# Construction Craft Workers' Perceptions of the Factors Affecting Their Productivity

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**Abstract:** In efforts to quantify craft workers' perspective of construction productivity, a nationwide survey involving 1,996 craft workers was employed. The survey quantified the relative impact of 83 productivity factors, which had been identified through a series of focus group sessions involving craft workers conducted on construction jobsites located throughout the United States. The findings show that craft workers do have a good understanding of the factors affecting their daily productivity, and most of the adversarial factors affecting productivity can be addressed by site management teams. Factors involving tools and consumables, materials, engineering drawing management and construction equipment were identified as having the greatest impact on productivity from the craft workers' perspective. A statistical comparative analysis was employed to distinguish the significant factors encountered by craft workers on projects with relatively low perceived productivity. The research further examined the differences in the perceived relative magnitude of productivity factors' influence on construction productivity based on respondents' union status and trade. These findings will be beneficial for engaging craft workers in productivity improvement and improving the efficiency of construction jobsites.

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## Introduction

It is widely perceived that construction labor productivity in the U.S. has gradually declined since the 1960s. Studies completed in the 1980s reported that construction real output (value added) per work hour declined by an annual rate of 2.4 to 2.8% between 1968 and 1980 (Allen 1985; BRT 1983; Stokes 1981). More recent research using construction macroeconomic data found that labor productivity continued to decline into 1999 at an annual compound rate of −0.48% (Teicholtz 2001). While these macroeconomic measures of construction productivity reveal steady declines, studies using microeconomic productivity data suggest otherwise. In a more recent study using microeconomic data, Goodrum et al. (2002) reported that labor productivity within 200 sampled activities improved by an annual compound rate of 1.2% from 1976 to 1998. Regardless of whether some micromeasures of productivity indicate improvement and some macromeasures indicate otherwise, the opportunity for improving construction productivity clearly exists.

Labor productivity is primarily affected by the ability of construction managers to plan, schedule, and direct the work (Olson 1982). Regrettably, management ineffectiveness is widely perceived as a principal cause of poor construction productivity (BRT 1983; Sanvido 1988). Consequently, there has been significant research on how to make management more effective in supporting craft workers on a jobsite (Haas et al. 1999). While preproject planning has a significant influence on project performance, productivity improvement through jobsite efforts can still impact up to 30% of the projects' cost (Kellogg et al. 1981).

As the major players executing the processes and activities in construction, craft workers have a significant influence on labor productivity (Maloney 1983). It is important to know what craft workers need and what affects their performance in order to accomplish productivity improvement (Oglesby et al. 1989). Unfortunately, craft workers' input and their perception of the issues that influence their daily productivity have rarely been sought, either because it takes time away from tasks that are to be done or because it is considered an infringement on management's right to control the work. However, craft workers are certainly in the ideal position to know where and how much of a site's productivity is lost or gained at the work face. A better understanding of the factors influencing labor productivity from the workforce's perspective can enable site management teams to more effectively allocate their limited resources, provide craft workers with better support, increase craft workers' motivation, and enhance craft workers' commitment to productivity improvement.

### Purpose and Scope

With this in mind, this paper presents quantitative information about the perception of craft workers (including foremen and general foremen) on the factors affecting their productivity. The priorities of these factors are identified through primary data collected from a survey of 1,996 craft workers on U.S. industrial construction projects. In addition to examining the overall priority of the factors, the paper also examines how the factors varied by projects on which survey respondents believed that productivity was good or better versus respondents on other projects in which

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**Table 1.** Characteristics of the Participating Projects in the Focus Group Sessions [Reprinted with Permission, CII (2006a)]

| ID | Type | Union/ nonunion | U.S. location | Stage of completion at time of focus group | Size[a] |
|---|---|---|---|---|---|
| 1 | Industrial/remediation | Union | West | 40% completion | Large |
| 2 | Electrical generation | Union | West | 20% completion | Large |
| 3 | Industrial process | Nonunion | West | 25% completion | Small |
| 4 | Industrial process | Nonunion | South | Finishing punch list items | Large |
| 5 | Petrochemical | Nonunion | South | 10% completion | Large |
| 6 | Industrial process | Nonunion | South | 50% completion | Small |
| 7 | Electrical generation | Union | Midwest | 15% completion | Large |
| 8 | Electrical generation | Union | West | 15% completion | Large |
| 9 | Electrical generation | Nonunion | South | 75% completion | Large |

[a]A large project was classified with a budget more than $50 million and a small project with less than $50 million.



productivity was perceived as less than good. Finally, the relative importance of the factors is also examined by union and trade status of the respondents.

### Background

Identifying the factors that impact construction productivity is not a new effort. There have been numerous efforts of identifying and classifying the factors that impact construction productivity, with a few attempting to identify the relative importance of the individual factors.

A Department of Energy (DOE) study surveyed craftsmen and foremen on 12 energy (nuclear or nuclear-related facility) projects in order to quantify the various problems that reduce construction productivity at the jobsite (Borcherding et al. 1980; Borcherding and Garner 1981). The major factors impacting labor productivity were ranked as: (1) material availability; (2) tool availability; (3) work redone; (4) overcrowded work area; (5) inspection delays; (6) foreman incompetence; (7) crew interference; (8) craft turnover and absenteeism; and (9) foreman changes. Engineering lead time was considered to have a major impact on many of these factors. Obviously, the unique challenges (for example strict QA/QC tolerances, complex design and frequent change orders) that were present on many nuclear power plant projects did influence the DOE findings.

Rojas and Aramvareekul (2003) conducted a web-based survey to identify the relative importance of 18 factors affecting labor productivity. A total of 64 responses from owners, consultants, general contractors, electrical contractors, and mechanical contractors were sampled. Factors were classified into four categories, including management systems and strategies (e.g., scheduling), man power (e.g., experience and motivation), industry environment (e.g., adverse working conditions) and external conditions (e.g., scope changes). The survey results indicated that management systems and strategies had the greatest influence on labor productivity, followed by manpower, industry environment, and external conditions.

Liberda et al. (2003) reported a research effort to identify the relative importance of 51 productivity factors categorized under the headings of labor, management, and external factors by interviewing 20 industry experts. Management factors, such as lack of detail planning, inadequate supervision, and lack of information, were found to account for half of the most critical 15 factors.

Even though different methodologies have been adopted to classify and identify the relative magnitude of the factors that have an impact on construction productivity, these studies have shown that the most significant factors could be influenced by management. However, few if any input from craft workers, an extremely important element in the construction process, was obtained. Furthermore, a great number, if not all, of these factors can simultaneously exist on a jobsite, but practical resources do not exist for jobsite management teams to measure and eliminate all negative factors affecting craft workers' ability to be productive. Knowledge about which factors have the greatest impact should be useful for productivity improvement.

## Research Methodology

### Focus Groups

Initially, focus group sessions were used to document the major factors impacting construction productivity from the perspective of craft workers in order to better develop the research's questionnaire (Dai et al. 2005). In an attempt to gain an industry-wide perspective, nine industry projects were selected across the United States with varying types of construction, union/nonunion work status, geographic location, status of completion, and project size (Table 1).

Eighty-three factors emerged from the focus group sessions and were categorized into 11 areas as shown in Table 2.

## Survey Efforts

While the focus groups identified the study's array of productivity factors that existed on jobsites from the craft workers' perspective, a survey was performed to quantify the relative importance of these factors. To collect the desired information, a craft worker survey was developed based on the major factors identified in the focus group sessions.

The craft worker survey, consisting of three parts, was designed to identify the perception of craft workers on the factors influencing construction productivity. In part one, respondents were requested to provide demographic information including their union status, trade, and position. In addition, project productivity performance was rated by respondents on a seven-point Likert scale, with 1 being the worst job they had ever experienced, and 7 being the best job. In the second part of the craft worker survey, respondents indicated the frequency of 26 factors and assessed their impact on productivity. The frequency of each factor was rated on a seven-point Likert scale with 1 indicating something that has never happened and 7 indicating a constant occurrence. The impact of each factor on productivity was also

**Table 2.** Factors Affecting Labor Productivity [Reprinted with Permission, CII (2006a)]

| |
|---|
| Supervisor direction |
| • **Inadequate instruction provided** |
| • **Not receiving directions due to size of the project** |
| • Receiving compliments for doing a good job |
| • Being notified of mistakes when they occur |
| • Lack of goals for craft workers |
| Communication |
| • **Different languages spoken on a project** |
| • Disregard of crafts' productivity improvement suggestion |
| • Lack of "Big Picture" view on behalf of the crafts |
| • Craft worker importance |
| • Lack of communication among site management |
| Safety |
| • **Shortage of personal protective equipment** |
| • Lack of site safety resources |
| Tools and consumables |
| • **Availability of consumables** |
| • **Restrictive project policy on consumables** |
| • **Availability of hand tools** |
| • **Availability of power tools** |
| • **Lack of power source for tools** |
| • **Lack of extension cords** |
| • **Inexperienced tool room attendants** |
| • **Misplaced tools** |
| • **Poor quality power tools** |
| Materials |
| • **Availability of material** |
| • **Poor material quality** |
| • **Availability of bulk commodities** |
| • **Errors in prefabricated material** |
| • Difficulty in tracking material |
| Engineering drawing management |
| • **Drawing errors** |
| • **Availability of drawings** |
| • **Slow response to questions with drawings** |
| • Drawing legibility |
| • Needed information not on drawings |
| Labor |
| • Availability of skill training |
| • Jobsite orientation program |
| • Availability of health and safety training |
| • Qualified craftsmen |
| • Craftsmen's pride in their work |
| • Craftsmen's incentive |
| • Motivated craft workers |
| • Equal pay on projects in a geographic area |
| • Craft workers' trust in supervisors |
| Foreman |
| • Foremen people skill |
| • Qualified foremen |
| • Fair/just performance reviews |
| • Foremen allowing crafts to work autonomously |
| • Lack of construction knowledge on behalf of foremen |
| • Lack of authority to discipline craft workers |
| • Lack of proper resource allocation |
| Supervisor direction |
| • Proper managerial and administrative support |
| • Excessive paperwork |
| Superintendent |
| • Superintendent's people skill |
| • Qualified superintendents |
| • Lack of experience on behalf of superintendents |
| • Respect for craft workers |
| • Micromanagement on behalf of superintendent |
| • Political/performance competitions within company |
| • Inconsistent safety policies established by different superintendents |
| • Different work rules by superintendents |
| Project management |
| • **Delay in work permits** |
| • **Out of sequence work assignments** |
| • **Absenteeism** |
| • Reasonable project goals and milestones |
| • Respect for craft workers and foremen |
| • Layoff of qualified craft workers |
| • Awareness of on-site activities and project progress |
| • Pulling people off a task before it is done |
| • Jobsite congestion |
| • Different pay scales for the same job on a project |
| • Different per diem rate |
| • Incentive for good performance |
| • Material storage area too far from workface |
| • Insufficient size of material storage area |
| • Shortage of temporary facilities |
| • Coordination between the trades |
| • Slow decisions |
| • Correct crew size |
| • Vehicle traffic routes |
| • Weather protection |
| Construction equipment |
| • **Availability of crane or forklift** |
| • **Availability of manlift** |
| • **Waiting for people and/or equipment to move material** |
| • Poor equipment maintenance |
| • Equipment repairs |
| • Maintenance of power tools |

Note: Frequency factors are shown in bold.

rated on the seven-point scale, with 1 as having no impact on productivity and 7 indicating extreme impact on productivity. Other factors with frequency on a job site that is difficult to identity were included in the third part of the craft worker survey. This part investigated respondents' agreement with 57 statements and their perception of the factors' impact on productivity. The agreement on each factor was rated by each respondent on a seven-point scale, with 1 indicating strongly disagree and 7 indicating strongly agree. The agreement factors also used a seven-point impact scale, but their impact was scored differently than the impact on the frequency factors. For the agreement factors, the impact scale ranged from 1 indicating a very negative impact to 7 indicating a very positive impact. The researchers included the bipolar impact scale since the agreement factors included both positive and negative worded issues. Therefore, if a respondent disagreed with a negative worded issue (e.g., "There is not



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| | ← Less Agreement More → | | | | | | | ← Negative Impact Positive → | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Strongly Disagree | Mildly Disagree | Neither Agree Nor Disagree | | Mildly Agree | | Strongly Agree | Very Negative | Small | | No Impact | Small | | Very Positive |
| 54. The equipment on this job is not properly maintained. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 55. When the equipment on this job breaks down, it is quickly repaired. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Fig. 1.** Example of survey questions (Dai 2006)



enough room on the site for material storage"), the respondent would have likely indicated that his or her experience with the issue would have been positive (i.e., that having enough room on the site for material storage had a positive impact). Positive and negative worded issues were intentionally mixed to improve the quality of responses as the example shows in Fig. 1.

In order to help discussion, the factors investigated in the second section of the craft worker survey are simply called the frequency factors, and the factors in the third section are called the agreement factors.

There were 1,996 respondents from 28 projects across the United States (Table 3). As shown in Fig. 2, the top four responding trades were pipefitting, electrical work, carpentry, and ironworking.

Among the survey participants, union and nonunion workers account for 49.5 and 50.5%, respectively. This near balance in the population is attributed to the industrial nature of the sampled projects. Furthermore, the majority of survey respondents were journeymen (56.1%), followed by foremen and general foremen (26.0%), apprentices (9.6%), helpers (7.2%), and others (1.1%).

**Table 3.** Participating Projects in the Craft Worker Survey

| Project ID | Union status | State | Size[a] | Sample size |
|---|---|---|---|---|
| 1 | Union | Pennsylvania | Small | 46 |
| 2 | Union | Washington | Large | 44 |
| 3 | Union | Iowa | Large | 35 |
| 4 | Union | California | Large | 130 |
| 5 | Union | Arizona | Large | 239 |
| 6 | Nonunion | Florida | Large | 14 |
| 7 | Nonunion | Texas | Small | 25 |
| 8 | Nonunion | Tennessee | Small | 55 |
| 9 | Nonunion | Georgia | Small | 28 |
| 10 | Union | Louisiana | Small | 37 |
| 11 | Nonunion | Mississippi | Small | 30 |
| 12 | Union | Tennessee | Small | 60 |
| 13 | Union | Illinois | Small | 82 |
| 14 | Nonunion | Colorado | Large | 16 |
| 15 | Nonunion | Tennessee | Small | 14 |
| 16 | Union | Georgia | Large | 83 |
| 17 | Union | Washington | Large | 112 |
| 18 | Union | Missouri | Small | 58 |
| 19 | Nonunion | Colorado | Small | 40 |
| 20 | Nonunion | North Carolina | Large | 193 |
| 21 | Nonunion | Louisiana | Large | 54 |
| 22 | Nonunion | Texas | Small | 66 |
| 23 | Nonunion | Texas | Large | 36 |
| 24 | Nonunion | North Carolina | Small | 45 |
| 25 | Nonunion | South Carolina | Small | 110 |
| 26 | Union | Florida | Small | 15 |
| 27 | Nonunion | Florida | Large | 324 |
| 28 | Union | Illinois | Small | 5 |

[a]A large project was classified with a budget more than $50 million and a small project with less than $50 million.

## Data Analysis

Two scales were used to rank and analyze the factors in the survey. For the frequency factors, the scale was determined by mean values with respect to their frequency and impact according to Eq. (1). The severity score is equal to the severity index divided by 49, the maximum value of the severity index, and multiplied by 100

$$\text{severity index}_{\text{frequency}} = \frac{\Sigma F_i \times I_i}{N} \quad (1)$$

where $F_i$=frequency given to a factor by respondent $i$ and ranges from 1 to 7; $I_i$=impact given to a factor by respondent $i$ and ranges from 1 to 7; and $N$=total number of respondents for a question.

The agreement factors were ranked on a scale based on the weighted percentage of negative impact and the weighted percentage of agreement or disagreement, depending on whether the

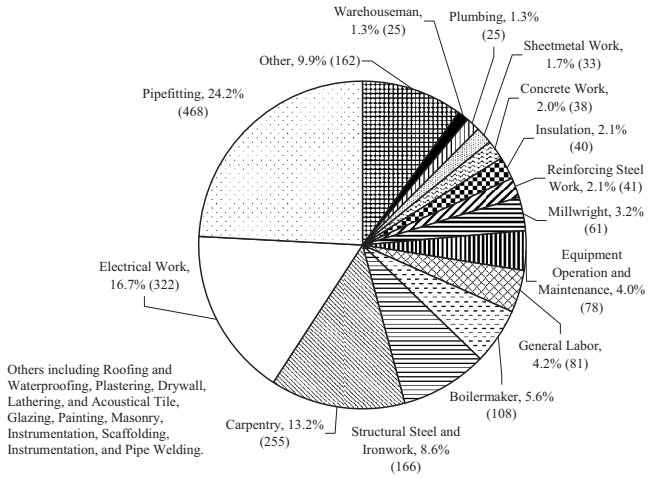


**Fig. 2.** Distribution of surveyed trades [CII (2006b), Reprinted with Permission]

factor was stated as a positive or negative issue. The weighted percentage of disagreement ($R$) for a positive stated issue was calculated using the following formula with a maximum of 50 if all respondents strongly disagreed with a statement:

$$R = (A \times 1 + B \times 2 + C \times 3)/6 \quad (2)$$

where $A$=percentage of respondents rating the positive issue as 3 (mildly disagree); $B$=percentage of respondents rating the positive issue as 2 (between mildly disagree and strong disagree); and $C$=percentage of respondents rating the positive issue as 1 (strongly disagree).

The weighted percentage of impact ($I$) was calculated using the following formula with a maximum of 50 if all respondents rated the issue as having a very negative impact on productivity:

$$\mathrm{I} = (X \times 1 + Y \times 2 + Z \times 3)/6 \quad (3)$$

where $X$=percentage of respondents rating the impact of the issue as 3 (small negative impact); $Y$=percentage of respondents rating the impact of the issue as 2 (between small negative and very negative impact); and $Z$=percentage of respondents rating the impact of the issue as 1 (very negative impact).

Finally, the severity index for the agreement factors was calculated by Eq. (4). The severity score is equal to the severity index divided by 2,500, which is the theoretical maximum value of the severity index, and multiplied by 100

$$\text{severity index}_{\text{agreement}} = R \times I \quad (4)$$

The factors were compared on the basis of the craft workers' perception of project productivity performance. This analysis allowed the writers to identify the factors that had the greatest impact on the surveyed projects perceived to have less than good productivity versus those projects perceived to have good or better productivity. Further analysis was performed to examine the difference in perception between union and nonunion respondents, and the difference between the survey's four major trades: pipe fitters, electricians, carpenters, and ironworkers.

## Findings and Application

### *Overall Most Significant Factors*

Regardless of a project's productivity or different project characteristics, the research measured the relative impact of all 83 factors on construction productivity. The severity score of each factor was normalized on a scale of 0 to 100, with the scale increasing with greater severity, which facilitates comparisons across the two scales. Next, the factors were grouped by category as defined by the focus group sessions (Table 1). The average normalized score for each of the 11 categories are shown in Table 4. The writers did not assign weights to individual factors when calculating the severity scores for each category as reported in this paper. Using factor analysis, the writers have examined the latent structure of the 83 factors and how the latent factors are weighted when regressed against project productivity, but this is reported elsewhere (Dai 2006) due to page limitations within this paper.

All of the tangible categories, tools and consumables, materials, engineering drawing management, and construction equipment, were rated as having a greater impact on productivity compared to the other seven categories. This indicates that construction labor productivity improvement is possible through jobsite efforts. The listing of the top 10 specific factors provided deeper insight into the factors affecting construction labor productivity as shown in Table 5.

**Table 4.** Normalized Severity Scores for Productivity Categories [Reprinted with Permission, CII (2006b)]

| Category | Average normalized severity score |
|---|---|
| Tools and consumables | 69.0 |
| Materials | 57.1 |
| Engineering drawing management | 53.8 |
| Construction equipment | 50.5 |
| Supervisor direction | 30.5 |
| Safety | 23.8 |
| Communication | 21.3 |
| Project management | 21.0 |
| Labor | 14.4 |
| Foremen | 8.7 |
| Superintendents | 5.3 |

It is noted that seven of the top ten factors involved equipment, tools and consumables, and materials. In addition, another two involved engineering drawing management. Among the significant factors, slow response to questions with drawings and inadequate instruction provided by supervisors led to the unavailability of necessary data for craft workers. This finding coincides with a recent study that found construction workers typically only have 70% of the necessary data on-site, and only 30% of the data is available at the location of the work (Tulacz 2005). Obviously, these factors are manageable on the jobsite during construction phase, except for drawing errors. The impact of drawing errors can be mitigated to some extent through the efforts of jobsite management teams.

Many of the participating projects experienced problems with equipment availability. For example, one craft worker explained,

**Table 5.** Top 10 Most Significant Productivity Factors

| Issue | Normalized severity score |
|---|---|
| I have to wait for people and/or equipment to move the material I need. | 100.0 |
| There are errors in the drawings that I use. | 91.7 |
| When there is a question or problem with a drawing, the engineers are slow to address the issue. | 89.9 |
| If I need a manlift to do my job, there are not any available. | 84.3 |
| When I need a crane or forklift to help me, there are not any available. | 83.6 |
| I can't get the consumables I need to do my job. | 82.2 |
| I have to search in a lot of places to find the tools I need to do my job. | 78.4 |
| When I go to install prefabricated items, work has to be done on them to fix quality problems. | 75.2 |
| I can not get the power tools from the contractor that I need to do my job. | 74.7 |
| My supervisor does not provide me with enough information to do my job. | 72.0 |



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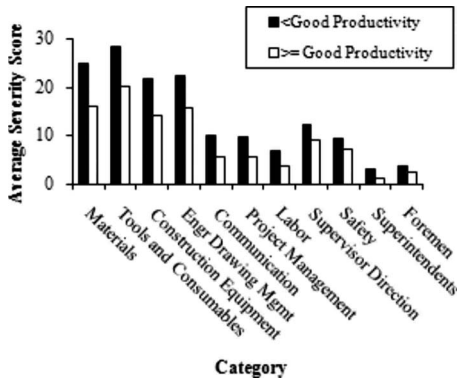


**Fig. 3.** Severity scores of productivity categories based on craft workers' perception of productivity

> Say you've got one forklift on the job, you've got some material to be moved, but he's (the operator) got three trucks to unload; well that takes priority and you've got to sit there and wait.

Many craft workers from the investigated projects referred to engineering-related issues. The following scenario describing engineering issues exemplified what happened on some of the investigated projects:

> The engineer would produce drawings that don't work for anything an electrician uses to support a system. Sometimes they'd just leave things out.

As evidenced by the data, the factors within the control of the jobsite management team are viewed by craft workers as the major sources of impact on daily productivity. Unfortunately, these significant factors were always at the top of the list from project to project, which could significantly demotivate craft workers. A craft worker from one participating project expressed his frustration in the following account:

> In general, there's a lack of planning. It seems there is a lack of coordination amongst the [management] ranks. As a craft worker, that's all we really can do is plan our day. And the people above us have to plan the rest of the work. Getting material, keeping the tools out here, keeping what we need out ahead of us. Planning leads to productivity.

### *Most Significant Factors Based on Workers' Perception of Productivity Performance*

The research further examined the difference in the severity score for each factor between craft workers who rated their project's productivity as good or better and craft workers who rated their project's productivity as less than good. Fig. 3 ranks the difference of the category severity scores between craft workers who rated their project's productivity as less than good and other craft workers who rated their project's productivity as good or better. The category severity scores provide a macroview of the difference in the factors affecting craft workers' productivity between the two groups. However, each category consists of different numbers of frequency factors and agreement factors, and the severity scores of the frequency and agreement factors are calculated through two different approaches as discussed earlier. Therefore, statistical analysis was only conducted to examine the difference in the individual factors between the groups. Table 6 identifies the top specific factors with the greatest difference between these two scenarios.

The category with the greatest difference was materials, followed closely by tools and consumables and construction equipment. Regarding materials, a surprising issue to the writers was the frequency of the poor quality with prefabricated items. One worker from a sampled project explained this in the following account:

> Most everything these days comes in prefabricated so you don't technically need a pipefitter, but only in a dream world does prefab pipe fit the first time you go to install it.

Overall, craft workers who rated project productivity as good or better tended to rate the factors with a lower severity score compared to craft workers who rated their project productivity as less than good. Due to space limitations within this paper, Table 6 only lists the factors with the difference of the severity score greater than 6.0, and it includes the before-mentioned problems with prefabricated components. It should be noted that while Table 6 lists the severity scores for individual factors, the study measured the statistical significance for each factor based on their respective seven-point impact scale. Since the severity scores for the agreement factors are based on weighted percentages of all responses, it was not possible to use the severity score to measure the agreement factors' statistical differences. For the frequency factors, a higher impact number indicates that the factor had a greater negative impact on their productivity. Meanwhile for the agreement factors, a lower impact number indicates that the factor had a greater negative impact on their productivity.

Reflecting the differences among categories (Fig. 3), many of the specific factors in Table 6 involved the availability of equipment, materials, and tools and consumables. Fortunately, many of the factors are relatively easy to address on a project and can even be improved through policy changes. For example, one craft worker provided an example of how a restrictive project policy on consumables hurts their productivity: "Workers knew that they would need three drill bits to drill one hole in some steel but every time they went to the tool room, they'd only be issued one bit at a time." On the contrary, it is surprising that payment or monetary issues ranked relatively low in terms of both the severity score and the difference of severity score based on craft workers' perception of project productivity. Although there was a significant difference regarding the payment in terms of the severity score based on the craft workers' perception of project productivity (it is listed last on Table 6), there are many other issues that had a greater substantial and statistical relation with craft workers' productivity perception.

### *Union versus Nonunion Work Force*

Another analysis was conducted to examine the difference among union and nonunion respondents (Fig. 4). It is intriguing to note that the perceptions of union and nonunion respondents followed the same pattern. Tangible categories (e.g., tools and consumables, and materials) ranked higher than nontangible categories (e.g., communication and superintendents). This reinforces the previous conclusion that the factors affecting craft workers' productivity are manageable from the perspective of both union and nonunion respondents. To examine the primary difference by union status, the writers examined the difference in severity

**Table 6.** Comparison of Severity Scores of Productivity Factors Based on Craft Workers' Perception of Productivity

| Description[a] | Severity score—craft workers' productivity perception[b] | | Severity score difference | Impact scale—craft workers' productivity perception | | $F$-value[c] |
|---|---|---|---|---|---|---|
| | <Good | >=Good | | <Good | >=Good | |
| **I have to wait for people and/or equipment to move the material I need.** | 43.5 | 27.8 | 15.7 | 4.36 (604) | 3.43 (987) | 98.83[d] |
| **When there is a question or problem with a drawing, the engineers are slow to address the issue.** | 39.0 | 25.2 | 13.8 | 4.07 (578) | 3.22 (965) | 66.81[d] |
| **If I need a manlift to do my job, there are not any available.** | 36.9 | 23.4 | 13.5 | 4.03 (593) | 3.15 (983) | 78.29[d] |
| There is a lack of communication between the management personnel on this project. | 18.2 | 6.0 | 12.2 | 3.10 (622) | 3.96 (1,018) | 85.87[d] |
| **I have to search in a lot of places to find the tools I need to do my job.** | 33.7 | 22.2 | 11.5 | 3.72 (604) | 2.98 (993) | 54.28[d] |
| **When I need a crane or forklift to help me, there are not any available.** | 35.3 | 23.9 | 11.4 | 4.00 (604) | 3.25 (988) | 64.34[d] |
| **I've been assigned to do work before prerequisite work has been done.** | 26.8 | 15.8 | 11.0 | 3.34 (580) | 2.54 (979) | 77.49[d] |
| **Project policy prevents me from getting the amount of consumables I need at one time to do my job efficiently.** | 30.7 | 20.1 | 10.7 | 3.58 (600) | 2.88 (989) | 50.33[d] |
| **When I need bulk commodities (such as bolts and fasteners, emery cloth, or stock lumber), I can not find them.** | 29.6 | 19.1 | 10.4 | 3.51 (598) | 2.80 (987) | 55.89[d] |
| **I can't find the materials I need to do my job.** | 30.3 | 20.3 | 10.0 | 3.65 (599) | 2.93 (996) | 62.33[d] |
| **If I have a problem or a question, it is difficult to get in touch with my supervisor because our work area is so large.** | 25.1 | 15.3 | 9.76 | 3.21 (607) | 2.54 (1,002) | 50.89[d] |
| **I can't get the power tools from the contractor that I need to do my job.** | 31.3 | 21.6 | 9.75 | 3.61 (602) | 3.01 (987) | 35.24[d] |
| **Power tools that I use on this job break down after little use because the company buys cheap, off-brand tools.** | 28.6 | 18.9 | 9.65 | 3.37 (604) | 2.74 (986) | 38.99[d] |
| **When I go to install prefabricated items, work has to be done on them to fix quality problems.** | 31.3 | 21.9 | 9.38 | 3.63 (594) | 2.97 (986) | 49.58[d] |
| **There are errors in the drawings that I use.** | 36.8 | 27.5 | 9.27 | 4.04 (586) | 3.38 (977) | 44.54[d] |
| **I can't get the hand tools from the contractor that I need to do my job.** | 29.3 | 20.2 | 9.11 | 3.51 (602) | 2.91 (991) | 36.88[d] |
| **When I do find the materials that I need, there are quality problems with it.** | 24.2 | 15.7 | 8.52 | 3.18 (600) | 2.55 (995) | 50.62[d] |
| On this project, craft workers do not trust the supervisors. | 11.7 | 3.6 | 8.07 | 3.45 (619) | 4.28 (1,028) | 80.02[d] |
| **The drawings that I need to do my job are not available.** | 27.6 | 19.9 | 7.78 | 3.44 (586) | 2.92 (972) | 27.93[d] |
| There is a lot of travel on this job because material is not stored close enough to the work area. | 12.7 | 5.6 | 7.15 | 3.28 (611) | 3.90 (1,023) | 52.21[d] |
| **I have been delayed in my work because I have to wait for work permits (hot work permits, confined space permits, etc.)** | 26.6 | 20.4 | 6.19 | 3.31 (589) | 2.87 (980) | 21.44[d] |
| The pay on this project is equal to what is paid in the area. | 14.9 | 8.9 | 6.01 | 3.61 (625) | 4.03 (1,033) | 14.07[d] |

[a]Frequency factors are shown in bold.

[b]The numbers out of the parentheses and in the parentheses refer to the severity score and the sample size, respectively.

[c]$F$-value is computed based on the impact scale for each factor.

[d]Indicates the difference between the two groups is significant at the 99% confidence level.



scores for specific factors, while using the factors' impact scales in order to make statistical inferences between these two populations.

Table 7 lists the top 10 factors based on the perception difference between union and nonunion respondents. The factor with the biggest difference in the severity score between union and nonunion respondents is about their wages. Among the nonunion respondents, 33.3% strongly disagreed with the statement that the pay on their project was comparable to what was paid in their geographic area; a total of 55.5% disagreed, and only 31.1% agreed. Conversely, a total of 57.0% of the union respondents agreed to some extent, and only 27.0% disagreed. The lack of monetary bonuses for good performance is another factor that nonunion respondents rated significantly higher than union respondents. Furthermore, nonunion respondents experienced more communication problems due to the differences in languages spoken on the jobsite than union respondents. One reason could be that a majority of the nonunion projects were located in the southern United States, which has a larger population of Hispanic craft workers than in other regions of the United States. On the other

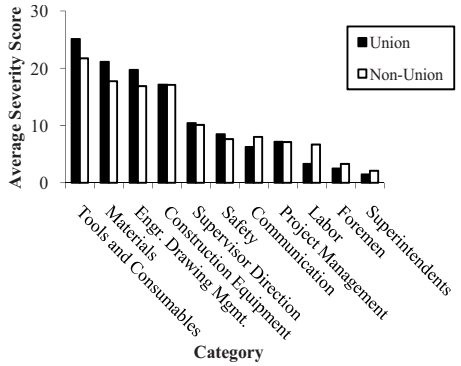


**Fig. 4.** Severity scores of productivity categories by union status

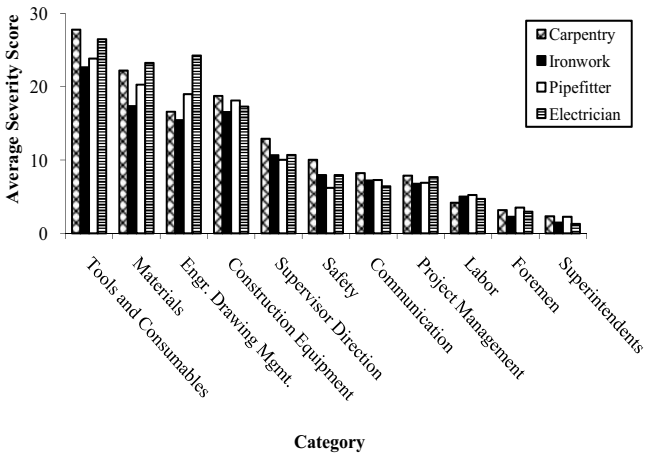


**Fig. 5.** Severity scores of productivity categories by trades

hand, union respondents rate tool and material issues significantly more severe than nonunion respondents. In particular, union respondents reported greater severity with tool room and warehouse attendants not understanding what was needed when asked by the craft workers. During the focus groups, it was reported that senior craft workers were commonly used to staff tool rooms when many first entered the industry. This allowed senior craft workers to share their knowledge, and if necessary, to train younger craft workers in the proper use of hand tools. According to the focus group participants, entry level workers now commonly staff the tool rooms, which craft workers indicate is a function of projects outsourcing the tool room and supply function to commercial suppliers as well as labor cost saving efforts.

### *Difference between Trades*

The analysis revealed the differences between the survey's four major crafts: pipefitting, electrical work, carpentry, and ironworking. Fig. 5 shows the breakdown of the category severity score for the four major crafts surveyed. Overall, the four trades follow the same pattern, and tangible categories tended to be perceived as more severe than nontangible factors. The average severity score for each category varies by trades. The differences in category severity score between the four major trades are mixed. Although the review of the category scores is intriguing, the writers once again examined the differences among individual factors to ascertain statistical differences, based on the factors' impact scales.

Table 8 presents the top three factors based on severity score for carpentry, ironwork, pipefitting, and electrical crafts. The top three factors ranked by the carpentry and ironwork trades were the same: (1) waiting for people or equipment to move material; (2) availability of consumables; and (3) availability of crane or forklift. The pipefitters and electricians rated engineering drawing management factors relatively higher. The pipefitters rated wait-

**Table 7.** Comparison of Severity Scores of Productivity Factors by Union Status

| Description[a] | Severity score[b] | | Severity score difference | Impact scale | | $F$-value[c] |
|---|---|---|---|---|---|---|
| | Union | Nonunion | | Union | Nonunion | |
| The pay on this project is equal to what is paid in the area. | 4.4 | 20.0 | 15.6 | 4.53 (792) | 3.26 (853) | 151.39[d] |
| **Tool room or warehouse attendants don't understand what I need when I ask for it.** | 22.2 | 13.7 | 8.5 | 2.88 (754) | 2.28 (811) | 42.04[d] |
| **When there is a question or problem with a drawing, the engineers are slow to address the issue.** | 34.7 | 26.6 | 8.1 | 3.85 (738) | 3.27 (792) | 32.16[d] |
| Project management pays monetary bonuses for good performance. | 15.6 | 22.6 | 7.0 | 3.21 (744) | 2.98 (837) | 6.60[d] |
| **I have trouble communicating with other workers because we don't speak the same language.** | 14.9 | 21.8 | 7.0 | 2.47 (765) | 2.90 (823) | 17.73[d] |
| **I have to search in a lot of places to find the tools I need to do my job.** | 30.1 | 23.4 | 6.7 | 3.51 (764) | 3.03 (819) | 23.91[d] |
| **When I go to install prefabricated items, work has to be done on them to fix quality problems.** | 28.8 | 22.5 | 6.3 | 3.47 (753) | 3.00 (815) | 25.96[d] |
| **When I need bulk commodities (such as bolts and fasteners, emery cloth, or stock lumber), I can't find them.** | 25.6 | 20.9 | 4.7 | 3.28 (757) | 2.87 (815) | 19.04[d] |
| **On the job, I can't find any place to plug in power tools.** | 24.4 | 20.3 | 4.0 | 3.21 (761) | 2.84 (807) | 15.79[d] |
| Craftsmen have no incentive on this project to seek additional training or certifications. | 5.6 | 9.6 | 4.0 | 4.01 (779) | 3.74 (855) | 9.08[d] |

[a]Frequency factors are shown in bold.

[b]The number in the parentheses refers to the sample size.

[c]$F$-value is computed based on the impact scale for each factor.

[d]Indicates the difference between the two groups is significant at the 99% confidence level.

**Table 8.** Comparison of Severity Scores of Productivity Factors by Trades

| Description[a] | Severity scores[c] | | | | $F$-value[b] | Observed significance level |
|---|---|---|---|---|---|---|
| | Carpentry | Ironwork | Pipefitter | Electrician | | |
| **I have to wait for people and/or equipment to move the material I need.** | 39.2 (201) [4.13] | 31.9 (132) [3.69] | 35.7 (402) [3.88] | 32.2 (268) [3.76] | 2.09 | 0.10 |
| **I can't get the consumables I need to do my job.** | 35.0 (203) [3.96] | 29.1 (123) [3.69] | 26.8 (404) [3.39] | 31.1 (271) [3.77] | 5.12 | 0.00 |
| **When I need a crane or forklift to help me, there aren't any available.** | 33.5 (200) [3.87] | 26.7 (128) [3.42] | 31.3 (407) [3.76] | 27.4 (266) [3.54] | 2.40 | 0.07 |
| **When there is a question or problem with a drawing, the engineers are slow to address the issue.** | 28.6 (198) [3.36] | 26.3 (130) [3.36] | 34.2 (400) [3.85] | 37.9 (268) [4.09] | 7.31 | 0.00 |
| **There are errors in the drawings that I use.** | 26.1 (204) [3.30] | 26.7 (129) [3.44] | 32.4 (403) [3.79] | 43.9 (268) [4.39] | 16.37 | 0.00 |
| **I have to search in a lot of places to find the tools I need to do my job.** | 29.3 (202) [3.49] | 24.4 (128) [3.28] | 29.5 (406) [3.41] | 33.0 (273) [3.81] | 2.97 | 0.03 |

Note: Shading highlights the three most severe factors for each trade respectively.

[a]Frequency factors are shown in bold.

[b]$F$-value is computed based on the impact scale for each factor.

[c]The number in the parentheses refers to the sample size and the trade's corresponding impact scale is shown in brackets.

ing for people or equipment to move material and engineers' slow response to questions with drawings and drawing errors as the most significant factors. The electricians' top three factors were: (1) drawing error; (2) engineers' slow response to questions with drawings; and (3) misplaced tools. As shown in Table 8, the differences between the four trades' perceptions on the impact of waiting for people and/or equipment to move the material, and availability of a crane or forklift were not significant at the 95% confidence level. Conversely, the differences among the four trades' perception on the impact of consumable availability, engineers' slow response to questions with drawings, drawing errors and misplaced tools was significant at the 99% confidence level. The notable differences regarding the impact of engineering drawing management on the electrical and pipefitting craft workers compared to craft workers in the carpentry and ironwork trades is most likely indicative of the variation in skill level among these four trade groups.

Overall, the analyses by trades indicate that there are factors that have a significant impact across all trades. However, site management should be aware that significant differences do exist among trades when specific factors are considered.

## Conclusion

For too long, the craft worker's perception regarding construction productivity has been generally ignored by researchers and many site management teams. One pipefitter involved in the research efforts said: "I have been a fitter for 30 years, and no one has ever taken the time to administrate a survey like this or asked me questions like this." The nearly 2,000 craft workers who participated in this study proved not only that their insights and suggestions are invaluable but that craft workers on the whole are eager to participate. Engaging the work force and measuring their perceptions of productivity, identifying the overarching factors and addressing the most significant factors, may not only lead to improvement in motivation and overall project performance, but may also help attract or retain more craft workers in the construction industry.

Certainly, one of the primary challenges facing the construction industry is the shortage of skilled craft workers (Tulacz 2005). Attention has been focused on the need to increase construction real wages to help resolve the shortage (Allmon et al. 2000). While wage is important to craft satisfaction, this research identified that there are a great deal of other issues that will increase craft satisfaction by allowing them to be more productive and also help motivate them to stay in the construction industry throughout their career. From the craft workers' perspective, the major categories of productivity factors involved tools and consumables, material, engineering drawing management, and construction equipment. The most significant factors affecting craft workers' daily productivity were manageable on the jobsite during construction, except for drawing errors. Therefore, daily actions taken at the jobsite can make a significant difference on a project's productivity.

Moreover, compared to craft workers who rated their project productivity as good or better, craft workers who perceived project productivity as less than good tended to report more problems with material, tools and consumables, and construction equipment. It was also found that respondents who considered project productivity performance less than good rated the lack of communication among site management and out-of-sequence work assignments substantially more severe than the respondents rating their project's productivity performance good or better.

The study finds that, in general, union and nonunion craft workers perceive that the tangible factors had a greater impact on their productivity compared to nontangible factors. In regard to tangible factors, union respondents reported higher severity scores than nonunion respondents. In contrast, nonunion respondents rated intangible categories including communication, labor, foremen, and superintendents as having relatively higher impacts than union counterparts.

This paper also reveals the category impact on productivity varies by trades, and the differences in category severity score are mixed. Therefore, the mix of the trades should be considered when soliciting the input from craft workers.

Although this research focused upon industrial construction projects, its methodology can be transferred to other construction markets. Researchers could follow the same methodology as discussed in this paper to engage craft workers in a productivity improvement program.



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