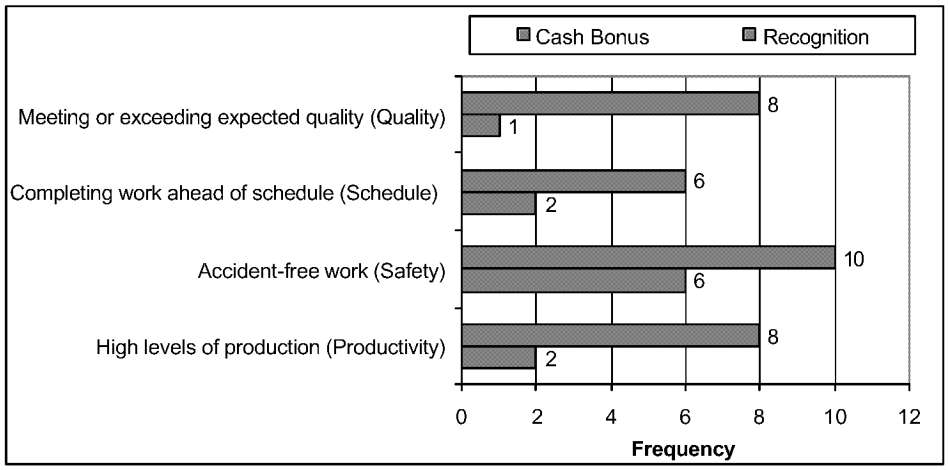


Figure 6.14 Cash Bonuses and Recognition

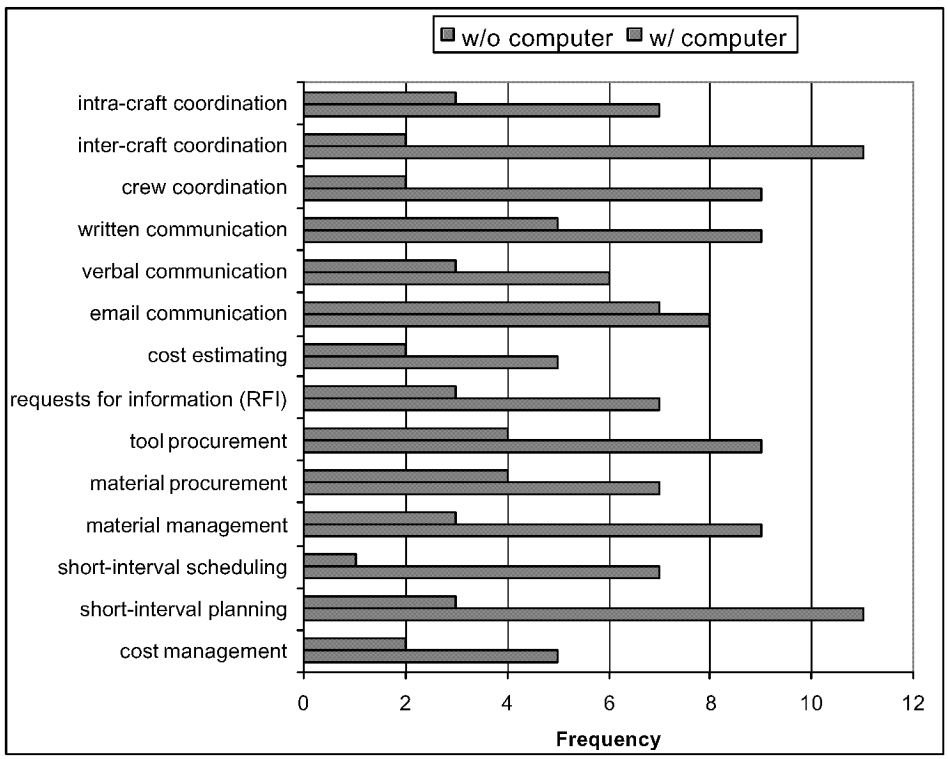


Figure 6.15 Management Functions of Workers

Even though the workers did not use computers extensively in the management functions, they were familiar with e-mail, the Internet, word processing, spreadsheets, presentation, and financial packages as shown in Figure 6.16. More usage of computers should be encouraged on site, as applicable.

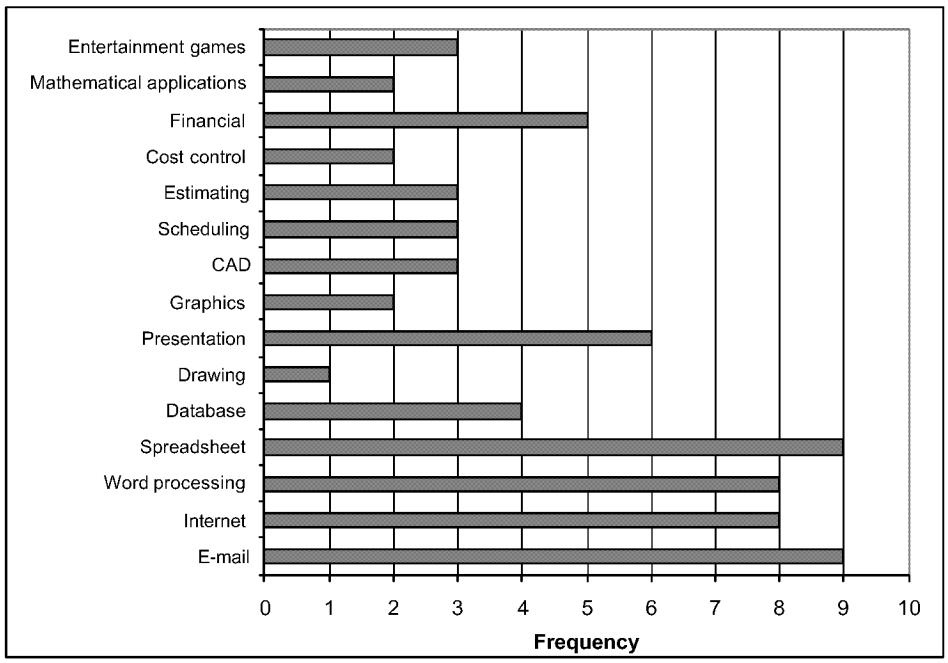


Figure 6.16 Worker Familiarity with Computer Application
(Multiple Answers per Person)

Out of 14 respondents, 11 have working spouses or partners: 7 with permanent (≥40 hrs/week) jobs and 4 with temporary (≤20 hrs/week) jobs. Out of 14 respondents, 10 are reluctant to be relocated and 5 will only accept jobs that do not require relocation. It appears that relocation may be a significant factor for workers to leave the construction industry.

The attendees of the workshop generally agreed that the Tier II strategy would enhance the performance of construction. For the question, "If the Tier II Work Force Strategy works, will the factors like safety, quality and productivity be improved?", 5 respondents strongly agreed, 7 agreed, and 1 was neutral.

Out of 14 respondents, 9 would recommend their son or daughter to enter a craft training program to pursue a career in field construction if the Tier II strategy was part of the career path. Among 14 respondents, 12 would pursue training for Tier II management skills even if it would be offered outside working hours.

From these results, it appears that the workers feel the Tier II Strategy is viable and promising and they want to be part of it. In addition to the results presented here, most of the attendees showed strong support for the idea of the Tier II Work Force Strategy in open discussion at the workshop, and they sincerely expected the strategy could be implemented in the construction industry in the near future.

6.3 FIRST APPLICATION OF TIER II STRATEGY IMPLEMENTATION INDEX: NO.1 PROJECT (POWER PLANT PROJECT)

Several pilot projects for the Tier II strategy application are currently under consideration by the CCIS Work Force Research Team. Many owners and general contractors showed interest in participating in the Tier II Work Force Strategy implementation. Two pilot projects, which seemed the most appropriate for Tier II strategy, were selected and preliminary data were gathered. The first project was a power plant project in a huge energy center and the second project

was a Selective Catalytic Reduction (SCR) project, which reduces NOx emissions to an existing power generation plant. This Section 6.3 describes the first pilot project with analytical results and the next Section 6.4 describes the second pilot project in detail.

The data for several other projects will be gathered, analyzed, and presented through future research to determine the relationship between construction success and the level of Tier II implementation. The purpose of these two pilot projects was to gather preliminary Tier II data to assess current skill level of workers and current implementation level of Tier II elements, and also show the exemplary procedures and methodologies to assess Tier II implementation.

6.3.1 No.1 Project Description

The CCIS Tier II research team was invited by a general contractor to conduct a baseline assessment of an energy related project. The company is a billion dollar revenue non-union general contractor specializing in industrial projects. This first pilot project was construction of a combined cycle power plant in a huge energy center, which is located in the Southeast U.S. The company's management believed that the characteristics of the work force in the project were aligned with those proposed under the Tier II Work Force Strategy. This was the first construction site where the Tier II Strategy Implementation Index was tested and measured. Relevant feedback was gained in the process.

The energy center will be a co-generation energy center fueled by natural gas. This center will supply steam to a major facility while generating an additional 660 megawatts. Under a 20-year agreement, an energy trading corporation will purchase 168 megawatts of output for sale to the wholesale power market. The remainder of the power will be marketed on the Southeastern U.S. wholesale power market.

At the time of a site visit (November 2001), the construction phase of the project was approximately 50% complete (start/finish: November 2000/November 2002), with about 300 craft workers employed. The number of workers was expected to increase to a peak of about 450 in February 2002, and the estimated total work-hours for the project period were between 800,000 and 1,000,000 hours.

On a two-day site visit on November 1-2, 2001, the project was evaluated with the Tier II metrics at the worker and project levels. Other relevant input was gained at the site from the journeymen and management-level people interviewed. Several weeks in advance of the site visit, the CCIS research team discussed and planned with the company's Vice President of Construction how to gather the Tier II preliminary baseline data.

The elements were scored according to the evaluation criteria and combined together to form an Individual Worker Skills Index score and a Tier II Project Index score for implementation of the Tier II strategy. The project success was also estimated using a simplified metric at the same time as explained in

Section 6.3.4. Detailed explanations and results are given in the following sections.

6.3.2 Individual Worker Skills Assessment

Twenty-seven workers performed the self-assessments of their technical and management skills using the Individual Worker Skills Index, and completed worker profile questionnaires. The workers belonged to the three key crafts of the project, which were electricians, millwrights, and pipefitters. The individuals interviewed were among the best workers on the project. Followings are summarized descriptive statistics of the workers obtained from worker profile questionnaires:

- Half of the workers consider themselves skilled in a secondary craft and the other half consider themselves semi-skilled in a secondary craft.
- 24 of 27 (roughly 90%) consider themselves multi-crafted.
- Average age of the 27 workers interviewed is 39 years old.
- 40% of the workers have supervisory responsibilities in their job.
- 26% of the workers are at the foreman or general foreman level.
- Workers have worked an average of 6 years with the company (range between 0 and 19).
- Most of the interviewed workers believe the Tier II concept will work.
- The mean, median and mode for their work satisfaction and motivation score in the current project is **8** (on a scale from 1 to 10 with 1=very low and 10=very high).

Based on the workers' self-evaluation as shown in Figure 6.17, 3 out of 27 workers (11%) were qualified as Tier II workers by acquiring at least 150 out of a maximum possible score of 200 points. There were 6 workers in the range between 125 and 149, who could be Tier II workers easily with some more training.

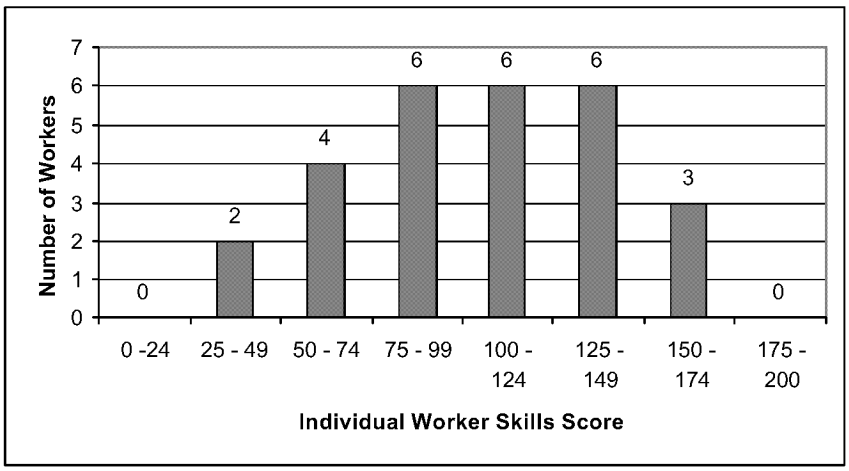


Figure 6.17 Self-Evaluation of No.1 Project Workers

The workers' technical and management skills scores with descriptive information are presented for each craft in Table 6.4. The average technical and management skills scores for all interviewed craft workers turned out to be same, both **52.0**. Millwrights showed the highest combined score and a significantly higher score in technical skills compared to other groups. In contrast, pipefitters showed relatively low combined scores mostly due to low management skills.

Table 6.4 Average Skills Scores for Three Key Crafts on the No.1 Project (Power Plant Project)

	No. of Workers	Avg. Yrs. w/ Company	**Avg. Tech. Skills Score**	**Avg. Mgmt. Skills Score**	**Combined Worker Skills Score**	Range	No. of Tier II Workers
Pipe Fitter	8	2	44.8	39.8	84.5	46 - 125	0
Millwright	11	8	60.5	58.8	119.2	76 - 160	2
Electrician	8	6	47.8	55.0	102.8	50 - 173	1
Total Average:	**27**		**52.0**	**52.0**	**104.1**		3

The average score achieved and the maximum possible score for each element of the Individual Worker Skills Index categories are presented for each craft in Table 6.5 and Figure 6.18. This comparison identified the specific areas where effort should be focused to improve current skill levels. Generally the skill level of the workers was close to the current, best possible level because the workers were among the best workers on the site. Pipefitters showed a somewhat lower level of skills than the others in both technical and management skills. Specifically, their scores of training, planning, and work record were not compatible with the scores of other trades.

Table 6.5 Average Score for Each Element of Individual Worker Skills Index on the No.1 Project (Power Plant Project)

Category	Element	Pipe Fitters	Millwrights	Electricians	Max
Technical Skills	Certification	13.5	18.9	15.0	40
	Experience	24.5	29.1	23.0	40
	Training	6.8	12.5	9.8	20
	Sum:	**44.8**	**60.5**	**47.8**	**100**
Management Skills	Administration	2.3	4.1	3.8	10
	Computer	3.5	2.5	4.3	10
	Planning	9.4	16.9	12.8	30
	Job Management	7.8	11.5	9.5	20
	Work Record	16.9	23.9	24.8	30
	Sum:	**39.8**	**58.8**	**55.0**	**100**

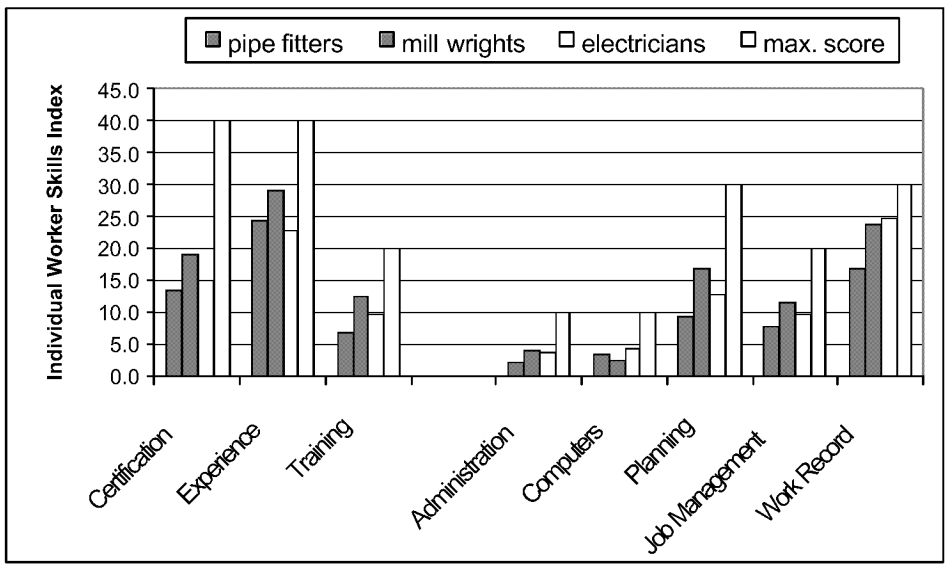


Figure 6.18 Average Score for Each Element of Individual Worker Skills Index on the No.1 Project (Power Plant Project)

Figure 6.19 shows the technical and management skill scores achieved by each individual. A combined score (technical + management) of at least 150 points is required to be qualified as a "Tier II Worker". Only one electrician and two millwrights are eligible to be Tier II workers at this time; however, about 40% (11 of 27) of the interviewed workers recorded more than 120 points, and so they could become eligible for Tier II workers easily with some additional training and support from management. It is noteworthy that 13 of 27 workers showed higher management skills than technical skills.

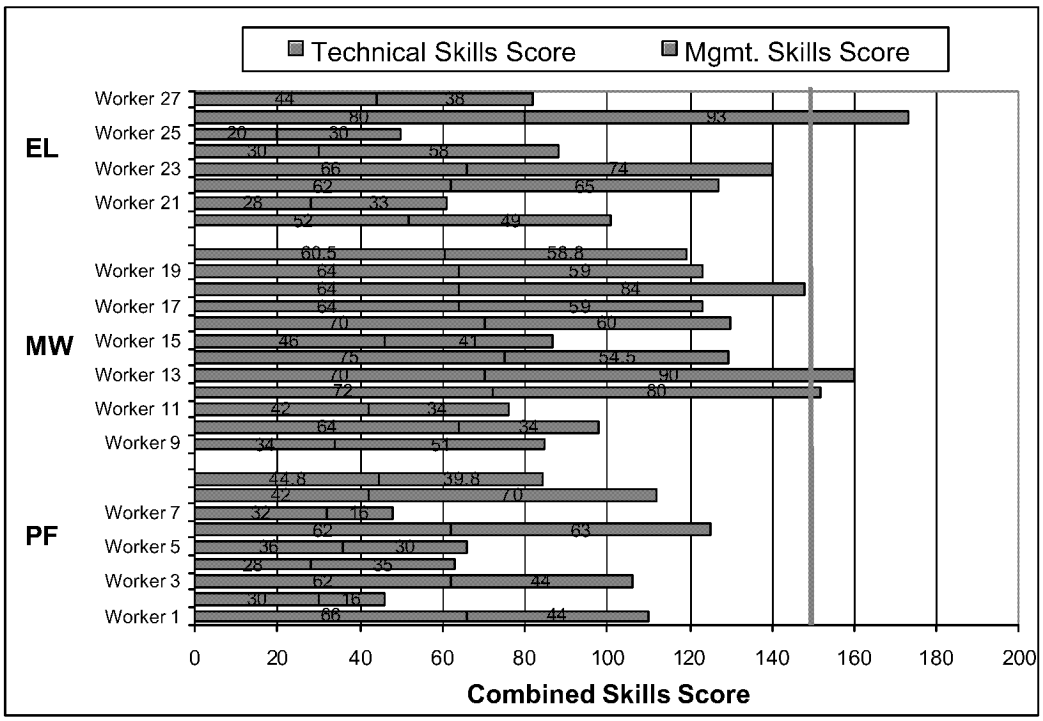


Figure 6.19 Individual Worker's Technical and Management Skills on the No.1 Project (Power Plant Project)

6.3.2.1 Average Skills Score for All Craft Workers

Most of the 27 workers who completed the Tier II Individual Skills Index were journeymen. They were selected by the site management team, based on their high skill levels and distinguished work record under the company's evaluation system. Therefore, they were among the best workers and were not representative of the total project work force.

Thus, the average scores of the Individual Worker Skills for all craft workers on the project were predicted through regression analysis, based on the correlation of the interviewees' Individual Worker Skills Index scores and their corresponding job position (between 1A and 7B) as defined by the company. The skill level of workers in the company was defined by job position from 1A: entry -level craft worker to 7B: general foreman II (supervisor). Level 1B through 4A are semi-skilled employees and level 4B is the uncertified journeyman. Level 5A is the company's certified journeyman. The complete craft progression chart with description is attached in Appendix G for reference.

The process to predict the average skills score of all craft workers is as follows. First, number 1 to 15 was given for each job position 1A to 7B as shown in Table 6.6 and the 27 workers who performed the self-assessment were given a corresponding scale based on their job position in the company. Regression analyses were performed between the job position of workers and the scores of their technical skills as well as management skills.

Table 6.6 Job Position and Corresponding Scale

1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	5C	6A	6B	7A	7B
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Regression analysis is the part of statistics that deals with investigation of the relationship between two or more variables related in a non-deterministic fashion (Devore 1995) and it is a very powerful quantitative research tool. A simple form of estimating the linear relationship between a dependent variable (Y) and an independent variable (X) is a bivariate regression, which is used in this research.

The general form of a linear prediction equation is:

$$Y = b_0 + b_1 X$$

where: b_0 = intercept coefficient

b_1 = bivariate regression coefficient

The coefficient of determination, denoted by R^2, represents the proportion of observed Y variation that can be explained by its linear relationship with X and it ranges between 0 and 1. The higher the value of R^2, the more successful is the linear regression model in explaining y variation.

To determine whether or not the model with its independent variables is a significant predictor of the dependent variable (i.e., Is b_1 significantly different from 0?), a statistical significance test is performed using the F-statistic. The linear regression model is statistically significant if the computed F-statistic is greater than the F-critical value for the defined probability level.

Microsoft Excel was used for all the statistical computations for this study. For the Excel output interpretation, if the obtained significance level (significance F, p-value) associated with the F-statistic is less than 0.05 (at 95 percent confidence, level of significance: α=0.05), the linear regression model is statistically significant. The significance level of the test, denoted by α, was set to 0.05, which is normal for statistical analysis.

The analysis result of the Individual Technical Skills score and job position for the 27 workers is given in Figure 6.20 and Table 6.7. The regression equation and R^2 value are included in the body of Figure 6.20 and the significance test statistics are shown in Table 6.7. According to the equation, each additional one higher job position increases the Individual Technical Skills score by 3.5324.

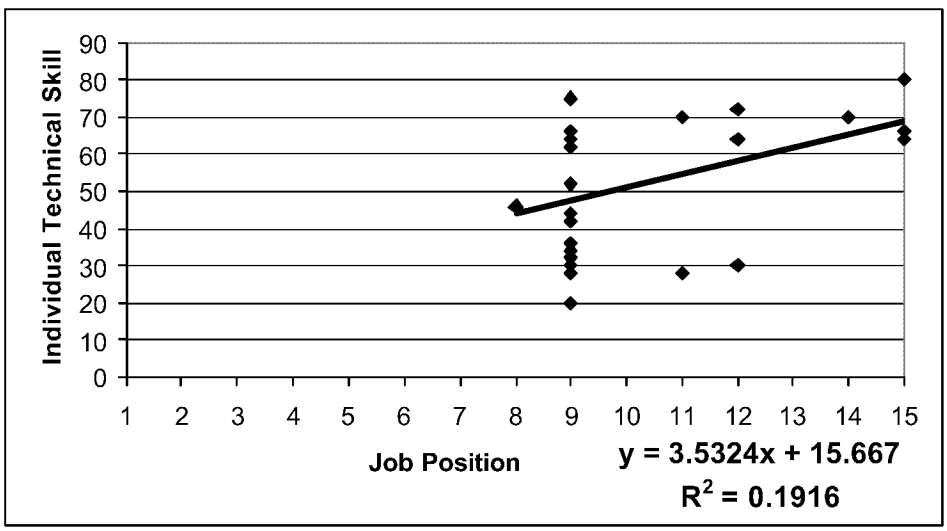


Figure 6.20 Individual Technical Skills vs. Job Position

The relationship is statistically significant because the obtained significance level is 0.022 as shown in Table 6.7 and less than the predetermined

significance level of the test, α=0.05. About 19 percent of the variation in the Individual Technical Skills score can be explained by its linear relationship with the scale of job position.

Table 6.7 ANOVA Results for Individual Technical Skills and Job Position

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1542.592	1542.592	5.924	0.022
Residual	25	6510.371	260.415		
Total	26	8052.963			

The same analysis was performed for the Individual Management Skills and job position, and the results are given in Figure 6.21 and Table 6.8. The original equation was Y = 6.4738 X – 14.638 and the R^2 value was 0.4487. However, the intercept value of -14.638 did not make sense because the skill level 1 and 2 produced negative values for the corresponding Individual Management Skills score. Therefore, the intercept coefficient was set to 0 to give reasonable values. According to the adjusted equation, each additional one higher job position increases the Individual Management Skills score by 5.111.

This relationship is statistically significant because the obtained significance level is 0.00017 as shown in Table 6.8, which is much less than α=0.05. About 43 percent of the variation in the Individual Management Skills score can be explained by its linear relationship with the scale of job position.

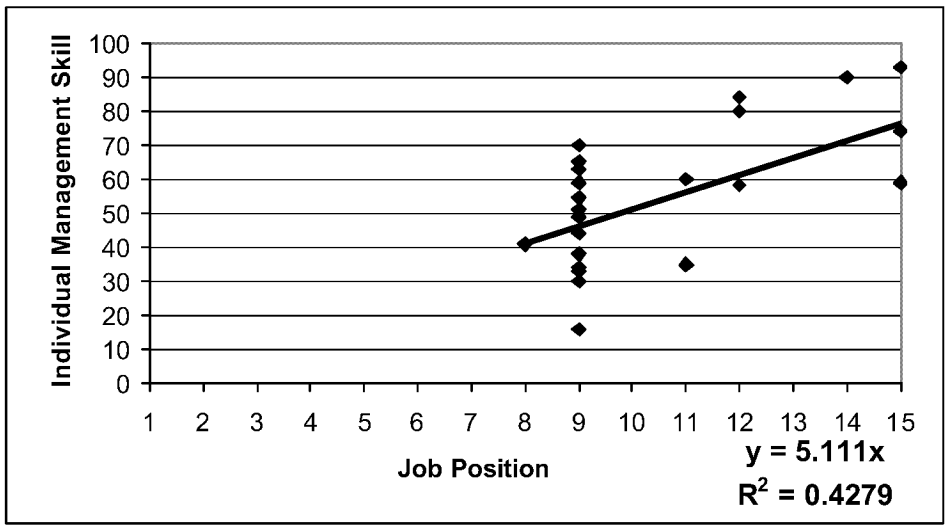


Figure 6.21 Individual Management Skills vs. Job Position

Table 6.8 ANOVA Results for Individual Management Skills and Job Position

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4941.793	4941.793	19.449	0.00017
Residual	25	6606.448	254.094		
Total	26	11548.241			

Based on the regression equations, the Individual Technical and Management Skills scores for all the job positions from 1A to 7B were estimated and then they were multiplied by weights determined by the percentage of workers in the project who belong to the specific job position. The multiplied results were then summed up to give the weighted average Technical and Management Skills scores for all the craft workers in the project. Table 6.9 summarizes the procedures and results of the computation.

Table 6.9 Average Individual Skills Score Computation

Job Position	Scale	Count	Weight (%)	Estimated Individual Tech. Score	Weighted Avg. Tech. Score	Estimated individual Mgmt. Score	Weighted Avg. Mgmt. Score
1A	1	22	8.0%	19.2	1.5	5.1	0.4
1B	2	4	1.5%	22.7	0.3	10.2	0.1
2A	3	13	4.7%	26.3	1.2	15.3	0.7
2B	4	12	4.4%	29.8	1.3	20.4	0.9
3A	5	10	3.6%	33.3	1.2	25.6	0.9
3B	6	5	1.8%	36.9	0.7	30.7	0.6
4A	7	5	1.8%	40.4	0.7	35.8	0.7
4B	8	64	23.3%	43.9	10.2	40.9	9.5
5A	9	86	31.3%	47.5	14.8	46.0	14.4
5B	10	1	0.4%	51.0	0.2	51.1	0.2
5C	11	7	2.5%	54.5	1.4	56.2	1.4
6A	12	31	11.3%	58.1	6.5	61.3	6.9
6B	13	0	0.0%	61.6	0.0	66.4	0.0
7A	14	10	3.6%	65.1	2.4	71.6	2.6
7B	15	5	1.8%	68.7	1.2	76.7	1.4
Sum		**275**	**100 %**		**43.8**		**40.7**
Average Individual Skills Score for All Craft Workers = 84.6							

It is worth mentioning that the Individual Skills scores that the interviewed workers achieved were proportional to their position within the company, and the scores increased in a fairly linear proportion with some statistical significance. This suggests that the worker evaluation system of the company and the Tier II Individual Worker Skills Index are consistent.

The average worker skill scores obtained from the regression analysis represent the scores of the entire work force at the project. The scores are **43.8** points for Technical Skills and **40.7** points for Management Skills. These scores were used as input to compute the Project Craft Technical Skills and Project Craft

Management Skills scores of the Tier II Project Index as explained in the following section.

6.3.3 Tier II Project Implementation Assessment

The first two categories of the Tier II Implementation Index are based on the results of the Individual Worker Skills Index discussed in the previous section. The remaining three categories regarding the utilization of the workers are based on information obtained from the Site Management Team.

The Tier II Project Index represents the level of implementation of the Tier II strategy elements at the project level. Table 6.10 shows the scores obtained for each category with the maximum score that is possible to obtain. The Tier II Project Index value for this pilot project is **4.08 out of 10** as shown in Table 6.10. The score for each element of the five categories of the index is included in Appendix H.

The scores for each category are less than half of the maximum possible and relatively lower than expected. The skills of average workers are less than the current, possible level and the overall utilization of skilled workers is less than anticipated. Only Craft Utilization appeared to be good.

The score for Craft Utilization is 9.9 out of the maximum 15. The site management team indicated that they expect a high percentage, about 30%, of the Tier II workers in their key crafts and also the worker turnover of the project is low because the company has provided career paths for workers through a craft

progression program. However, the use of multi-skilled workers was low and more multi-skilling would improve the Tier II score.

Table 6.10 Tier II Project Index of the No.1 Project (Power Plant Project)

Category		Category Value	Weight	Project Score	Max. Possible Score
Project Average Technical Skills ** for project's key crafts*	(A)	43	0.40	17.2	40
Project Average Management Skills ** for project's key crafts*	(B)	30	0.20	6.0	20
Information Technology Utilization	(C)	32	0.10	3.2	10
Craft Utilization	(D)	66	0.15	9.9	15
Organization	(E)	30	0.15	4.5	15
SUM		201	1.00	40.8	100

Tier II Project Index = SUM (A+B+C+D+E) / 10 = **4.08** **Out of 10.0**

It is necessary to provide more skills training for the workers on the project to be qualified as the Tier II workers, especially management skills training. Even though the company has a reputation for comprehensive craft training, the current skill levels of workers are not enough for the project to be a successful Tier II project.

IT utilization scored low and it seems that the workers do not use computers on site that much. It was indicated that there was not enough hardware for workers to use. The questionnaire answers of the second CCIS workshop indicated that many workers are familiar with basic functions of computers including e-mail, Internet, word processing, presentation, and spreadsheet. They should be given opportunities to utilize IT on the job site with proper instructions. IT will play an important role in future construction even though it currently comprises only 10% of the Tier II index score.

It would be compatible with the Tier II strategy to change the organizational structure into a more advanced form of high performance workplace. More emphasis should also be given on the communication including established formal and informal channels, open access to management, frequent meetings with workers, and information sharing.

6.3.4 Project Success Assessment

Metrics for evaluation of Project Success in Construction Phase are currently under development by the CII BM&M research team in cooperation with the CCIS. In the meantime, the construction success is evaluated using the simplified metric provided in Appendix J. As in the Tier II project implementation assessment, the scoring for the construction success was based on a consensus of the Site Management Team and that score for the project was 7, on a scale of 1 to 10.

The score for construction success is relatively high compared to the Tier II Implementation Index. However, the project was in an early stage, around 50% complete, and so its success rating may be different after completion. This success index is very subjective at this stage and detailed quantitative metrics for construction success are still under development as mentioned. It is also probable that the current success level of the project is a result of good management other than the Tier II strategy factors.

6.3.5 Summary of No.1 Project Application

The primary purpose of this initial application of the Tier II Strategy Implementation Index was to gather preliminary baseline data for the continuous Tier II research effort. In that regard, it has provided valuable insight. Follow-up data will be collected in the future as a continuous CCIS research effort during the project and after the project is completed. This pilot project also provided processes and methods for analysis. The additional projects implementing the Tier II strategy could be analyzed using the same methodologies presented in this dissertation.

The secondary purpose was to identify the areas in which the company could improve its Tier II strategy implementation. The following conclusions and recommendations are presented:

1. The skill level of the interviewed workers on the project was generally close to the current, best possible level. The structured technical training and certification programs developed by the company have contributed to

the skill levels of the workers and also provided a structured career path for the workers. However, more skills training is necessary for these workers on the project to be qualified as Tier II workers.

2. The average score of the interviewed workers on the Management Skills is almost the same as the Technical Skills score, which is not usual in the current situation of the construction industry. It is probable that this resulted from the fact that some of the workers interviewed were foreman or general foreman. Even so, the score is higher than anticipated.
3. The utilization of the Tier II workers was less than expected. Only Craft Utilization appeared to be effective.
4. It is suggested that the company consider expanding its training courses to include Information Technology. IT utilization scored low and it seems that the workers do not use computers on the site that much because there is not enough hardware for workers to use. Although major benefits of the IT Utilization may be realizable in the future, the morale benefits from offering such courses may be significant.
5. The company's management should address the issue of Organization, with particular emphasis on Communications and High Performance Work Teams (HPWT). The company already has had experiences with High Performance Work Teams and the experience would be useful in developing an appropriate level of implementation of the concept.

6.4 SECOND APPLICATION OF TIER II STRATEGY IMPLEMENTATION INDEX: NO.2 PROJECT (ENVIRONMENTAL PROJECT)

This section describes the second pilot project, an environmental project. The same procedures and methodologies as the first pilot project were applied to analyze the Tier II implementation on the second pilot project.

6.4.1 No.2 Project Description

This second pilot project was the installation of Selective Catalytic Reduction (SCR) units to reduce NOx emissions for a huge energy company, which is located in the U.S. Gulf Coast area. The project is over $200 million and will be completed by May 2003. At the time of the visit (February 19, 2002), the construction phase of the project was around 60% complete (start/finish: January 2000 / May 2003). There will be about 550 workers on site during the peak time. The Tier II Strategy Implementation Index was tested and measured as in the first pilot project. Relevant feedback was gained in the process.

The project was evaluated with the Tier II indices at the worker and project levels as in the first pilot project. Other relevant information was gained at the site from the craft workers and management-level people interviewed.

The elements were scored according to the evaluation criteria and combined together to form an Individual Worker Skills Index score and a Tier II Project Index score for implementation of the Tier II strategy. Detailed explanations and results are given in the following sections.

6.4.2 Individual Worker Skills Assessment

One hundred twenty workers performed self-assessments of their technical and management skills using the Individual Worker Skills Index. Out of the 120 craft workers, there were 62 boilermakers, 27 iron workers, 9 operating engineers, 7 welders, 6 sheetmetal workers, 5 pipefitters, and 4 insulators.

The workers interviewed were randomly selected. Among the 120 workers, 43 workers (36%) considered themselves multi-crafted. The average years of experience in their primary craft was 17.5 years.

Out of the 120 workers, 9 workers (8%) were qualified as Tier II workers based on the workers' self-evaluations as shown in Figure 6.22. They obtained at least 150 points out of a maximum combined score of 200 points. It is notable that there were 21 workers in the range between 125 and 149, who could be Tier II workers easily with some targeted training for deficient skills.

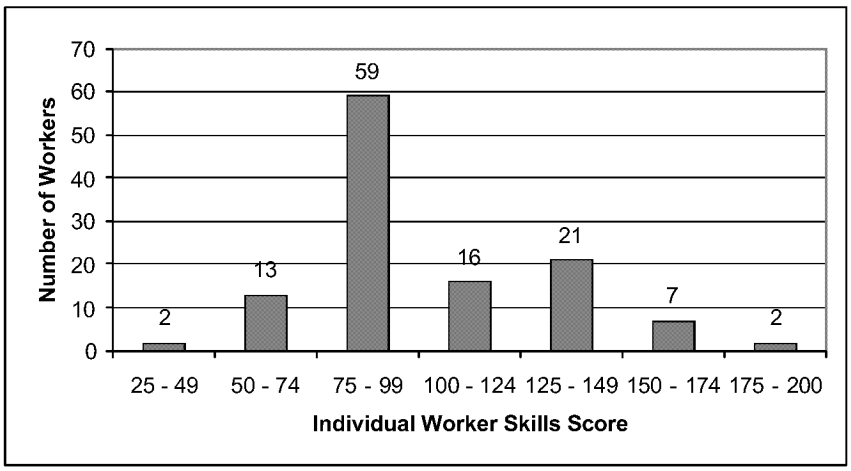


Figure 6.22 Self-Evaluation of No.2 Project Workers

The workers' technical and management skills scores with descriptive information are presented for each craft in Table 6.11. The average scores for all interviewed craft workers for technical and management skills were **55.9** and **45.3** respectively. Boilermakers showed the highest combined score, especially in technical skills, compared to other crafts. In contrast, insulators showed relatively low combined scores in both technical and management skills. Pipefitters scored high in technical skills, but low in management skills. Compared to the first pilot project, a power plant project, the average technical skills score in this second pilot project was higher than that of the first one, however, the average management skills score was somewhat lower than that of the first one resulting low combined score (Power Plant Project - Average Technical Skills: 52.0, Average Management Skills: 52.0).

Table 6.11 Average Skills Scores for Craft Workers on the No.2 Project (Environmental Project)

	No. of Workers	**Avg. Tech. Skills Score**	**Avg. Mgmt. Skills Score**	**Combined Worker Skills Score**	Range	No. of Tier II Workers
Boilermaker	62	60.5	46.4	106.8	50.8 - 180.8	7
Ironworker	27	53.6	45.9	99.5	62.4 - 174	2
Operating Engineer	9	50.7	45.0	95.7	73.1 - 134.2	0
Welder	7	52.7	41.3	94.0	70.2 - 129.3	0
Sheetmetal	6	40.6	54.9	95.5	36 - 137	0
Pipe Fitter	5	60.0	32.5	92.5	78.5 - 124.8	0
Insulator	4	35.3	32.6	67.9	42.1 - 81.2	0
Total Average:	**120**	**55.9**	**45.3**	**101.1**		**9**

The average score achieved and the maximum possible score for each element of the Individual Worker Skills Index categories are presented for each craft in Table 6.12. Figure 6.23 and Figure 6.24 show the graphical representation of average scores for elements of the technical skills and management skills.

Table 6.12 Average Score for Each Element of Individual Worker Skills Index on the No.2 Project (Environmental Project)

		Boiler-Maker	**Iron-worker**	**Operating Engineer**	**Welder**	**Sheet-metal**	**Pipe Fitter**	**Insu-lator**	**Max**
Technical Skills	Certification	19.2	14.8	7.5	21.9	10.6	16.7	5.0	40
	Experience	36.7	34.5	40.0	20.9	25.8	40.0	25.5	40
	Training	4.6	4.2	3.2	10.0	4.2	3.2	4.8	20
	Sum:	**60.5**	**53.6**	**50.7**	**52.7**	**40.6**	**60.0**	**35.3**	**100**
Management Skills	Administration	2.0	2.7	2.8	3.2	2.5	0.0	0.6	10
	Computer	1.9	2.6	2.9	0.8	2.5	1.0	0.3	10
	Planning	9.0	8.4	6.7	4.4	13.3	3.8	2.3	30
	Job Management	6.3	5.8	4.8	6.5	8.8	1.3	1.5	20
	Work Record	27.2	26.4	27.7	26.3	27.8	26.4	27.9	30
	Sum:	**46.4**	**45.9**	**45.0**	**41.3**	**54.9**	**32.5**	**32.6**	**100**

This comparison identified the specific areas where effort should be focused to improve current status. The technical skill level of the workers was generally close to the current, best possible level; however, the training element scores were much lower than expected. Union workers probably have little

training after apprenticeship. More craft training and skill updating should be emphasized and provided to workers in order to qualify them as Tier II workers.

All elements in the management skills category except the element of work record were extremely low. It seemed that craft workers in the project were not provided management skills training and they have not performed management functions. The workers' personal performance record in safety, attendance, quality, productivity, and initiative were very high.

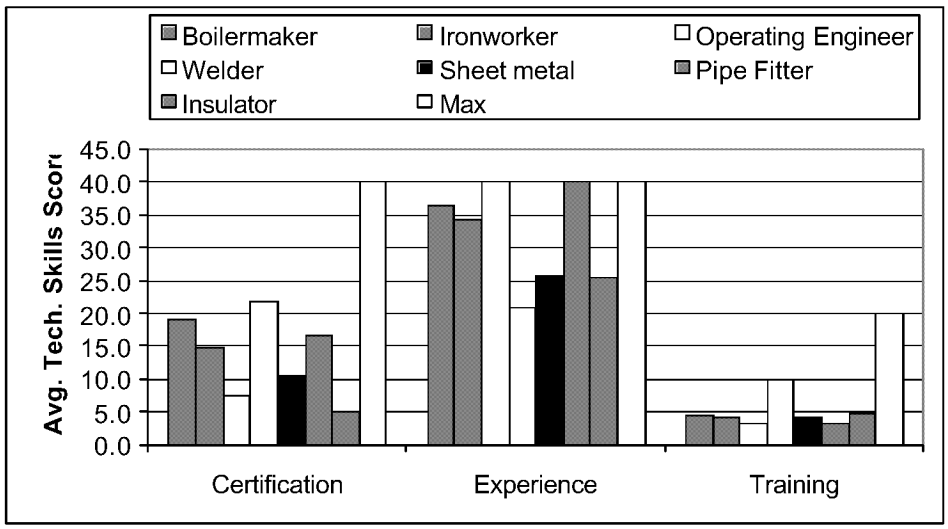


Figure 6.23 Average Technical Skills Score

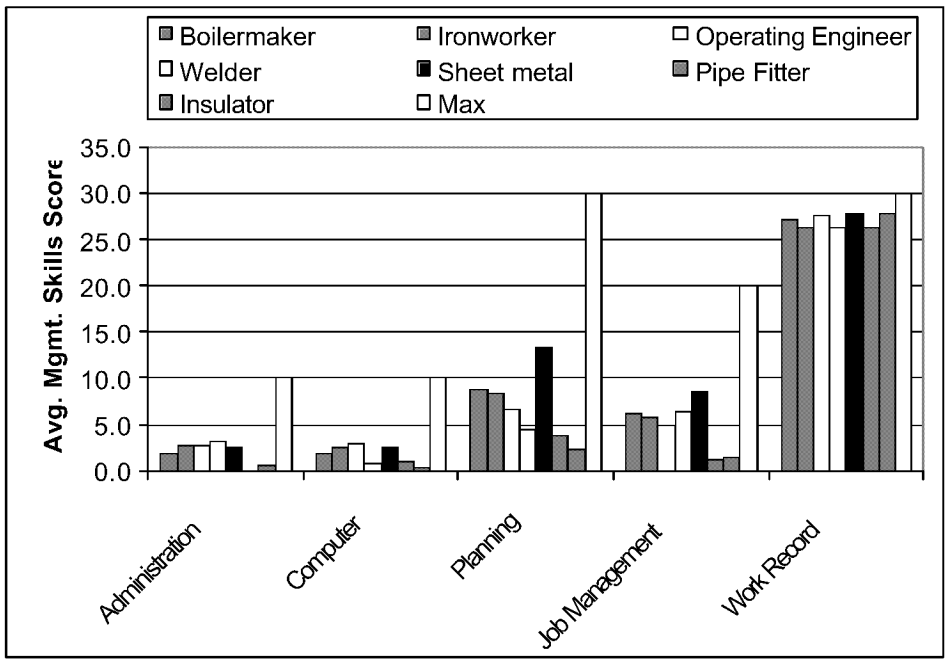


Figure 6.24 Average Management Skills Score

Figure 6.25 shows the technical and management skill scores achieved by each individual, a combined score (technical + management) of 150 points or more, is required to be qualified as a "Tier II Worker". Among 62 boilermakers, only 7 were eligible to be Tier II workers. Among 27 ironworkers, 2 were qualified as Tier II workers. The other crafts did not have any workers eligible to be a Tier II worker. However, about 28% (33 out of 120) of the interviewed workers recorded more than 120 points, so they could reach the skill level of Tier II worker easily with some additional training and support from management. It is noteworthy that 29 of 120 workers showed higher management skills than technical skills.

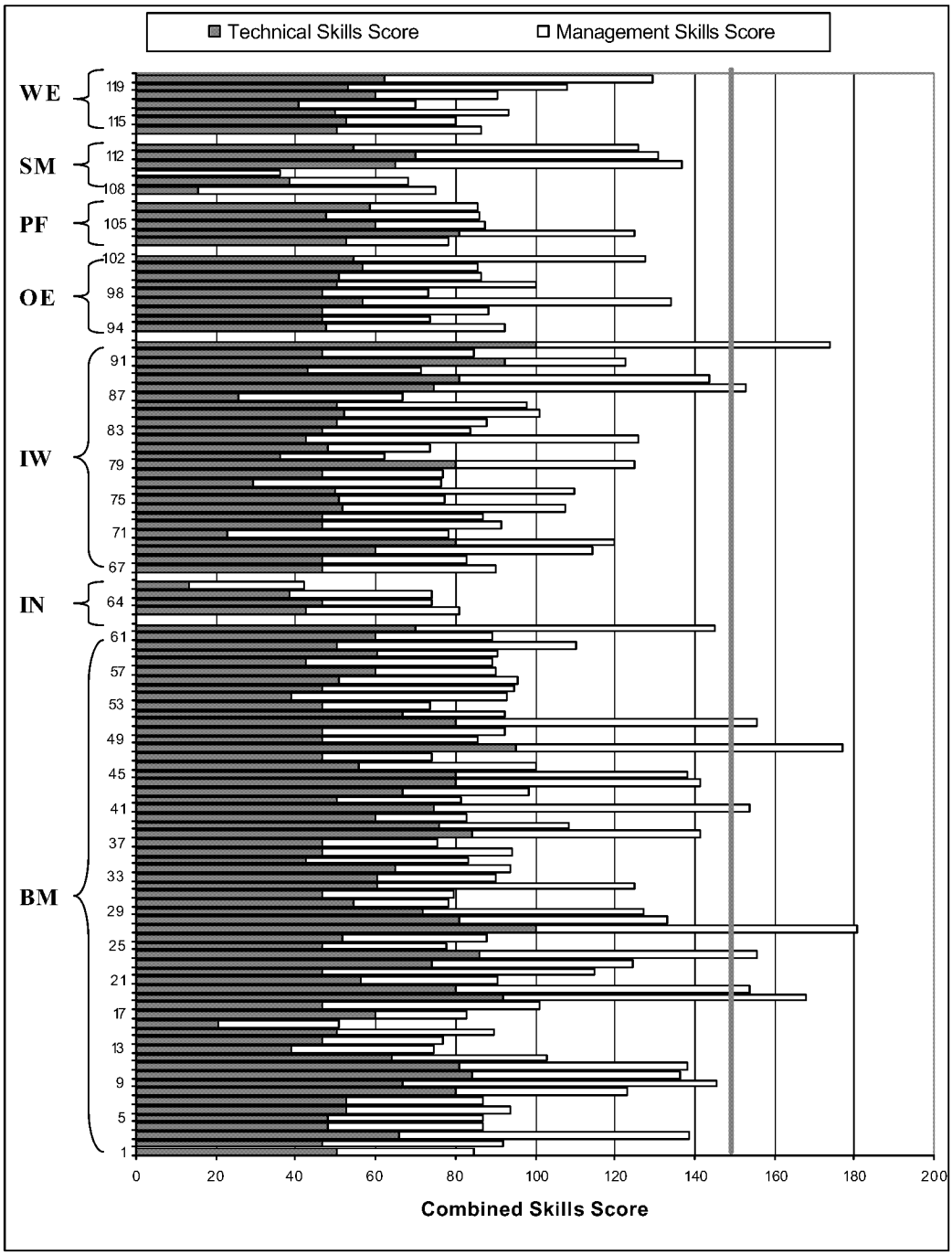


Figure 6.25 Individual Worker's Technical and Management Skills on the No.2 Project (Environmental Project)

6.4.3 Tier II Project Implementation Assessment

The first two categories of the Tier II Project Index are based on the results of the Individual Worker Skills Index discussed in the previous section. The remaining three categories of the Tier II Project Index, which are about effective utilization of the workers, are based on information obtained from the Site Management Team.

The Tier II Project Index represents the level of implementation of the Tier II strategy elements at the project level. Table 6.13 shows the scores obtained for each category with the maximum score that is possible to obtain. The Tier II Project Index for this pilot project is **3.70 out of 10**. The score for each element of the five categories of the Tier II Project Index is included in Appendix I.

The scores for each category are less than half of the maximum possible and relatively lower than expected. The skills of average workers are less than the current, possible level. It is necessary to provide more skills training for the workers in the project to be qualified as Tier II workers, especially management skills training. The utilization of skilled workers is also less than anticipated. Especially, the scores of Information Technology Utilization and Craft Utilization were extremely low.

Table 6.13 Tier II Project Index of the No.2 Project (Environmental Project)

Category		Category Value	Weight	Project Score	Max. Possible Score
Project Average Technical Skills ** for project's key crafts*	(A)	43.4	0.40	17.4	40
Project Average Management Skills ** for project's key crafts*	(B)	41	0.20	8.2	20
Information Technology Utilization	(C)	12	0.10	1.2	10
Craft Utilization	(D)	18	0.15	2.7	15
Organization	(E)	50	0.15	7.5	15
SUM		164.4	1.00	37.0	100

Tier II Project Index = SUM (A+B+C+D+E) / 10 = **3.70** **Out of 10.0**

IT Utilization scored extremely low, 1.2 out of the maximum 10. The site management team indicated that the project information was moderately integrated, but was not accessible to craft workers. Computers were not available for craft workers on site. Only field management had access to project information and electronically updated it.

The score for Craft Utilization was 2.7 out of the maximum 15. There were few Tier II workers and worker turnover ratio was high even though the use of multi-skilled workers was high. Out of 120 respondents, 43 workers (36%) were multi-crafted.

Compared to the low scores on IT and Craft Utilization, the score for Organization was relatively high. However, the company should put more effort to change the organizational structure into a more advanced form of high performance workplace to be compatible with the Tier II strategy. More emphasis should also be given to communications including established formal and informal channels, open access to management, frequent meetings with workers, and information sharing.

6.4.4 Project Success Assessment

The construction success was evaluated using the same simplified metric as the first pilot project, which is provided in Appendix J. The scoring for the construction success was based on a consensus of the Site Management Team and that score for the project was 7, on a scale of 1 to 10.

The score for construction success is relatively high compared to the Tier II Implementation Index. However, the project was around 60% complete, and so its success rating may be different after completion. This success index is very subjective and detailed quantitative metrics for construction success are under development as mentioned. It is also probable that the current success level of the project is a result of good management other than the Tier II strategy factors.

6.4.5 Summary of No.2 Project Application

As in the application on the No.1 Project (power plant project), the application of the Tier II Strategy Implementation Index on the No.2 Project

(environmental project) gathered preliminary baseline data to assess the current level of the Tier II strategy implementation and provided valuable insight. The future projects implementing the Tier Ⅱ strategy could follow the same process for implementation and could be analyzed using the same methodologies presented in the two pilot projects.

Several deficient elements were identified and the company needs to pay more attention to those elements in order to adopt the Tier II strategy. The conclusions and recommendations for the No.2 Project (environmental project) are as follows:

1. The technical skill level of the workers on the No.2 Project was generally close to the current, best possible level. However, the score for the training element was lower than anticipated. More craft training and skill updating should be provided to workers for them to be qualified as Tier II workers.
2. The average score of the interviewed workers on the management skills was lower than that of the technical skills. All elements in the management skills category except the element of work record were extremely low. It seemed that craft workers on this project were not provided management skills training and they have not performed management functions. The workers' personal performance record in safety, attendance, quality, productivity, and initiative were very high.
3. The utilization of the craft workers on the project was significantly less than expected. IT and Craft Utilization was extremely low. The project information was not accessible to craft workers, and computers were not

available for craft workers on site. Some project information was integrated electronically, but only field management had access to it and electronically updated it. There were few Tier II workers and worker turnover ratio (measured as total hires divided by peak workforce) was high. However, the use of multi-skilled workers was high. Out of 120 respondents, 43 workers (36%) were multi-crafted.

4. If the Tier II strategy is to be pursued on this project, the company should provide more extensive management skills training in administrative, computer, planning, and job management skills. Most of the management training has been provided through on the job training (OJT), however, formalized training with standardized curriculum should be provided to current workers for them to advance into Tier II workers.

6.5 COMPOSITE ASSESSMENT OF ALL WORKERS

The Individual Worker Skills Index has been applied to three data sets including workshop attendees, No.1 Project, and No.2 Project. The separate assessments of three data sets are combined in this section to give general idea about the current skill level of craft workers.

Out of total 161 workers from three data sets, only 16 workers (10%) were qualified as Tier II workers as shown in Figure 6.26. They obtained at least 150 points out of a maximum combined score of 200 points. The element, Crew Mix, under the Craft Utilization category specifies that 40% of Tier II workers in key crafts are ideal, future state and 20% are currently good state. It should be noted that there were 31 workers in the range between 125 and 149, who could be Tier II workers easily with some targeted training for deficient skills. More training should be given to workers in management skills as well as technical skills.

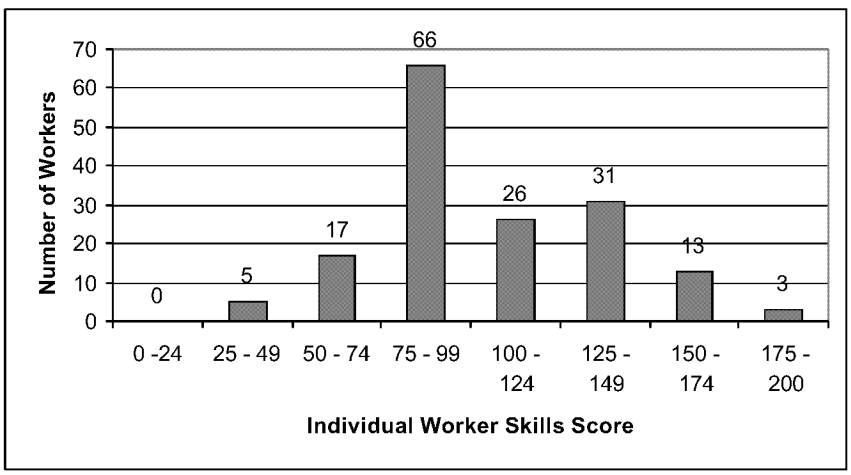


Figure 6.26 Self-Evaluation of Total Workers

Detailed analyses for each element of technical and management skills categories for these three data sets have been given in the previous sections.

As shown in Table 6.14, the total number of workers who participated in this study is 161 and the average technical skills score and average management skills score of all workers are **55.9** and **48.1** respectively. The skill level of all workers in the sample is close to the current, best possible level and the technical skill level of workers is generally higher than the management skill level. The scores of workshop attendees are significantly higher than those of other two groups because most of them are above foreman level workers with significant work experience.

Table 6.14 Composite Assessment of All Workers

	Workshop Attendees (Union & Non-Union)		No.1 Pilot Project (Non-Union)		No.2 Pilot Project (Union)					
Craft	No. of Workers	No. of Tier II Workers	No. of Workers	No. of Tier II Workers	No. of Workers	No. of Tier II Workers	No. of Workers	Avg. Tech. Skills Score	Avg. Mgmt. Skills Score	Combined Worker Skills Score
Pipe Fitter	4	2	8		5		17	54.0	43.9	97.9
Millwright	1		11	2			12	55.4	57.2	112.6
Electrician	4		8	1			12	53.2	58.5	111.7
Boilermaker	1				62	7	63	60.4	46.6	107.0
Ironworker					27	2	27	53.6	45.9	99.5
Operating Engineer					9		9	50.7	45.0	95.7
Welder					7		7	52.7	41.3	94.0
Sheetmetal					6		6	40.6	54.9	95.5
Insulator					4		4	35.3	32.6	67.9
Plumber	1						1	68.0	71.0	139.0
Carpenter	3	2					3	83.3	71.7	155.0
Total:	**14**		**27**		**120**		**161**	**55.9**	**48.1**	**104.1**
	Avg. Tech. Skills Score	Avg. Mgmt. Skills Score	Avg. Tech. Skills Score	Avg. Mgmt. Skills Score	Avg. Tech. Skills Score	Avg. Mgmt. Skills Score				
	63.9	**65.3**	**52.0**	**52.0**	**55.9**	**45.3**				
	129.1		**104.1**		**101.1**					

6.6 SUMMARY

The five data sets were collected and analyzed in this study to validate the viability of the Tier II Work Force Strategy Implementation Index and gather preliminary baseline data to evaluate the current status of the industry regarding the Tier II workers and the Tier II elements. The processes employed in obtaining the data sets and the analyzed results of those data were discussed in this chapter.

The first data set tested the sensitivity of the Tier II Strategy Implementation Index. The results of the assessment based on the CII Model Plant Project showed that the Tier II Strategy Implementation Index is not significantly sensitive to the judgment of evaluators.

The second and third data sets were gathered from the second CCIS workshop. They were the second CCIS workshop attendees' self-evaluations and questionnaires. The application of the Individual Worker Skills Index was very easy to employ and the results showed that the current workers are not eligible for Tier II status immediately. However, the workers who attended the workshop could be qualified as Tier II workers easily with specific training and support for the weak elements. The answers from questionnaires gave the Tier II Strategy Implementation Index related characteristics of the workers and their perception about the Tier II Work Force Strategy. Most of the workers supported the concepts of the Tier II strategy and they expected the strategy could be realized in the construction industry in the near future.

The fourth and fifth data sets were collected from active construction projects by applying the Tier II Strategy Implementation Index. This provided a

beginning point for determining the current status of the industry with respect to the Tier II strategy and the application also provided procedures and methodologies to implement and assess the Tier II Strategy Implementation Index. The average skill level of workers was not high enough to be Tier II eligible and the implementation level of Tier II elements were generally lower than expected even though the first pilot project, a power plant project, was thought to be most applicable for the Tier II strategy. Several recommendations were given to the site management team to improve the implementation level of the Tier II elements and improve workers' qualification.

From the results of the five data sets, it can be concluded that the Tier II strategy is very promising and the Tier II Strategy Implementation Index is easily applicable to the real projects as a viable tool. The Tier II Index is also very useful to measure the current status of implementation of the Tier II strategy.

Chapter 7: Conclusions and Recommendations

This chapter completes the study of the development and assessment of the Tier II Work Force Strategy Implementation Index. The research objectives are briefly reviewed and the conclusions from the results of analyses are discussed. Recommendations for future research and industry users are provided based on findings of this study and the knowledge gained through the research process. Finally, contributions of this study are discussed.

7.1 Review of Research Objectives

The objectives of this research, as presented in Chapter 1, were as follows:

1. Identify common characteristics of a Tier II Work Force Strategy and necessary elements for implementation.
2. Develop effective, simple, and easy-to-use metrics to measure the level of implementation for the Tier II Work Force Strategy.
3. Gather some preliminary data to assess current skill level of craft workers and status of the construction industry for Tier II strategy implementation.
4. Validate the viability and usefulness of the Tier II Strategy Implementation Index.

This study identified characteristics of the Tier II strategy and necessary elements for its implementation through joint efforts of the CCIS Work Force Research Team, Steering Committee, and many industry experts. The Tier II

Strategy Implementation Index is composed of two different indices: (1) Individual Worker Skills Index and (2) Tier II Project Implementation Index. The Individual Worker Skills Index measures the skill level of craft worker in two categories such as technical and management skills, and the two categories consists of eight weighted elements. The Tier II Project Implementation Index contains five major categories weighted according to their relative importance. The five categories are broken into ten weighted elements. The five categories are as follows: Project Craft Technical Skills, Project Craft Management Skills, IT Utilization, Craft Utilization, and Organization. At this time, the weights and evaluation criteria for measuring each element are based upon input from industry experts. Thus, the indices are available for immediate use. As enough data are gathered, it would be possible to add new elements and adjust weights based on the statistical analysis and experience.

The viability and usefulness of the Tier II metrics have been validated through the exploratory assessment of pilot projects and the self-evaluation of the second CCIS workshop attendees. The Individual Worker Skills Index was very effective in gathering information about the skill level of craft workers. The Tier II Project Implementation Index was easy to apply to active projects and useful for gathering information about the implementation level of the Tier II strategy. The indices gave the management team a platform to discuss the project specific issues and helped identify critical elements for improvement.

7.2 CONCLUSIONS

Several conclusions can be drawn from this study as follows:

1. **The Tier II Strategy Implementation Index is viable and insensitive for different evaluators.**

   The Tier II Strategy Implementation Index was first tested using CII Model Plant data to determine its sensitivity and viability. The results showed that the metrics are not sensitive based on the different evaluators' judgment. Using the same project information, 67% of the scores by evaluators were within the range of Mean ± SD and 100% were within the range of Mean ± 2 SD. The metrics were also proven to be doable, simple, and easy to use. The evaluators had no difficulty understanding how to score them after receiving brief instructions.

   The Tier II Strategy Implementation Index provides not only a method of evaluating the level of Tier II implementation on a project, but it also provides a road map to successful implementation of the Tier II strategy. It provides a basis for all project participants to communicate and identify the deficient elements using an objective tool for Tier II strategy implementation.

   The development of the Tier II Strategy Implementation Index has been successful and gained favorable responses from the industry through the CII Annual Conference in San Francisco, California and the CII CPI Conference in Austin, Texas. Both management and workers agreed with the concept of the Tier II Work Force Strategy. However, the Tier II

Implementation Index is still in the early stage and will require further evolution. There is no project fully employing the elements of the Tier II Index. Even the first pilot project, a power plant project, which was thought to be most applicable for the Tier II strategy has obtained a Tier II implementation score of 4.08 out of a maximum 10. Continuous support from all participants of the industry is essential for the success of the Tier II strategy.

2. **The Tier II metrics offer stretch goals for the future.**

   The Tier II Project Implementation Index is composed of five categories: Project Craft Technical Skills, Project Craft Management Skills, IT Utilization, Craft Utilization, and Organization. The inclusion of craft management skills itself represents that the Tier II Index is a stretch goal for the future. The workers should have administrative, computer, planning, and job management skills with good work record in addition to technical skills to be qualified as Tier II workers. The index also has a category such as IT Utilization, which is not common in current construction industry. Other elements such as multiskilling and high performance work team were also included in the index. In the scoring system for each element, only three possible scores (0, 5, 10) were given. A score of 0 represents the unacceptable, worst state, and a score of 5 represents the currently good state. A score of 10 represents the ideal, future state that can be achieved after the Tier II element is completely implemented in the future.

3. **The number of Tier II workers is currently low.**

   Based on the results from the self-evaluation of workers at the second CCIS workshop and the pilot projects, only few craft workers in the industry currently can be qualified as Tier II workers. Of the total 161 workers who were evaluated in this study, only 16 workers (10%) were eligible for Tier II workers even though the workers in the sample were among the best workers in the industry and their technical skill level was thought to be higher than usual workers. The first pilot project company's management believed that the characteristics of the work force were aligned with those proposed under the Tier II strategy; however, the skill level of workers was not to the Tier II level even though they showed higher management skills than their counterparts in the second pilot project. More training should be given in management skills as well as technical skills. However, it is reasonable to assume that most of the journeyman level workers could be qualified as Tier II workers easily after specific targeted training is provided for the deficient skills.

4. **The level of Tier II strategy implementation is currently low.**

   In addition to the low number of Tier II workers, the utilization level of workers was low in both of the pilot projects with regard to the Tier II standards. IT Utilization, Craft Utilization, and Organization categories should get more attention for the Tier II strategy to be successful. The construction industry should provide not only more skills training for workers but also more support and atmosphere for better utilization of

workers including multi-skilling, reduced turnover, electronic integration of information, hardware availability, emphasis on communications, and high performance work teams with empowerment.

5. **The Project Success Index needs more development.**

   The project success in construction phase was evaluated using the simplified metric provided in Appendix J. The score for the construction success was based on a consensus of the site management team and that score for both of the pilot projects was 7, on a scale of 1 to 10. This simplified metric is acceptable for the time being, however, more detailed quantitative Project Success Index is currently under development by the CII BM&M research team in cooperation with the CCIS and will be used in the future project applications.

6. **The Tier II research is ready for baseline data gathering.**

   This study validated that the Tier II Strategy Implementation Index is viable and insensitive. And then, the index was applied to pilot projects to obtain the preliminary assessment of current workers' skill level and the Tier II implementation on construction projects. Procedures and methodologies to assess the Tier II implementation were provided through pilot project applications. The Tier II research team is now ready for baseline data collection to reflect more accurate status of the construction industry regarding the Tier II implementation and to prove the effectiveness of the Tier II strategy. Data collection will continue as a perpetual effort in the CCIS work force research team and hopefully the

industry will be convinced with the results, resulting in rapid adoption of the strategy.

7.3 RECOMMENDATIONS

The following recommendations are based on the findings and experience gained through working on the development and assessment of the Tier II Work Force Strategy Implementation Index. The study of the Tier II strategy is still in the early stage of development and many improvement opportunities exist.

1. More data should be gathered in the future research from projects implementing the Tier II strategy, and then the relationship between the level of Tier II strategy implementation and the project success in construction phase should be determined. Theoretically, high level of implementation would result in improved project performance in cost, schedule, productivity, safety, and quality. The database accumulated in the future will establish benchmarking points for comparison and research. The construction project success index, which is being developed by the CII BM&M team, should be incorporated in the future data analysis. Unlike the usual research data collected, this study could not obtain the data from past projects because the Tier II strategy is a new concept and there were few projects adopting the Tier II elements. Thus, the data collection and analysis in this dissertation were limited to validate the viability and usefulness of the Tier II Strategy Implementation Index.

2. Considerations should be given to the weights assigned to the categories and subsequent elements. The weights are based on input from industry experts. Statistical analysis should be used to further develop those weights as enough data are collected. The elements and evaluation criteria for each element also could be changed as the Tier II strategy evolves and more data are gathered in the future.
3. The Tier II Strategy Implementation Index could be used as a planning tool in addition to a measuring tool. If a company wishes to implement the Tier II strategy on a project, it will be necessary to score each of the elements on a "planned" basis and then identify and provide the necessary training activities to achieve that score. At the project's completion, it will be possible to assess the level of success in achieving the planned goals.
4. Project suitability index, which is a standard tool to help management determine whether to pursue the Tier I or the Tier II strategy, should be developed after getting enough data to discriminate the difference of the two strategies. The suitability index will assess the characteristics of a construction project through adjustment factors such as domestic or international project, geographic project location, industry sector, project type, project size, project risk, contract type, local/regional labor availability, number of workers on project, and open shop versus union status.
5. More industry participants should be informed about the Tier II strategy to get more involvement and acceptance by the industry. Especially, current

workers and candidates of future work force should be informed about the new opportunity to choose construction as their career. It is essential that the industry, including owners, contractors, labor associations, and academia, work together to make the Tier II strategy successful. Through the cooperation of the entire industry, the Tier II strategy could be refined and further developed, and finally it could be the new standard for work force management in construction.

6. Training and certification programs should be standardized with cooperation from union and non-union sectors together. Support of a standardized national certification program is important to ensure that craft skill levels are being measured on a consistent basis. Owners should continuously support the effort of contractors in the training and certification of workers.

7.4 CONTRIBUTIONS

The following discussion lists the primary contributions of this study.

1. The primary contribution of this study is the validation of the Tier II Strategy Implementation Index as a viable tool. The Tier II Index was applied as explained in Chapter 6 to test the sensitivity and viability of the Tier II Index. The Tier II Strategy Implementation Index can be immediately used on real projects.
2. The Tier II Strategy Implementation Index will provide several benefits for the future of the construction industry. First, it will be a checklist that a

project team can use for determining the necessary steps to follow in implementing the Tier II Work Force Strategy. Second, it will be an industry standard for rating the level of the Tier II strategy implementation. Third, it will be a means to monitor progress of the Tier II implementation effort at various stages of the project. Fourth, it will be a tool for project participants to communicate the project specific issues and identify critical elements for improvement using a common basis for the Tier II implementation. Finally, it will be a benchmarking tool for companies to use in evaluating the level of the Tier II implementation versus project success, both within the company and externally in the long run.

3. The Tier II Work Force Strategy provides a new formalized structure for work force management in construction, which did not exist previously. It is also a revolutionary approach to revive the construction industry facing the shortage of skilled workers. It will provide the craft workers with career paths and higher compensation through extensive skills training. Eventually the poor image of construction would be improved through the Tier II strategy.

Appendix A

CCIS Work Force Steering Committee and Faculty

CCIS Work Force Steering Committee

Name	Title	Affiliation
Daniel J. Bennet	President	National Center for Construction Education and Research
David M. Bush	President & CEO	Adena Corporation
Keith Byrom	General Manager	Zachry Construction Corp.
Randy Evans	Vice President	BE&K, Inc.
Edward S. Givens	Associate Director	Construction Industry Institute
Kenneth E. Hedman	Vice President	Bechtel
James S. Jeffress	Construction Manager	DuPont Engineering
Theodore C. Kennedy	Chairman	BE&K, Inc.
Douglas McCarron	General President	United Brotherhood of Carpenters and Joiners of America
James W. Mortell	Senior Vice President	Cherne Contracting Corp.
James G. Slaughter, Jr.	President	S&B Engineers and Constructors, Ltd.
Richard L. Tucker	Director	Center for Construction Industry Studies
Kent Underwood	Project Manager	Solutia, Inc.
Lowell Wiles	Vice President	Williams Group International, Inc.

Faculty

Dr. John D. Borcherding	Dr. William R. Kelly
Dr. Robert W. Glover	Dr. Stephen R. Thomas
Dr. Carl T. Haas	Dr. Richard L. Tucker

Appendix B

List of Workshop Attendees

February 2001 Workshop Attendees

Daniel Bennet
National Center for Construction Education and Research

Bob Berry
BE&K

G.E. Brown
Kellogg Brown & Root

David Bush
Adena Corporation

Keith Byrom
Zachry Construction Corp.

David Clements
BMW Constructors

Ed Dodd
Williams Power Corp.

James W. Early
BE&K

Randall Evans
BE&K

Michael Haller
Walbridge Aldinger Company

James Hilgers
Washington Group/Rust Constructors

Norman Hill
Reliant Energy

Chris Hyvonen
Kiewit Industrial Company/Kiewit Construction Group

James Jeffress
DuPont

J. Dudley Light
United Brotherhood of Carpenters and Joiners of America

Earl Massner
The Procter & Gamble Company

Joe McKee
Austin Industrial

James Mortell
Cherne Contracting Corporation

Kenneth Nipp
BE&K

Jimmy Parker
Day & Zimmermann

James Platner
The Center to Protect Workers' Rights

R. L. Raspberry
Houston Gulf Coast Building and Construction Trades Council

Steve Satrom
Air Products and Chemicals

Gary Schumacher
Murphy Company

James Slaughter, Jr.
S&B Engineers & Constructors

H. Martin Smith
Chicago Bridge & Iron Company

Kenneth Smith
BE&K

Bobby Stalvey
Integrated Electrical Services

Jim Stinson
Houston Built-Rite Partnership

Arthur Washburn
S&B Engineers & Constructors

Lowell Wiles
Williams Group International

July 2001 Workshop Attendees

David Brooks
Zachry Construction Corp.

Hector Cardona
Zachry Construction Corp.

Joey Donald
BE & K Construction

Randall Evans
BE & K Construction

Chuck Gowan
BMW Constructors

Mary Hodge
BE & K Construction

Tonya Hynds
Bechtel / Becon

Allan Jamail
Pipefitters Local Union 211

Steve Kokosa
Foster Wheeler

J. Dudley Light
United Brotherhood of Carpenters & Joiners of America

Bryan Little
Becon

Tim Lowther
Houston Built-Rite Partnership

Joe Middlebrook
Zachry Construction Corp.

Saulo Muñoz
Becon

Michael Nielson Sr.
BE & K Construction Corp.

Dennis Nollkamper
Bexar Electric IES

Troy Roder
Foster Wheeler

Rusty Saunders
Becon

Claudia Shelton
Bechtel

Jim Stinson
Houston Built-Rite Partnership

Bobby Watford
Ace Electric

Appendix C

Analytical Hierarchy Process (AHP) Questionnaire

(Distributing Weights of Tier II Index Categories)

5 Categories

Project Craft Technical Skills: Craft Certification, Technical Experience, Continuing Training and Education, % of Tier II Workers

Project Craft Management Skills: Administrative Skills, Computer Skills, Planning, Job Management, Work Record

Information Technology Utilization: Integrated Information Access, Hardware

Craft Utilization: Crew Mix, Use of Multi-skilled Workers, Worker Turnover

Organization: Communications, High Performance Work Place

Procedure

Fill in the upper half of the matrix by comparing 5 categories pairwisely with a scale of 1/9 to 9. The element that appears in the left-hand column of the matrix is always compared with the element in the top row.

Pairwise Comparison Scale

Level of Importance	Definition
1	Equal importance
3	Weak importance of one over another
5	Essential or strong importance of one over another
7	Very strong or demonstrated importance of one over another
9	Absolute importance of one over another
2, 4, 6, 8	Intermediate values between adjacent scale values

Example

Tier II Strategy	Technical Skills	Management Skills	IT Utilization	Craft Utilization	Organization
Technical Skills	1	5	5	2	5
Management Skills		1	2	1 / 5	2
IT Utilization			1	1 / 5	1 / 3
Craft Utilization				1	5
Organization					1

Your Reply

Tier II Strategy	Technical Skills	Management Skills	IT Utilization	Craft Utilization	Organization
Technical Skills	1				
Management Skills		1			
IT Utilization			1		
Craft Utilization				1	
Organization					1

Appendix D

AHP Results

(Valid Responses and Average Weights)

Average Weights from the Steering Committee Meeting

	4	6	7	8	9	12	Avg. Weights
Craft Technical Skills	0.31	0.47	0.07	0.45	0.51	0.43	**0.37**
Craft Management Skills	0.26	0.09	0.33	0.24	0.24	0.10	**0.21**
IT Utilization	0.15	0.03	0.11	0.15	0.05	0.06	**0.09**
Craft Utilization	0.18	0.25	0.21	0.05	0.09	0.32	**0.19**
Organization	0.10	0.15	0.28	0.12	0.11	0.09	**0.14**
							1.00

Average Weights from the 2nd CCIS Workshop

	2	*3*	*6*	*7*	*8*	*10*	*16*	*19*	*20*	*21*	*22*	*23*	*24*	*Avg. Weights*
Technical Skills	0.40	0.31	0.23	0.47	0.37	0.32	0.47	0.23	0.48	0.42	0.46	0.30	0.45	**0.38**
Management Skills	0.13	0.21	0.21	0.25	0.19	0.32	0.25	0.23	0.25	0.21	0.27	0.27	0.18	**0.23**
IT Utilization	0.12	0.14	0.18	0.08	0.14	0.17	0.05	0.08	0.05	0.04	0.05	0.12	0.11	**0.10**
Craft Utilization	0.18	0.14	0.19	0.10	0.16	0.07	0.09	0.23	0.13	0.04	0.12	0.23	0.13	**0.14**
Organization	0.16	0.19	0.19	0.10	0.14	0.12	0.14	0.23	0.10	0.29	0.10	0.08	0.12	**0.15**
														1.00

Appendix E

Questionnaire for Testing Sensitivity of Tier II Strategy Implementation Index

Information and Rationale for completing a Tier II assessment using the CII Model Plant as an Example Project[1]

GENERAL PROJECT DATA

1. Project Information

Project: CII Model Plant

Construction Phase
Duration (construction phase): 78 weeks
Start Date: March 14, 2000
Finish Date: July 31, 2001

Total Work-Hours: 100,000

Peak Work Force
No. of Workers: 500 (330 on key crafts)
Date: February 20, 2001

Project Location: Gulf Coast

2. Construction Phase Success Score[2]: 4 (on a scale from 1 to 10)

[1] The CII Model Plant is a Theoretical Project used to provide a baseline for research. Refer to CII Publication 2-1. Some of the information used to complete the Tier II Index is based on assumed information for illustration of the Tier II index evaluation procedure.

[2] This score is based on the construction success criteria presented in Appendix J.

INDIVIDUAL WORKER EVALUATION FORMS

Individual Worker's Technical Skills and Management Skills forms should be completed for each individual on the project, who is belonging to key crafts. The average of each index is used for the Project Evaluation. Here, a journeyman is used for demonstration of the metrics. **An imaginary journeyman: John Doe**

Individual Technical Skills

- Craft Certification score:

Journeyman trade: Certified Pipe fitter. Substantial experience in welding but not certified.

- Tech. Experience Score:

Five yrs. of experience after obtaining certification as a pipe fitter.

- Continuous Training/Education score:

120 combined hours of on-the-job and classroom training. On the job training is recognized by the company as such.

Individual Management Skills

- Administrative skills score:

John is certified in processing RFI's. Currently pursuing certification in materials management.

- Computer skills score:

John is certified on being capable of handling e-mails and accessing information via Internet. He is also familiar with Primavera™.

- Planning skills score:

John has some training in short-term planning and scheduling but no certification.

- Job Management skills score:

Similarly, John has limited training only in selection of work means and methods.

- Work Record score:

John has a superior work record in safety, attendance and quality. Results in productivity and initiative are modest.

John Doe's total Individual Assessment (combining Tech. and Mgmt. Skills) = _____ points; thus, John Doe [does / does not] qualify as a Tier II worker.[3]

---

[3] Tier II worker when combined score ≥ 150 points

Individual Worker's Technical Skills

Name: _____

Elements	Weights	Evaluation Criteria	Score	Journeyman Score	Weighted Score
Craft Certification	4.0	Certified in 3 crafts	10		
		Certified in 2 crafts	5		
		No certification	0		
Technical Experience	4.0	More than 10 years of experience at the certified craft level	10		
		5 years of experience at the certified craft level	5		
		Less than 1 year of experience atthe certified craft level	0		
Continuous Training and Education	2.0	More than 200 hours of training and skill updating in the last 3 years	10		
		100 hours of training and skill updating in the last 3 years	5		
		No training or skills updating since first craft certification	0		

Sub-Total =

Individual Worker's Management Skills

Name: _____

Elements	Weights	Evaluation Criteria	Score	Journeyman Score	Weighted Score
Administrative (*cost management, scheduling, material management, RFI, and estimating*)	1.0	Certified in at least 4 administrative skills	10		
		Certified in 2 administrative skills	5		
		No certified administrative skills	0		
Computer (*e-mail / internet, word processing, spreadsheet, scheduling, estimating, CAD, and material management*)	1.0	Certified in at least 5 computer skills	10		
		Certified in 3 computer skills	5		
		No certified computer skills	0		
Planning (*material, equipment, tools and information request, short-term planning, and scheduling*)	3.0	Certified in planning skills	10		
		160 hours of training but not certified in planning skills	5		
		No training and certification	0		
Job Management (*crew coordination, inter- and intra- craft coordination, selection of work means and methods, and leadership*)	2.0	Certified in job management functions	10		
		160 hours of training but not certified in job management functions	5		
		No training and certification	0		
Work Record (*safety, attendance / truancy, quality, productivity, and initiative*)	3.0	Superior in all categories	10		
		Superior in some, modest in others	5		
		Weak in most categories	0		

Sub-Total =

PROJECT EVALUATION FORMS

Project Average Technical Skills *(Based on 165 key crafts journeymen)*

- Average project craft technical skills score:

The average score after evaluating journeymen in key crafts on the project is 40 points.

- % of Tier II workers score:

13% of journeymen are certified as Tier II

Project Average Management Skills *(Based on 165 key crafts journeymen)*

- Average project craft technical skills score:

The average score after evaluating journeymen in key crafts on the project is 34 points.

Information Technology Utilization

- Integrated Info. Access score:

Information in the project is integrated, but at the work face workers have only access to schedule and materials info. Workers cannot update, nor request materials/other info.

- Hardware score:

There is one computer in the trailer available to foremen

Craft Utilization

- Crew mix score:

60% of key crews crafts have Tier II workers, but average less than 20%

- Use of Multiskilled workers score:

70% of key crews crafts have multi-skilled workers, but average only about 10%

- Worker turnover score:

The ratio of planned total hires / peak workforce = 3.1

Organization

- Communications score:

Management meets regularly with foremen; site has a newsletter; information is posted on bulleting boards; information is available to workers upon request. Open door policy. (Good one-way information flow).

- HPWP score:

Four levels of supervision exist between workers and general project superintendent. Good information flow procedures exist. No empowerment for workers' generation of ideas.

Project Average Technical Skills

Project: _____

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Average Score from Individual Evaluation on Technical Skills *	7.0	Greater than 75 points	10		
		50 points	5		
		Less than 25 points	0		
% of Tier II workers *	3.0	40% or more of journeymen are certified as Tier II workers	10		
		20% of journeymen are certified as Tier II workers	5		
		Less than 10 % of journeymen are certified as Tier II workers	0		

** for project's key crafts*

Sub-Total (A) =

Project Average Management Skills

Project: _____

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Average Score from Individual Evaluation on Management Skills *	**10.0**	Greater than 75 points	10		
		50 points	5		
		Less than 25 points	0		

** for project's key crafts*

Sub-Total (B) =

Information Technology Utilization

Project: _____

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Integrated Information Access	6.0	All information* is stored, integrated, continuously updated, and accessed by Tier II workers electronically	10		
		3 types of information* are stored, integrated, continuously updated, and accessed by Tier II workers electronically	5		
		Information* is not directly accessed by Tier II workers	0		
Hardware	4.0	Tier II workers have wireless, wearable computers	10		
		Hardware is nearby and shared among crews	5		
		No hardware is available to Tier II workers	0		

* Information includes schedule, costs, materials and equipment management, safety, drawings, and worker skills

Sub-Total (C) =

Craft Utilization

Project: _____

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Crew Mix	4.0	Key crafts' crews (on avg.) have at least 40% of Tier II workers	10		
		Key crafts' crews (on avg.) have at least 20% of Tier II workers	5		
		Less than 50% of key crafts' crews have Tier II workers	0		
Use of Multiskilled Workers	2.0	Key crafts' crews (on avg.) have at least 40% multiskilled workers	10		
		Key crafts' crews (on avg.) have at least 20% multiskilled workers	5		
		Less than 50% of key crafts' crews have multiskilled workers	0		
Worker Turnover (Total Hires / Peak Workforce)	4.0	Less than 2	10		
		Equal to 3	5		
		Greater than 4	0		

Sub-Total (D) =

Organization

Project: _____

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Communications	6.0	Proactive information flow to and from workers about the project, established formal & informal channels, open access to management, frequent meetings with workers, all workers are familiar with all aspects of the project	10		
		Informal communication channels, regular meetings with workers, workers can receive project information requested, open door policy	5		
		Rigid hierarchical structure for communication, only information that management deems necessary to workers is provided.	0		
High Performance Work Place	4.0	Delegation of appropriate authority and accountability to High Performance Work Teams (HPWT). Clear definition of authority, accountability and expectations to each team. Training of all teams in HPWT approach. Expected utilization by crews of management skills and IT informat ion available thru Tier II workers	10		
		Hierarchical structure, but with 2-way information & idea flow between crews and management	5		
		Rigid hierarchical structure	0		

Sub-Total (E) =

Craft Determination
(CII Model Plant Example)

Total peak work force	500
Peak key craft work force	330
Assumed peak no. of journeymen (key crafts)	165

Key Crafts for the CII Model Plant Project

Trade Classification	Peak Trade Usage
Carpenter	52
Concrete Finisher	10
Electrician	30
Instrumentation Worker	10
Iron Worker	34
Millwright	35
Pipe Fitter	60
Rigger	13
Structural Steel Erector	15
Surveyor	11
Welder	60
Total:	**330**

Appendix F

Questionnaire for Workers (2nd Workshop)

Version 1.3

Tier II Craft Worker Workshop Questionnaire

1. WHAT IS YOUR AGE? _____
2. WHAT IS YOUR GENDER? ☐ FEMALE ☐ MALE
3. WHAT IS YOUR LEVEL OF EDUCATION?

☐ 0-8 YEARS OF SCHOOL
☐ SOME HIGH SCHOOL
☐ HIGH SCHOOL DIPLOMA
☐ GED EQUIVALENT
☐ COMPLETED VOCATIONAL OR TECHNICAL PROGRAM
☐ SOME COLLEGE (NO DEGREE)
☐ ASSOCIATE DEGREE (2 YEAR PROGRAM)
☐ BACHELORS DEGREE (4 YEAR PROGRAM)
☐ SOME POST GRADUATE EDUCATION
☐ MASTERS DEGREE
☐ PH.D.

4. WHAT IS YOUR PRESENT JOB TITLE? (CHECK ONE)

☐ PROJECT MANAGER
☐ ASSISTANT PROJECT MANAGER
☐ SUPERINTENDENT
☐ ASSISTANT SUPERINTENDENT
☐ CRAFT SUPERINTENDENT
☐ FOREMAN
☐ CRAFTSMAN
☐ APPRENTICE/HELPER
☐ OTHER (PLEASE SPECIFY) _____

5. WHAT IS YOUR PRIMARY CRAFT(S)? (CHECK ALL THAT APPLY)

☐ BOILERMAKER
☐ CARPENTER
☐ CONCRETE FINISHER
☐ CRANE OPERATOR
☐ EQUIPMENT OPERATOR
☐ ELECTRICIAN
☐ INSTRUMENT FITTER
☐ GLASS/GLAZING WORKER
☐ INSTRUMENT TECHNICIAN
☐ INSULATION WORKER
☐ LABORER
☐ MASON
☐ MECHANIC
☐ MILLWRIGHT
☐ OPERATING ENGINEER
☐ PLUMBER
☐ PAINTER
☐ PIPE FITTER
☐ ROOFER
☐ REINFORCING RODMAN
☐ RIGGER
☐ STRUCTURAL IRONWORKER
☐ SHEETMETAL WORKER
☐ WELDER
☐ OTHER (LIST) _____

6. On average, what percentage of your work time is spent working in this craft?
_____ %

7. Are you required to have a license to do this work without su pervision? ☐ Yes ☐ No (Go to 8)

7a. If Yes to above question, what agency grants the license?
_____

7b. Do you have a license? ☐ Yes ☐ No

7c. Are you certified to do specific types of work? (For example, plumbers can be certified to install gas lines in hospitals or research labs.) ☐ Yes ☐ No

7d. What types of work are you certified to do? _____

7e. What organization provided that certification? _____

8. How have you received your craft training in your primary craft? (Check all that apply)

☐ Graduate of union sector apprenticeship program
☐ Graduate of company non-union apprenticeship program
☐ Passed NCCER Wheels of Learning Program in your craft
☐ Graduate of company craft certification program
☐ Basic military training in construction
☐ On the job task training only
☐ Military "C" school training in a craft
☐ On the job craft training only
☐ Vocational program
☐ Other (specify) _____

9. What other crafts do you have substantial skills in? (Check all that apply)

☐ Boilermaker
☐ Millwright
☐ Carpenter
☐ Operating Engineer
☐ Concrete Finisher
☐ Plumber
☐ Crane operator
☐ Painter
☐ Equipment Operator
☐ Pipe fitter
☐ Electrician
☐ Roofer
☐ Instrument Fitter
☐ Reinforcing Rodman
☐ Glass/Glazing Worker
☐ Rigger
☐ Instrument Technician
☐ Structural Ironworker
☐ Insulation Worker
☐ Sheetmetal Worker
☐ Laborer
☐ Welder
☐ Mason
☐ Other (list) _____
☐ Mechanic

10. Do you regularly work outside of your primary craft when you are working in construction?

☐ Yes ☐ No (Go to 11)

10a. What other crafts do you work in besides your primary craft?
_____

10b. Have you done any construction work outside of your primary craft in the past 12 months?

☐ YES ☐ NO

10c. Referring to the secondary craft, during the past 12 months, what percentage of your weekly work time is spent working in this craft? _____ %

10d. What types of work do you typically do in this craft? _____

11. HOW HAVE YOU RECEIVED YOUR CRAFT TRAINING IN YOUR SECONDARY CRAFT? (CHECK ALL THAT APPLY)

☐ GRADUATE OF UNION SECTOR APPRENTICESHIP PROGRAM

☐ GRADUATE OF COMPANY NON-UNION APPRENTICESHIP PROGRAM

☐ PASSED NCCER WHEELS OF LEARNING PROGRAM IN YOUR CRAFT

☐ GRADUATE OF COMPANY CRAFT CERTIFICATION PROGRAM

☐ BASIC MILITARY TRAINING IN CONSTRUCTION

☐ ON THE JOB TASK TRAINING ONLY

☐ MILITARY "C" SCHOOL TRAINING IN A CRAFT

☐ ON THE JOB CRAFT TRAINING ONLY

☐ VOCATIONAL PROGRAM

☐ OTHER (SPECIFY) _____

12. HOW WOULD YOU DESCRIBE THE SKILL LEVEL OF THE WORK YOU DO IN THE SECONDARY CRAFT. IS THAT WORK UNSKILLED, SEMI-SKILLED, OR SKILLED?

☐ UNSKILLED ☐ SEMI-SKILLED ☐ SKILLED

13. DO YOU CONSIDER YOURSELF TO BE MULTICRAFTED AND CROSS-TRAINED? ☐ YES ☐ NO

14. FOR THE MULTICRAFTS, WHAT DO YOU CONSIDER TO BE POSSIBLY EFFECTIVE COMBINATIONS OF CRAFTS? (CHOOSE 2 OR 3 FROM THE CRAFTS LISTED BELOW.)

_____ AND _____ AND _____

_____ AND _____ AND _____

_____ AND _____ AND _____

_____ AND _____ AND _____

_____ AND _____ AND _____

BOILERMAKER
CARPENTER
CONCRETE FINISHER
CRANE OPERATOR
EQUIPMENT OPERATOR
ELECTRICIAN
INSTRUMENT FITTER
GLASS/GLAZING WORKER
INSTRUMENT TECHNICIAN
INSULATION WORKER
LABORER
MASON
MECHANIC
MILLWRIGHT
OPERATING ENGINEER
PLUMBER
PAINTER
PIPE FITTER
ROOFER
REINFORCING RODMAN
RIGGER
STRUCTURAL IRONWORKER
SHEETMETAL WORKER
WELDER

15. IN YOUR CURRENT JOB, DO YOU HAVE SUPERVISORY RESPONSIBILITY? ☐ YES ☐ NO (GO TO 16)

15A. How long have you been a supervisor? _____ (Circle Unit) Days/ Weeks/ Months/ Years

15B. How many workers do you supervise? _____ Workers

15C. What crafts do you currently supervise?

_____

15D. Do you only work as a supervisor or do you both work your craft and supervise other workers?

☐ Only Supervise ☐ Work and Supervise

15E. About what percentage of your work time is spent on supervisory duties?

_____ %

15F. Have you been through a program which trained you as a supervisor?

☐ Yes ☐ No

15G. How long did that program last? _____ (Circle Unit)

Days/ Weeks/ Months/ Years

15H. Do you regularly use a computer as part of your supervisory duties?

☐ Yes ☐ No

16. In the past three years what type(s) of training have you completed? (Check all that apply.)

Have you participated in the following training program?	Yes	No	How many programs have you participated in during the last three years?	How many total hours of training have you completed in the last three years?
Safety Training	☐	☐		
Skills Training in your primary craft	☐	☐		
Skills Training in a secondary craft	☐	☐		
Training with new construction technologies	☐	☐		
Computer Hardware Training	☐	☐		
Computer Software Training	☐	☐		
A. Email/Internet	☐	☐		
B. Word Processing	☐	☐		
C. Spreadsheet	☐	☐		
D. Scheduling	☐	☐		
E. Estimating	☐	☐		
F. CAD	☐	☐		
G. Other (list)	☐	☐		
H. Other (list)	☐	☐		
Scheduling Training	☐	☐		
Planning Training	☐	☐		

MATERIALS MANAGEMENT TRAINING	☐	☐		
COMMUNICATIONS SKILLS	☐	☐		
MANAGEMENT TRAINING	☐	☐		
COST CONTROL TRAINING	☐	☐		
COST ESTIMATING TRAINING	☐	☐		
FORMAL VOCATIONAL COURSES (FOR HIGH SCHOOL, COMMUNITY COLLEGE, OR UNIVERSITY CREDIT)	☐	☐		
COLLEGE COURSES	☐	☐		
other (list) _____	☐	☐		
other (list) _____	☐	☐		

17. WHAT SECTOR OF CONSTRUCTION IS YOUR PRIMARY AREA OF EXPERIENCE?

☐ RESIDENTIAL CONSTRUCTION ☐ LIGHT INDUSTRIAL

☐ BUILDING CONSTRUCTION ☐ HEAVY INDUSTRIAL

☐ INFRASTRUCTURE ☐ OTHER (SPECIFY) _____

18. WHAT TYPE OF HEAVY INDUSTRIAL CONSTRUCTION PROJECTS HAVE YOU WORKED ON? (CHECK ALL THAT APPLY)

☐ AUTOMOTIVE ASSEMBLY/MANUFACTURING ☐ PHARMACEUTICAL MANUFACTURING

☐ CHEMICAL MANUFACTURING ☐ OIL REFINING

☐ CONSUMER PRODUCTS MANUFACTURING ☐ PULP AND PAPER

☐ ELECTRICAL (GENERATING) ☐ OTHER (SPECIFY) _____

☐ METALS REFINING/PROCESSING

19. HOW MANY YEARS OF EXPERIENCE IN CONSTRUCTION IN EACH OF THE FOLLOWING CATEGORIES DO YOU HAVE?

APPRENTICE _____ YEARS

JOURNEYMAN _____ YEARS

FOREMAN _____ YEARS

AREA FOREMAN _____ YEARS

ASSISTANT SUPERINTENDENT _____ YEARS

SUPERINTENDENT _____ YEARS

ASSISTANT PROJECT MANAGER _____ YEARS

PROJECT MANAGER _____ YEARS

20. HOW LONG HAVE YOU BEEN WITH YOUR PRESENT FIRM? _____ YEARS

21. HOW MANY DIFFERENT EMPLOYERS HAVE YOU WORKED FOR WHILE WORKING IN CONSTRUCTION?

_____

22. WHAT IS THE LONGEST CONTINUOUS EMPLOYMENT YOU HAVE HAD WITH ONE FIRM?

_____ YEARS

23. WHAT IS THE SHORTEST EMPLOYMENT YOU HAVE HAD WITH ONE FIRM?

_____ (CIRCLE UNIT) DAYS/WEEKS/MONTHS/YEARS

24. WHAT IS THE LONGEST CONTINUOUS EMPLOYMENT YOU HAVE HAD ON ONE PROJECT?

_____ YEARS

25. WHAT IS THE SHORTEST EMPLOYMENT YOU HAVE HAD ON ONE PROJECT?
_____ (CIRCLE UNIT) DAYS/WEEKS/MONTHS/YEARS

26. HOW DID YOU FIND YOUR CURRENT JOB? (CHECK ALL THAT APPLY.)

☐ WANT AD IN PAPER
☐ WORD OF MOUTH
☐ FRIEND OR FAMILY MEMBER RECRUITED ME
☐ UNION HIRING HALL
☐ REFERRED BY PRIOR EMPLOYER
☐ TRAINING PROGRAM DIRECTED ME TO THIS EMPLOYER
☐ WEB/INTERNET RECRUITING
☐ OTHER (LIST)

27. WHAT METHODS DO YOU USE TO FIND JOBS? (CHECK ALL THAT APPLY.)

☐ WANT AD IN PAPER
☐ WORD OF MOUTH
☐ FRIEND OR FAMILY MEMBER RECRUITED ME
☐ UNION HIRING HALL
☐ REFERRED BY PRIOR EMPLOYER
☐ TRAINING PROGRAM DIRECTED ME TO THIS EMPLOYER
☐ WEB/INTERNET RECRUITING
☐ OTHER (LIST)

28. WHAT TYPE OF CONSTRUCTION PROJECTS DO YOU WORK ON?

☐ UNION.
☐ OPEN SHOP.
☐ BOTH

29. ARE YOU CURRENTLY A BUILDING TRADE UNION MEMBER?

☐ YES ☐ NO (GO TO 32)

30. IF YES, WHAT UNION DO YOU BELONG TO? _____

31. HAVE YOU EVER BEEN A BUILDING TRADE UNION MEMBER? ☐ YES ☐ NO

32. HOW LONG HAVE YOU BEEN/OR WERE A UNION MEMBER? _____YEARS

33. WORK HISTORY. (FILL IN AS BEST YOU CAN)

	ANTICIPATED THIS YEAR	LAST YEAR
HOW MANY TOTAL HOURS DID YOU WORK?	___ hrs	___ hrs
HOW MANY PREMIUM HOURS DID YOU WORK?	___ hrs	___ hrs
HOW MANY HOURS DO YOU WORK IN AN AVERAGE WEEK?	___ hrs	___ hrs
OF THE 52 WEEKS IN A YEAR, ABOUT HOW MANY WEEKS DID YOU WORK?	____ WKS	__WKS
HOW MANY DAYS OF VACATION DID YOU HAVE?	____DAYS	___DAYS
HOW MANY DAYS WERE YOU OFF DUE TO BAD WEATHER?	____DAYS	___DAYS
HOW MANY DAYS WERE YOU OFF WORK DUE TO ILLNESS?	____ DAYS	___DAYS

34. AT WHAT AGE DID YOU FIRST START WORKING IN CONSTRUCTION? _____ YEARS OF AGE.

35. DID YOU WORK IN JOBS OTHER THAN CONSTRUCTION BEFORE YOU BEGAN TO WORK IN CONSTRUCTION?

☐ YES ☐ NO (GO TO 34)

33A. WHAT TYPE OF WORK DID YOU DO IN THOSE JOBS? _____

36. SINCE YOU STARTED WORKING IN CONSTRUCTION, HAVE YOU WORKED OUTSIDE OF CONSTRUCTION?

☐ YES ☐ NO (GO TO 35)

34A. WHAT TYPES OF WORK HAVE YOU DONE WHEN YOU WERE NOT WORKING IN CONSTRUCTION?

_____

34B. HOW LONG AGO DID YOU LAST WORK A NON-CONSTRUCTION JOB? _____(CIRCLE UNIT) DAYS/ WEEKS/ MONTHS/ YEARS

34C. HOW LONG DID THAT PERIOD LAST WHEN YOU WERE WORKING IN JOBS OTHER THAN CONSTRUCTION?

_____ (CIRCLE UNIT) DAYS/ WEEKS/ MONTHS/ YEARS

37. ARE YOU PAID OVERTIME WHEN YOU WORK LONG HOURS? ☐ YES ☐ NO (GO TO 36)

35A. ARE YOU PAID OVERTIME BY THE DAY? ☐ YES ☐ NO (GO TO 35B)

35A1. HOW MANY HOURS DO YOU HAVE TO WORK IN A DAY BEFORE BEING PAID OVERTIME?

_____ HOURS IN A DAY

35B. ARE YOU PAID OVERTIME BY THE WEEK? ☐ YES ☐ NO (GO TO 36)

35B1. HOW MANY HOURS DO YOU HAVE TO WORK IN A WEEK BEFORE BEING PAID OVERTIME?

_____HOURS IN A WEEK

38. DO YOU RECEIVE PREMIUM PAY OTHER THAN OVERTIME IF YOU WORK SIX DAYS A WEEK?

☐ YES ☐ NO

39. DO YOU RECEIVE PREMIUM PAY OTHER THAN OVERTIME IF YOU WORK IN THE EVENING OR AT NIGHT?

☐ YES ☐ NO

40. DO YOU RECEIVE PREMIUM PAY OTHER THAN OVERTIME IF YOU WORK SEVEN DAYS A WEEK?

☐ YES ☐ NO

41. DOES YOUR EMPLOYER PROVIDE CASH BONUSES OR OTHER PAY SUPPLEMENTS?

DOES YOUR EMPLOYER PROVIDE CASH BONUS OR OTHER PAY SUPPLEMENT FOR THE FOLLOWING REASONS?	YES	NO	WHEN IS THIS BONUS PAID?	HOW MUCH DID YOU EARN IN BONUSES LAST YEAR?
HIGH LEVELS OF PRODUCTION (PRODUCTIVITY)	☐	☐		$
ACCIDENT-FREE WORK (SAFETY)	☐	☐		$
COMPLETING WORK AHEADOF SCHEDULE	☐	☐		$
MEETING OR EXCEEDING EXPECTED QUALITY	☐	☐		$
Other (list) _____	☐	☐		$

42. DOES YOUR EMPLOYER PROVIDE RECOGNITION?

DOES YOUR EMPLOYER PROVIDE RECOGNITION FOR THE FOLLOWING REASONS?	YES	NO	HOW MANY TIMES WERE YOU RECOGNIZED LAST YEAR?

HIGH LEVELS OF PRODUCTION (PRODUCTIVITY)	☐	☐	
ACCIDENT-FREE WORK (SAFETY)	☐	☐	
COMPLETING WORK AHEAD OF SCHEDULE	☐	☐	
MEETING OR EXCEEDING EXPECTED QUALITY	☐	☐	
Other (list) _____	☐	☐	

43. HOW MANY DAYS OF PAID OR UNPAID VACATION DID YOU TAKE IN THE LAST 12 MONTHS?
_____ DAYS

44. HOW MANY DAYS OF PAID VACATION DOES YOUR EMPLOYER PROVIDE ANNUALLY?
_____ DAYS

45. HOW MANY DAYS DID YOU TAKE OFF OF WORK DUE TO SICKNESS IN THE LAST 12 MONTHS?
_____ DAYS

46. HOW MANY PAID SICK DAYS DOES YOUR EMPLOYER PROVIDE ANNUALLY? _____ DAYS

47. WHAT MANAGEMENT FUNCTIONS DO YOU PRESENTLY PERFORM? (CHECK ALL THAT APPLY.)

FUNCTION	I PERFORM THIS FUNCTION.		I USE A COMPUTER TO PERFORM THIS FUNCTION.	
	YES	NO	YES	NO
COST MANAGEMENT	☐	☐	☐	☐
SHORT-INTERVAL PLANNING	☐	☐	☐	☐
SHORT-INTERVAL SCHEDULING	☐	☐	☐	☐
MATERIAL MANAGEMENT	☐	☐	☐	☐
MATERIAL PROCUREMENT	☐	☐	☐	☐
TOOL PROCUREMENT	☐	☐	☐	☐
REQUESTS FOR INFORMATION (RFI)	☐	☐	☐	☐
COST ESTIMATING	☐	☐	☐	☐
COMMUNICATIONS	☐	☐	☐	☐
A. EMAIL	☐	☐	☐	☐
B. VERBAL	☐	☐	☐	☐
C. WRITTEN	☐	☐	☐	☐
CREW COORDINATION	☐	☐	☐	☐
INTER-CRAFT COORDINATION	☐	☐	☐	☐
INTRA-CRAFT COORDINATION	☐	☐	☐	☐

48. WHAT INFORMATION HARDWARE AND PERIPHERALS ARE YOU PROFICIENT AT USING? (CHECK ALL THAT APPLY.)

☐ DESKTOP OR LAPTOP PC
☐ SCANNERS (FLAT BED)
☐ GPS
☐ PERSONAL DIGITAL ASSISTANT (PDA) (PALM PILOT, ETC.)
☐ PLOTTERS
☐ TOTAL STATION
☐ HAND HELD COMPUTER (HP JORNODA, COMPAQ IPAQ, CASIO CASSEOPIA, ETC.)
☐ WIRELESS NETWORKS
☐ LASER LEVEL
☐ WORK STATION (SUN
☐ LCD/LDP PROJECTORS
☐ RF1D TAG

MICROSYSTEMS, HEWLETT PACKARD, SILICON GRAPHICS, ETC.)

☐ DIGITAL CAMERAS ☐ TOUCH SCREEN MONITOR ☐ OTHER (LIST) _____

☐ MODEMS ☐ TWO-WAY PAGER _____

☐ PRINTERS ☐ BAR CODE SCANNER _____

49. WHAT COMPUTER OPERATING SYSTEMS ARE YOU PROFICIENT WITH? (CHECK ALL THAT APPLY.)

☐ DOS ☐ PALM OS

☐ MICROSOFT WINDOWS 98, 2000 ☐ UNIX

☐ MICROSOFT WINDOWS NT ☐ OS/2

☐ MICROSOFT WINDOWS CE ☐ MACOS

☐ LINUX ☐ OTHER (LIST)

☐ POCKET PC

50. WHAT PROGRAMMING LANGUAGES ARE YOU PROFICIENT AT? (CHECK ALL THAT APPLY.)

☐ VISUAL BASIC ☐ HTML

☐ BASIC ☐ JAVA

☐ FORTRAN ☐ OTHER (LIST) _____ _____

☐ C/C++

51. WHAT APPLICATION PROGRAMS ARE YOU FAMILIAR WITH? (CHECK ALL THAT APPLY.)

☐ E-MAIL (MICROSOFT OUTLOOK, EUDORA, YAHOO, HOTMAIL, ETC.)

☐ INTERNET (MICROSOFT EXPLORER, NETSCAPE, YAHOO, LYCOS, ETC.)

☐ WORD PROCESSING (MS WORD, WORDPERFECT, ETC.)

☐ SPREADSHEET (MS EXCEL, LOTUS, QUATTRO PRO, ETC.)

☐ DATA BASE (MS ACCESS, DBASE, ETC.)

☐ DRAWING (VISIO, ETC)

☐ PRESENTATION (MS POWERPOINT, LOTUS FREELANCE, ETC.)

☐ GRAPHICS (ADOBE, 3D STUDIO MAX, ETC.)

☐ CAD (INTERGRAPH, AUTOCAD, MICRO STATION, ETC.)

☐ SCHEDULING (PRIMAVERA PROJECT PLANNER, SURETRAK PROJECT MANGER, MS PROJECT, ETC.)

☐ ESTIMATING (TIMBERLINE PRECISION, HCSS HEAVYBID, HARD DOLLAR EOS, ETC.)

☐ COST CONTROL (EXPEDITION, PROLOG, ETC.)

☐ FINANCIAL (QUICKEN, QUICKBOOKS, MS MONEY, ETC.)

☐ MATHEMATICAL APPLICATIONS (MATLAB, MATHEMATICA, SPSS, SAS, MINITAB, ETC.)

☐ ENTERTAINMENT GAMES (THE SIMS, BLACK & WHITE, DIABLO II, ULTIMA ONLINE, ETC.)

☐ OTHER (LIST) _____ _____ _____ _____ _____

52. HOW LONG HAVE YOU BEEN USING A COMPUTER? _____ YEARS

53. WHAT IS THE ONE COMPUTER APPLICATION PROGRAM THAT YOU USE MOST OFTEN AT WORK?

_____

54. WHERE DID YOU ACQUIRE YOUR COMPUTER SKILLS

☐ SELF-TAUGHT OFF THE JOB

☐ BY ON-THE-JOB USE

☐ THROUGH COMPANY SPONSORED TRAINING

☐ FORMAL EDUCATION/SCHOOLING

55. FOR WHICH OF THE FOLLOWING TASKS DO YOU USE A COMPUTER? (CHECK ALL THAT APPLY.)

☐ TIME REPORTS

☐ PROGRESS REPORTS

☐ ACCESS LATEST DRAWING REVISIONS

☐ ACCESS OTHER INFORMATION (SPECIFY) _____

☐ VISUALIZE FUTURE AND PRESENT WORK THROUGH 3-D DRAWINGS

☐ ORDER TOOLS

☐ ORDER MATERIALS

☐ ORDER SCAFFOLDING

☐ LOCATE TOOLS

☐ LOCATE MATERIALS

☐ LOCATE EQUIPMENT

☐ LOCATE SCAFFOLDING

☐ COMMUNICATE WITH OTHERS ON PROJECT BY EMAIL

☐ VISUALLY RECORD JOB PROGRESS WITH A DIGITAL CAMERA

☐ OTHER (SPECIFY) _____

56. WHICH TASKS DO YOU BELIEVE SHOULD BE COMPUTER AUTOMATED FOR THE ACHIEVEMENT OF THE TIER II WORKFORCE GOAL? (CHECK ALL THAT APPLY AND RATE THEIR IMPORTANCE.)

NOT IMPORTANT	MARGINALLY IMPORTANT	ESSENTIAL	CRITICAL	TASK
☐	☐	☐	☐	TIME REPORTS
☐	☐	☐	☐	PROGRESS REPORTS
☐	☐	☐	☐	ACCESS LATEST DRAWING REVISIONS
☐	☐	☐	☐	ACCESS OTHER INFORMATION (SPECIFY) _____
☐	☐	☐	☐	VISUALIZE FUTURE AND PRESENT WORK THROUGH 3-D DRAWINGS
☐	☐	☐	☐	ORDER TOOLS
☐	☐	☐	☐	ORDER MATERIALS
☐	☐	☐	☐	ORDER SCAFFOLDING
☐	☐	☐	☐	LOCATE TOOLS
☐	☐	☐	☐	LOCATE MATERIALS
☐	☐	☐	☐	LOCATE EQUIPMENT
☐	☐	☐	☐	LOCATE SCAFFOLDING
☐	☐	☐	☐	COMMUNICATE WITH OTHERS ON PROJECT BY EMAIL
☐	☐	☐	☐	VISUALLY RECORD JOB PROGRESS WITH A DIGITAL CAMERA
☐	☐	☐	☐	OTHER (SPECIFY) _____

☐ ☐ ☐ ☐ OTHER (SPECIFY) _____

☐ ☐ ☐ ☐ OTHER (SPECIFY) _____

☐ ☐ ☐ ☐ OTHER (SPECIFY) _____

57. IF THE TIER II WORKFORCE STRATEGY WORKS, WILL THE FACTORS LIKE SAFETY, QUALITY AND PRODUCTIVITY BE IMPROVED?

☐ STRONGLY DISAGREE ☐ DISAGREE ☐ NEUTRAL ☐ AGREE ☐ STRONGLY AGREE

58. WOULD YOU RECOMMEND TO YOUR SON OR DAUGHTER ENTERING A CRAFT TRAINING PROGRAM TO PURSUE A CAREER IN FIELD CONSTRUCTION?

☐ YES ☐ NO

WHY? _____

_____

_____

59. WOULD YOU RECOMMEND TO YOUR SON OR DAUGHTER ENTERING A CRAFT TRAINING PROGRAM TO PURSUE A CAREER IN FIELD CONSTRUCTION IF THE TIER II STRATEGY WAS PART OF THE CAREER PATH?

☐ YES ☐ NO

WHY? _____

_____

_____

60. WHO SHOULD PAY FOR THE MANAGEMENT SKILLS TRAINING THAT A TIER II WORKER IS REQUIRED TO POSSESS?

☐ SELF

☐ PROJECT – COMPANY

☐ PROJECT – OWNER & COMPANY

☐ COMPANY

61. IF YOU MUST PERSONALLY PAY FOR THE TIER II MANAGEMENT SKILLS TRAINING WOULD YOU PURSUE IT?

☐ YES ☐ NO

62. WHEN SHOULD THE TRAINING BE OFFERED?

☐ DURING WORKING HOURS

☐ OUTSIDE WORKING HOURS BUT HOURLY WAGES PAID FOR TRAINING TIME

☐ OUTSIDE WORKING HOURS BUT NO HOURLY WAGES PAID FOR TRAINING TIME

63. IF TRAINING FOR TIER II MANAGEMENT SKILL IS OFFERED OUTSIDE WORKING HOURS WOULD YOU PURSUE IT?

☐ YES ☐ NO IF HOURLY WAGE IS PAID FOR TRAINING TIME

☐ YES ☐ NO IF NO HOURLY WAGE IS PAID FOR TRAINING TIME

64. DOES YOU SPOUSE OR PARTNER WORK?

☐ LESS THAN 20 HOURS A WEEK

☐ MORE THAN 20 BUT LESS THAN 40 HOURS A WEEK

☐ 40 HOURS A WEEK

☐ MORE THAN 40 HOURS A WEEK

65. IS YOUR SPOUSE'S OR PARTNER'S JOB?

☐ TEMPORARY

☐ PERMANENT

66. IF YOUR NEXT CONSTRUCTION PROJECT REQUIRES YOU TO LOCATE? (CHECK ALL THAT APPLY)

☐ MY SPOUSE OR PARTNER RELOCATES WITH ME

☐ MY SPOUSE OR PARTNER DOES NOT RELOCATES WITH ME

☐ I ONLY ACCEPT JOBS THAT DO NOT REQUIRE RELOCATION

☐ I ONLY ACCEPT JOBS THAT REQUIRE RELOCATION IF NOTHING ELSE IS AVAILABLE

67. WHAT ARE THE CHARACTERISTICS OF GOOD PROJECT?

_____

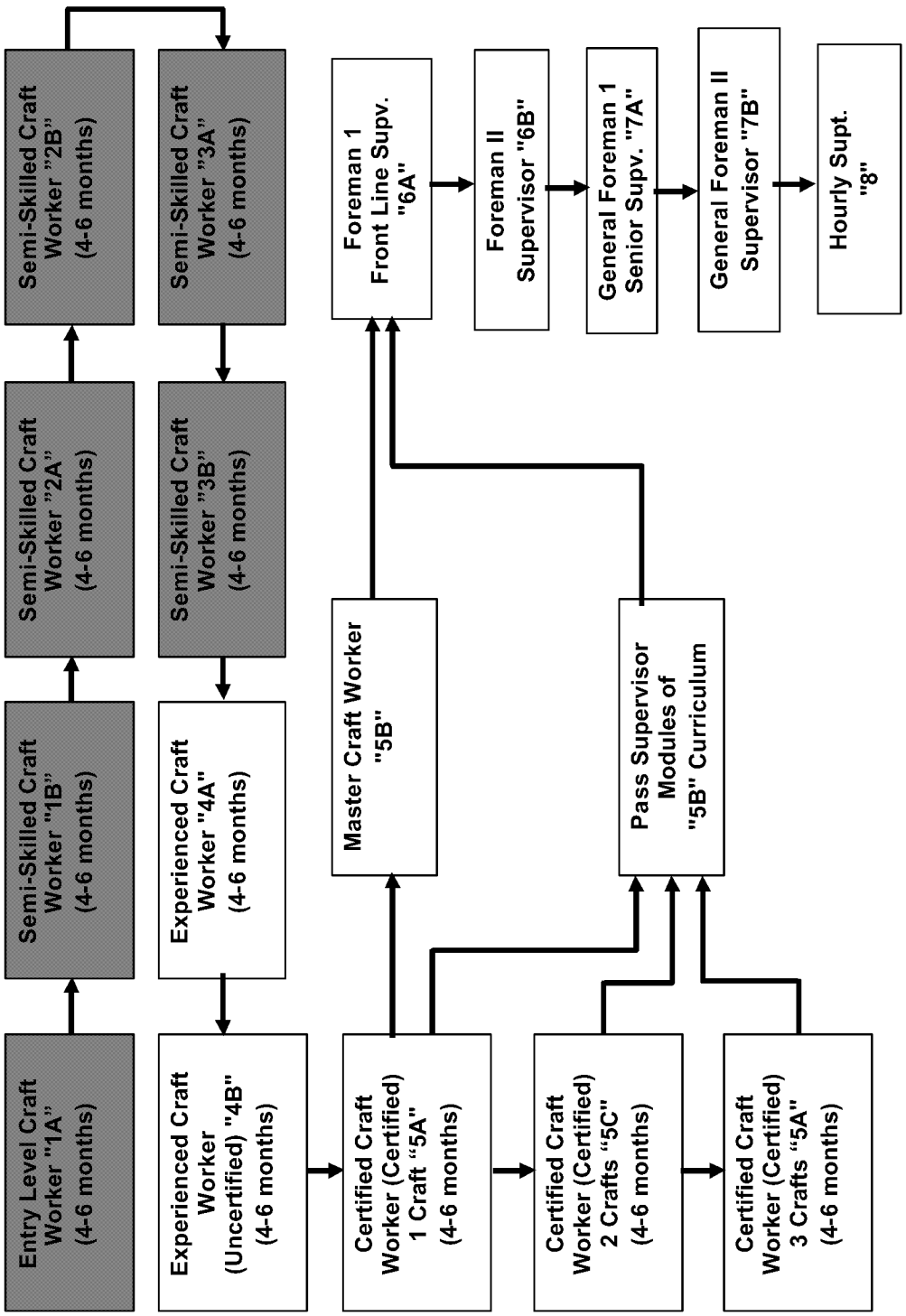
_____

_____

YOU HAVE NOW COMPLETED THE SURVEY. THERE IS SPACE PROVIDED BELOW, PLEASE FEEL FREE TO LEAVE ANY COMMENTS YOU MAY HAVE. AGAIN, WE THANK YOU FOR TAKING TIME TO FILL OUT THE QUESTIONNAIRE. YOU HELP IS GREATLY A PPRECIATED!

Appendix G

No.1 Project Company's Craft Progression Program



Appendix H

No.1 Project's Tier II Project Index

Project Average Technical Skills

Project: No.1 Project (Power Plant Project)

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Average Score from Individual Evaluation on Technical Skills *	7.0	Greater than 75 points	10		
		50 points	5		
		Less than 25 points	0	4	28
% of Tier II workers *	3.0	40% or more of journeymen are certified as Tier II workers	10		
		20% of journeymen are certified as Tier II workers	5		
		Less than 10 % of journeymen are certified as Tier II workers	0	5	15

** for project's key crafts*

Sub-Total (A) = **43**

Project Average Management Skills

Project: No.1 Project (Power Plant Project)

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Average Score from Individual Evaluation on Management Skills *	**10.0**	Greater than 75 points	10		
		50 points	5		
		Less than 25 points	0	3	30

** for project's key crafts*

Sub-Total (B) = **30**

Information Technology Utilization

Project: No.1 Project (Power Plant Project)

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Integrated Information Access	6.0	All information* is stored, integrated, continuously updated, and accessed by Tier II workers electronically	10		
		3 types of information* are stored, integrated, continuously updated, and accessed by Tier II workers electronically	5		
		Information* is not directly accessed by Tier II workers	0	4	24
Hardware	4.0	Tier II workers have wireless, wearable computers	10		
		Hardware is nearby and shared among crews	5		
		No hardware is available to Tier II workers	0	2	8

* Information includes schedule, costs, materials and equipment management, safety, drawings, and worker skills

Sub-Total (C) = **32**

Craft Utilization

Project: _No.1 Project (Power Plant Project)_

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Crew Mix	4.0	Key crafts' crews (on avg.) have at least 40% of Tier II workers	10		
		Key crafts' crews (on avg.) have at least 20% of Tier II workers	5		
		Less than 50% of key crafts' crews have Tier II workers	0	7	28
Use of Multiskilled Workers	2.0	Key crafts' crews (on avg.) have at least 40% multiskilled workers	10		
		Key crafts' crews (on avg.) have at least 20% multiskilled workers	5		
		Less than 50% of key crafts' crews have multiskilled workers	0	1	2
Worker Turnover (Total Hires / Peak Workforce)	4.0	Less than 2	10		
		Equal to 3	5		
		Greater than 4	0	9	36

Sub-Total (D) = **66**

Organization

Project: _No.1 Project (Power Plant Project)_

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Communications	6.0	Proactive information flow to and from workers about the project, established formal & informal channels, open access to management, frequent meetings with workers, all workers are familiar with all aspects of the project	10		
		Informal communication channels, regular meetings with workers, workers can receive project information requested, open door policy	5		
		Rigid hierarchical structure for communication, only information that management deems necessary to workers is provided.	0	3	18
High Performance Work Place	4.0	Delegation of appropriate authority and accountability to High Performance Work Teams (HPWT). Clear definition of authority, accountability and expectations to each team. Training of all teams in HPWT approach. Expected utilization by crews of management skills and IT information available thru Tier II workers	10		
		Hierarchical structure, but with 2-way information & idea flow between crews and management	5		
		Rigid hierarchical structure	0	3	12

Sub-Total (E) = **30**

Categories and Elements	Evaluation Criteria Score (1)	Element Weight (2)	Element Points (3) =(1) x (2)	Category Weight (4)	Project Score (5) =(3) x (4)
A. Project Average Technical Skills					
A1. Average Score from Individual Evaluation on Technical Skills	4	7.0	28		
A2. Percentage of Tier II Workers	5	3.0	15		
			43	0.40	17.2
B. Project Average Management Skills					
B1. Average Score from Individual Evaluation on Management Skills	3	10.0	30		
			30	0.20	6.0
C. Information Technology Utilization					
C1. Integrated Information Access	4	6.0	24		
C2. Hardware	2	4.0	8		
			32	0.10	3.2
D. Craft Utilization					
D1. Crew mix	7	4.0	28		
D2. Use of Multi-skilled Workers	1	2.0	2		
D3. Worker Turnover	9	4.0	36		
			66	0.15	9.9
E. Organization					
E1. Communications	3	6.0	18		
E2. High Performance Work Place	3	4.0	12		
			30	0.15	4.5

SUM 40.8

Tier II Strategy Implementation Index = SUM (A+B+C+D+E) / 10

= 40.8 / 10 = 4.08

out of 10.0

Appendix I

No.2 Project's Tier II Project Index

Project Average Technical Skills

Project: No.2 Project (Environmental Project)

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Average Score from Individual Evaluation on Technical Skills *	7.0	Greater than 75 points	10		
		50 points	5		
		Less than 25 points	0	6.2	43.4
% of Tier II workers *	3.0	40% or more of journeymen are certified as Tier II workers	10		
		20% of journeymen are certified as Tier II workers	5		
		Less than 10 % of journeymen are certified as Tier II workers	0	0	0

** for project's key crafts*

Sub-Total (A) = **43.4**

Project Average Management Skills

Project: No.2 Project (Environmental Project)

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Average Score from Individual Evaluation on Management Skills *	**10.0**	Greater than 75 points	10		
		50 points	5		
		Less than 25 points	0	4.1	41

** for project's key crafts*

Sub-Total (B) = **41**

Information Technology Utilization

Project: No.2 Project (Environmental Project)

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Integrated Information Access	6.0	All information* is stored, integrated, continuously updated, and accessed by Tier II workers electronically	10		
		3 types of information* are stored, integrated, continuously updated, and accessed by Tier II workers electronically	5		
		Information* is not directly accessed by Tier II workers	0	2	12
Hardware	4.0	Tier II workers have wireless, wearable computers	10		
		Hardware is nearby and shared among crews	5		
		No hardware is available to Tier II workers	0	0	0

* Information includes schedule, costs, materials and equipment management, safety, drawings, and worker skills

Sub-Total (C) = **12**

Craft Utilization

Project: No.2 Project (Environmental Project)

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Crew Mix	4.0	Key crafts' crews (on avg.) have at least 40% of Tier II workers	10		
		Key crafts' crews (on avg.) have at least 20% of Tier II workers	5		
		Less than 50% of key crafts' crews have Tier II workers	0	0	0
Use of Multiskilled Workers	2.0	Key crafts' crews (on avg.) have at least 40% multiskilled workers	10		
		Key crafts' crews (on avg.) have at least 20% multiskilled workers	5		
		Less than 50% of key crafts' crews have multiskilled workers	0	9.0	18
Worker Turnover (Total Hires / Peak Workforce)	4.0	Less than 2	10		
		Equal to 3	5		
		Greater than 4	0	0	0

Sub-Total (D) = **18**

Organization

Project: No.2 Project (Environmental Project)

Elements	Weights	Evaluation Criteria	Score	Project Score	Weighted Score
Communications	6.0	Proactive information flow to and from workers about the project, established formal & informal channels, open access to management, frequent meetings with workers, all workers are familiar with all aspects of the project	10		
		Informal communication channels, regular meetings with workers, workers can receive project information requested, open door policy	5		
		Rigid hierarchical structure for communication, only information that management deems necessary to workers is provided.	0	5	30
High Performance Work Place	4.0	Delegation of appropriate authority and accountability to High Performance Work Teams (HPWT). Clear definition of authority, accountability and expectations to each team. Training of all teams in HPWT approach. Expected utilization by crews of management skills and IT information available thru Tier II workers	10		
		Hierarchical structure, but with 2-way information & idea flow between crews and management	5		
		Rigid hierarchical structure	0	5	20

Sub-Total (E) = **50**

Categories and Elements	Evaluation Criteria Score (1)	Element Weight (2)	Element Points (3) =(1) x (2)	Category Weight (4)	Project Score (5) =(3) x (4)
A. Project Average Technical Skills					
A1. Average Score from Individual Evaluation on Technical Skills	6.2	7.0	43.4		
A2. Percentage of Tier II Workers	0	3.0	0		
			43.4	0.40	17.4
B. Project Average Management Skills					
B1. Average Score from Individual Evaluation on Management Skills	4.1	10.0	41		
			41	0.20	8.2
C. Information Technology Utilization					
C1. Integrated Information Access	2	6.0	12		
C2. Hardware	0	4.0	0		
			12	0.10	1.2
D. Craft Utilization					
D1. Crew mix	0	4.00	0		
D2. Use of Multi-skilled Workers	8.9	2.00	18		
D3. Worker Turnover	0	4.00	0		
			18	0.15	2.7
E. Organization					
E1. Communications	5	6.0	30		
E2. High Performance Work Place	5	4.0	20		
			50	0.15	7.5

SUM 37.0

Tier II Strategy Implementation Index = SUM (A+B+C+D+E) / 10

= 37.0 / 10 = 3.70

out of 10.0

Appendix J

Project Success Index in Construction Phase

Construction Success

The following criteria were used to define "Construction Success", and determine the corresponding score used on the application of the Tier II strategy. The in-depth metrics are under development by the CII BM&M research team and will be used in the future research instead of these criteria.

Score	Criteria
10	At least 10% under budget (construction phase) And, no lost time accidents And, on schedule And, easy start-up
5	On budget and schedule And, acceptable safety record Minor start-up problems
0	More than 10% over budget And, poor safety record (RIR > 5) And, schedule slippage And, significant start-up problems

Glossary

AHP – Analytical Hierarchy Process

BM&M – Benchmarking and Metrics

BRT – Business Roundtable

CAD – Computer Aided Design

CCIS – Center for Construction Industry Studies

CII – Construction Industry Institute

CI – Consistency Index

CPWR – Center to Protect Workers' Rights

CR – Consistency Ratio

FIAPP – Fully Integrated and Automated Project Process

HPWT – High Performance Work Team

IT – Information Technology

NCCER – National Center for Construction Education and Research

PDA – Personal Data Assistant

RFI – Request For Information

RCI – Random Consistency Index

ROI – Return On Investment

SD – Standard Deviation

SMWT – Self-Managed Work Team

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