Analysis and assessment of Factors Affecting Labor Efficiency in Construction

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ABSTRACT
Labor efficiency is one of the least studied areas within the construction industry. Efficiency improvements achieve high cost savings with minimal investment. Due to the fact that profit margins are small on construction projects, cost savings associated with productivity are crucial to becoming a successful contractor. The chief setback to improving labor productivity is measuring labor productivity. The main objective of this study is to assign a weight of importance to each of the top twelve factors affecting efficiency. A list of the top twelve factors affecting efficiency is compiled. A survey consisting of the ten factors and a brief explanation of each was sent to contractors in Central Maharashtra region of India which consist of industries and has boom in construction. Which they were asked to apply a weight to each of the twelve factors, totaling 100%. Results of this survey were then analyzed using the Delphi Method. These weights will be used in a future study to create a tool to help contractor’s grade productivity on their projects in the preplanning stage and plan improvements in the most beneficial areas. This productivity tool will be created by breaking each factor down into a list of activities. The project manager will assign a value to each activity representing how well their current project is achieving this activity. The total for each factor is then multiplied by its respective weight (generated in this study). The outcome of the tool will give a breakdown of areas for improvement along with values that allow for project managers to focus on the most beneficial areas.

Keywords
Activities, Efficiency measurement, labor efficiency

1. INTRODUCTION
Many definitions of the word “productivity” exist. For the basis of this study the Merriam-Webster definition will be used. Merriam-Webster defines productivity as the quality or state of being productive. Labor productivity is typically measured as output per worker or output per labor-hour. Although there are endless definitions for productivity, they all refer to productivity as a comparison of input versus output. Productivity = Output/ Input. Increased productivity occurs when either

1. Output is constant, while input is reduced, and/or

2. Input is constant, while either the quantity or quality of output has been increased or enhanced.

Construction is one of the nation’s largest industries. Construction accounted for 19% of the nation’s GDP in 2011-12 (Trading economics 2012). In 2016, the construction industry provided employment to more than 40 million people. A successful construction project is one that is completed on time, within budget, meets specified standards of quality, and strictly conforms to safety policies and precautions. All of this is feasible only if the premeditated levels of productivity can be achieved. All the same, productivity, or lack thereof, is one of the construction industry’s most prevalent problems. Due to the nature of construction projects, its importance to society and the existing economic resources, more emphasis should be given to improving productivity. In the end, this study will provide a weight of importance for each of the most common factors affecting productivity. These weights will then be used by a group of experts to compose a questionnaire that will provide construction managers and decision makers with a productivity tool that will enhance project productivity. Unlike other currently existing productivity tools, this tool can be used in the planning stage and serve as a checklist to guarantee a more productive completion of projects. Keep in mind this is not intended to serve as a remedy for all problems that occur on construction projects, but as one of the necessary tools for success.

The major intentions of this study are as follows:

• To assemble a list of the most notable factors affecting productivity within the construction industry today.

• To develop a weight for each individual factor based on the Delphi Method, with a total weight of 100 %.

• To create an example tool in which the weights derived will be used to help project managers and top decision makers assess the current productivity issues on their projects from the pre-planning stage through the project’s completion

2. METHODOLOGY
To identify the main factors associated with lost productivity on construction projects we should be aware of the problems associated with each factor and the problems must be completely understood. The top factors were identified by experts within the construction and human factors field of study. Each of these factors will be thoroughly defined ahead.
The next objective is to acquire a weight of importance for each of these factors. In order to ensure that the weights are not discussed between respondents, a survey is distributed to 25 contractors, in which they are asked to assign a weight to each of the factors. Once these weights are established, a future study will further break down each factor into its components. These components will enable the project managers to give themselves a score from 1 to 10 for each of the components within each factor. The final score can then be evaluated to serve as a checklist to ensure increased productivity all the way up to the completion of the project.

The main objectives of this study are as follows:

1. To expand upon the main factors affecting labor productivity
   a) Definition of the factor
   b) Common problems associated with each factor.

2. To allocate a weight to each factor based on its importance
   c) Each weight will be derived by surveys distributed to experts
   d) The Delphi Method will then be used to compile the survey responses.

3. To compose a sample productivity checklist to serve as an example of how the weights will be used in the future.

3. BACKGROUND

Construction requires extensive manual labor. Human performance and productivity are reliant on one another. Therefore, the most commonly used measure of productivity is the constant contract dollars of new construction work per work hour (Hendrickson 1998). A study by Teicholtz (2004) revealed that over 40 years (1964-2003) the construction industry lags compared to all other non-farm industries in developing and applying labor saving techniques and substituting equipment for labor. Figure 1 depicts construction labor productivity changes as opposed to all non-farm industries from 1964-2003.

Hendrickson (1998) addressed the time utilization of the average construction worker. Only 40% of a workers time is considered to be productive, with 55% unproductive time, and 5% personal time. Figure 2 shows a breakdown of the average workers time utilization.

Fig. 1 Labor productivity index for Indian construction industry and all non-farm industries from 1964 through 2015 (Bureau of Labor Statistics 2016).

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Fig. 2 Time utilization of worker productivity in the India.

Second approach is task productivity, which is calculated using labor man-hours as input and production units as output (Haskell 2004).

The first approach, the output based approach shows a comparison of the unit costs of buildings constructed in 1966 in dollars per square foot, compared to buildings built in 2003.

Using a factor of 5.68, the 2003 costs are then deflated back to 1966 costs. The outcome of this data shows a 12.34% decrease in costs per square foot. The outcome is further adjusted for qualitative changes in order to be able to make a qualitative comparison. Finally after applying a formula involving the qualitative productivity increase and the quantitative productivity increase, total productivity is found to have increased by 33.2%. The second approach, the input based approach studies two effects. The first one is the effect of observable increases in labor productivity, offset by increases in capital costs (Haskell 2004).

The second effect is the documented decrease in materials costs (Haskell, 2004). The result of this research, 32.4% falls very close to the result of the output based result of 33.2%.

The conclusions of this research is that the similarity of the outcomes based on two different approaches, input and output, prove that productivity within the construction industry have in fact increased over the last 37 years by about 33% (Haskell 2004).

Another recent study by Teicholtz (2004), mentioned earlier measured productivity within the construction industry over a 40-year period ranging from 1964 to 2003. This study measured productivity as constant contract dollars of new construction work per work hour (Teicholtz 2004).
results are the opposite of that cited by Haskell. Teicholtz finds that productivity has been decreasing over the last forty years at a rate of about 0.59 % per year.

3.1. Teicholtz summarizes this stating

The construction industry suffers from structural productivity problems that will not be rapidly cured. The slow erosion of labor productivity, the aging of the construction work force, the slow rate of change in field practice and the current lack of student preference for civil engineering education are serious indications that new approaches are needed to revitalize and bring fresh ideas into this industry (Teicholtz 2004).

By comparing these two studies, it is apparent that measuring productivity and deriving a pattern is dependent on the method of data collection and measurement. Different researchers will inevitably come up with different outcomes until a standard measure of productivity is derived or if a preplanning tool is created to guarantee significant increases in productivity early on in the project.

A study very similar to our study was conducted in Canada known as the “Productivity Improvements on Alberta Major Construction Projects.” Within this, a study conducted in the United Kingdom was cited. The workers were asked to rank a general list of common problems on their construction site and in addition they were asked to estimate the respective lost time per problem area (McTague 2002). The four tables included in Figure 2-3 illustrate the problems and their respective time loss.

Order of Factors Influencing Productivity

<table>
<thead>
<tr>
<th>Factor Overall Order</th>
<th>Factor Estimated Time Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Lack of Materials</td>
<td>1 Unsuitable Instructions</td>
</tr>
<tr>
<td>2 Crew Interference</td>
<td>2 Unclear Instructions</td>
</tr>
<tr>
<td>3 Repeat Work</td>
<td>3 Complex Specification</td>
</tr>
<tr>
<td>4 Supervision</td>
<td>4 Poor Workmanship</td>
</tr>
</tbody>
</table>

Estimated Time Loss per Problem in a 40-Hour Week

<table>
<thead>
<tr>
<th>Factor Estimated Time Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Lack of Materials</td>
</tr>
<tr>
<td>2 Crew Interference</td>
</tr>
<tr>
<td>2.5 Repeat Work</td>
</tr>
<tr>
<td>2 Supervision</td>
</tr>
<tr>
<td>2 Lack of Equipment, Tools</td>
</tr>
<tr>
<td>0.5 Absenteeism</td>
</tr>
</tbody>
</table>

Order of Causes of Lack of Materials

<table>
<thead>
<tr>
<th>Factor Overall Order</th>
<th>Factor Estimated Time Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Lack of Planning</td>
<td>1 Unsuitable Instructions</td>
</tr>
<tr>
<td>2 Transports within Site</td>
<td>2 Unclear Instructions</td>
</tr>
<tr>
<td>3 Improper Materials</td>
<td>3 Complex Specification</td>
</tr>
<tr>
<td>4 Interference</td>
<td>4 Poor Workmanship</td>
</tr>
<tr>
<td>5 Unnecessary Paperwork</td>
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</tbody>
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4. ANALYSIS

A survey was administered to the 25 Contracting Companies in Central Maharashtra. The goal was to identify and assign a weight to the top 10 factors affecting labor productivity in the construction industry. Each factor is defined and the potential problems within each factor are identified and explained within the literature review section of this study. The study was based upon the following 12 major productivity factors:

1. Tool Management
2. Inventory Management
3. Access Planning
4. Management Skills
5. Safety issues
6. Quality assurance
7. Planning of activities
8. Training of Labours
9. Age Factor
10. Temperature on site

The survey was distributed to the 25 contracting firms in Central Maharashtra. The survey gives a brief description of each factor and the contractor is asked assign a weight to each of the factors based on his or her knowledge and past experience in the construction industry. A complete copy of the survey can be found in Appendix A. The following are the descriptions as they appear in the survey:

1. Management of Construction Tools: In order to maintain large amounts of tools, tool rooms should be used to store non-permanently used tools. Periodic reports should be performed by tool room supervisors. Tool kits should be issued on the basis of trade and each person should be held accountable. A record should be kept of all tool kit assignments, as well as tools not included in the kits. Periodic site inventories are necessary to control loss, theft, and breakage. Some common problems associated with tool management include lack of tool availability, lack of the proper tools, poor tool maintenance, etc.

2. Managing Construction Equipment: Productivity of construction equipment is directly linked to how the equipment is used and how the crews and operators are assigned. Advanced planning is necessary to establish the length of time the equipment will be utilized. Strong efforts should be made to keep the same crew and operator on the same piece of equipment as much as possible. Some common equipment management problems include lack of equipment usage reports, lack of equipment safety checklists, and lack of proper scheduling of equipment.
3. Access: Site drawings should be available indicating where dense areas of labor are working and indicating their route to and from the site. Alternate plans to cut roads should only be made when other acceptable routes are ready. A common problem on construction sites is poor or disrupted access caused by holes and barricades and time spent finding alternate routes.

4. Management Skills: Management often times obscures progress on a project. Good management is required for profitability and success.

5. Safety Management: Everyone involved with a project should be concerned with the level of safety that is maintained. At a minimum, the level of safety on a project must comply with legislated criteria. Some common safety problems include lack of safety in the design, lack of safety training, lack of management support, lack of preventative maintenance on tools and equipment, etc.

6. Quality: Traditionally, generic quality tolerances are used on most projects. Therefore, experienced operators should be periodically reviewing quality on the project and interpreting the quality expectations on the project. Lack of quality control leads to increased costs associated with rework.

7. Schedule Management: Project schedules should establish guidelines as to when and how the project should be executed. Schedule requirements need to be communicated and properly managed throughout the entire project. Some common scheduling problems include outdated schedules, lack of schedule communication, lack of detail, trade stacking, etc.

8. Employee Training/Skills: Overall, there is a lack of formal training in the construction industry. High employee turnover rates deter investments in employee training. Lack of training causes delays due to rework and overall capability levels among workers.

9. Employee Age: Some studies have claimed that the working age is beginning to decline and impacts are becoming evident within the labor market. As the working age diminishes, new young laborers could become harder to come by.

10. Temperature/Humidity: High temperatures and humidity tend to slow down worker productivity. Jobsites should have appropriate rain gear and inclement weather planning.

5. CONCLUSION

The main factors were identified and defined. Each factor was then expanded upon within the literature review. The second objective of the study called for a list of weights for each of the 12 factors. The list and the factors are as follows:

1. Tool Management 6.43%
2. Equipment Management 8.87%
3. Access Planning 4.65%
4. Management Skills 18.39%
5. Safety issues 12.35%
6. Quality Control 8.78%
7. Scheduling 14.22%
8. Employee Training/ Skills 16%
9. Employee Age 5.61%
10. Temperature/ Humidity 4.70%

The third and final objective relates to the future applications of these percentages. In appendix, a worksheet and summary sheet have been created to serve as an example of how these weights can be applied in the future. In a completed set of worksheets, each of the 12 factors would consist of one work sheet. Each worksheet would contain a list of activities that are involved in obtaining 100% satisfaction within this factor. The contractor is asked to assign a value from 1 to 10 indicating how well they are achieving each particular activity on their current project. The values for all of the activities for each individual factor are summed and then transferred to the evaluation sheet at the end of the workbook. The total value for each factor is then multiplied by the factor’s respective weight. The results can then be used to make very specific plan for improving productivity early on in the project.

REFERENCES


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