

# **Assessing Labor Productivity**

**By**

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## **Abstract**

The analysis of the labor productivity of the workforce and the utilization of material and equipment are major factors in determining whether a construction project will be completed on time and within budget. Concerning the project budget, every construction project should have a budget established prior to the commencement of work. The contractor's goal should be to complete the project within the time frame and at the costs established in the budget. After construction has begun, an analysis of the project costs for materials, equipment, and labor should be performed on a periodic basis. Evaluating the material and equipment usage is relatively straightforward; however, there are multiple components within the construction process affecting labor productivity that must be considered when performing a labor productivity analysis. This paper describes many of these components and their effect on labor productivity. Regardless of whether the contractor is tracking the budget for the project, a labor productivity analysis must be performed. Also discussed are the many recommended methods for estimating lost productivity as well as the various methodologies that can be used to develop an analysis.

## **Introduction**

For a contractor to be successful on a project, everything needs to go well. The contract drawings need to be well prepared; changes need to be properly managed; weather conditions must be planned for; skilled and unskilled labor must be available and productive; supervision needs to be effective; government and regulatory requirements understood; materials, equipment, and supplies available; the site conditions adequate; and intangible factors such as morale, fatigue, and labor turnover maintained at acceptable levels. How often on a project has each of these components gone well?

Most, if not all, of these components affect a project's labor productivity. When a contractor budgets, or bids, a construction project, it generally bases its budget on historical data. However, no two projects are exactly alike. Designs change, locations are different, and other factors affect how this historical data applies to the project being budgeted. Therefore, each new project requires its own budget, or baseline, for labor, materials, and equipment. The most important is the labor utilization baseline. Generally, there are several labor baselines throughout a project. A baseline for the beginning and ending of a project, as well as an analysis of the progression of the job.

Once a project is progressing, the actual labor utilization for various phases should be compared to the same phases in the projected labor baselines. This is accomplished by performing a labor productivity analysis. These productivity analyses can be performed during the project, or after the project is completed. If, throughout the project duration, delays and disruptions occur, a productivity analysis should be performed to determine the effects those delays and disruptions had on the project. If certain delays and disruptions were caused by the

owner or a responsible third party, the damages suffered as a result of the productivity loss may be recoverable. According to the American Association of Cost Engineers International (AACE International), there are no uniform agreements within the construction industry defining a preferred method of calculating lost productivity.<sup>1</sup> AACE International's *Recommended Practice No. 25R-03 Estimating Lost Labor Productivity in Construction Claims* describes the many methods of calculating lost productivity, which will be discussed in this paper.

What is labor productivity and how is it measured? According to *Jelen's Cost and Optimization Engineering*, productivity refers to "quantities produced per employee hour of effort" or "the ratio of output to input."<sup>2</sup> Additionally, productivity can be defined by any of the following equations:<sup>3</sup>

$$\begin{aligned}\text{Productivity} &= \text{Output} \div \text{Input} \\ &= \text{Units} \div \text{Work-hours} \\ &= (\text{Total output}) \div (\text{Total work-hours})\end{aligned}$$

A construction project's output is generally measured in units of materials constructed, such as cubic yards of concrete placed, linear feet of pipe installed, square yards of flooring laid, or tons of steel erected per crew hour or man-hour.

Therefore, when budgeting a project, labor productivity baselines are determined for various periods of time throughout the project. For example, at the beginning of the project, productivity will be slow, as the craft crews are in a learning period (learning curve). Labor productivity will increase as the project continues, then likely level out; productivity often begins to decrease toward the end of the project. An experienced contractor will prepare its work plan accordingly.

To assess the true progress throughout the project, the actual labor productivity should be established to determine if the project is on track to be successful. When a contractor is not meeting the labor, material, and/or equipment productivity that was budgeted or anticipated, the project will cost more to perform or take longer to complete. In other words, if the contractor is expending more time or effort to complete a unit of production than originally planned, the result is a loss of money.<sup>4</sup>

Equipment and materials expenditures are easier to measure and track than labor. If the equipment is not working properly, or the proper piece of equipment was not ordered, it can be changed. If the material is not adequate, received timely, or utilized properly, that can be corrected or expedited. Labor productivity, however, is more difficult to determine. As a result, the contractor must be able to measure and track work hours and production in sufficient detail to determine the root cause of any loss of labor productivity.

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<sup>1</sup> "Recommended Practice No. 25R-03 Estimating Lost Labor Productivity in Construction Claims," *AACE International*, April 13, 2004.

<sup>2</sup> Brian Barker, *Jelen's Cost and Optimization Engineering, Third Edition*, ed. Kenneth K. Humphreys (New York: McGraw-Hill, Inc., 1991), pp.238-240, 426.

<sup>3</sup> Brian Barker, *Jelen's Cost and Optimization Engineering, Third Edition*, ed. Kenneth K. Humphreys (New York: McGraw-Hill, Inc., 1991), pp.238-240, 426.

<sup>4</sup> "Recommended Practice No. 25R-03 Estimating Lost Labor Productivity in Construction Claims," *AACE International*, April 13, 2004.

In evaluating labor productivity, one must distinguish between the terms productivity and production. According to AACE International, “production is the measure of output (i.e., things produced) whereas productivity is the measurement of production.”<sup>5</sup>

$$\text{Production} = \text{Output (units completed)}$$

The following two formulas can be used to calculate productivity.

$$\text{Productivity} = \frac{\text{Output (units completed)}}{\text{Input (work or equipment hours)}}$$

$$\text{Productivity Factor} = \frac{\text{Actual Productivity}}{\text{Baseline or Planned Productivity}}$$

In other words, the contractor may be able to achieve the planned production, but expend more cost in labor to achieve this production.

## Common Causes of Lost Productivity

Before discussing the various methodologies for estimating labor productivity, a review of the causes of excessive labor expenditures is necessary. AACE International has described most of the following causes, and it is important to distinguish which party is responsible for any of these events. If the owner or a third party is responsible for any of these events, the contractor may be able to recover any associated additional costs. If the contractor is responsible, it is simply a loss that affects the project’s bottom line. The following are descriptions of some of the most common events that can affect labor productivity:<sup>6,7</sup>

**Absenteeism** – If a construction crew is progressing effectively and crew members start missing work, the crew will not be able to maintain its prior efficiency. Either the remaining crew members must work harder or faster, or additional/new labor will have to be added. Any lost productivity or extra cost for this event may not be recoverable from other parties.

**Acceleration (direct or constructive)** – When a contractor either intends to or is directed to speed up work on a project for a period of time, it results in overtime and/or additional labor and contributes to excessive, unplanned costs. If the owner is responsible for the need to accelerate, these costs should be tracked and financial recovery pursued. If the need to accelerate is caused by the contractor, the resulting costs may not be recoverable.

**Beneficial Occupancy** – When the owner takes over a portion of the facility and the contractor is still not complete, the work will require more care and control, and there will likely be limited access to work areas and/or less time to complete the work. Each of these events will result in a loss of productivity. Generally, the contract time will stop for that area, but the slowed

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<sup>5</sup> “Recommended Practice No. 25R-03 Estimating Lost Labor Productivity in Construction Claims,” *AACE International*, April 13, 2004.

<sup>6</sup> *Ibid.*

<sup>7</sup> Intergraph Corporation. *Factors Affecting Construction Labor Productivity*. Huntsville, AL: 2012.

production will cost money. A contractor should allow beneficial occupancy if it can support the results.

**Changes in the Contract** – Changes will occur on a construction project. As long as the contractor is able to price the extra work accordingly, a loss of productivity should not occur. However, the cumulative impact of multiple changes may not be accounted for in each change order pricing. The contractor must document how each change order affects the original work and how multiple changes can cause labor productivity to be affected. Factors that affect the price of a change that may not be accounted for can include: (1) timing of the change, (2) complexity of the work, (3) amount of time it takes to get the change order formalized, (4) effect of the change on the interdependence of the other construction activities, (5) intensity of the work and timing within the project schedule, (6) management methods, and (7) owner's refusal to accept direct costs.<sup>8</sup> If these factors affect the contractor's work, the contractor should document these effects and seek recovery from the owner if the cost was not already included in each change order.

**Craft Turnover** – (see **Learning Curve**) If a crew experiences continual turnover of skilled craft labor, crew productivity will suffer as a result of the influx of new skilled laborers having to become familiar with the project. This will cause a lag in the crew re-establishing its prior productivity level.

**Crew Size Inefficiencies** – When a contractor budgets the crew sizes and utilization of craft crews, it is up to project supervision to utilize the budgeted crew sizes. Should the supervisor increase or decrease the budgeted crew size, inefficiencies will occur. If the crew is undermanned, the progress of the crew will suffer. If the crew is overmanned, the extra costs may not be recoverable even though the work may have been completed sooner. There is a delicate balance to manning the proper crew size.

**Crowding of Labor** – Each crew member must have adequate space to perform its work to maximize productivity. If a crew larger than anticipated is working in a space, there must be adequate space for each crew member to work. According to a study on crowding efficiency by square foot of space per worker, as the square footage per worker decreases, productivity of the worker decreases. The result of this study determined that between 200-300 square feet/worker was acceptable, with little impact on productivity, but below that level of spacing there is a loss in the amount of productive work accomplished.<sup>9</sup> **Defective Construction** – Any rework of a contractor's original work will be costly, not only in terms of lost labor hours, but also for reuse of equipment and materials. All of these losses will affect the bottom line and increase costs.

**Defective Design** – When contract drawings or specifications are erroneous, ambiguous, unclear, or defective, productivity will decline because crews will not be able to progress effectively until the errors are corrected. Crews will slow down or pace their work while awaiting

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<sup>8</sup> Ibbs, William and Vaughan, Caroline. *Change and Loss of Productivity in Construction: A Field Guide*. Oakland, CA: The Ibbs Consulting Group, 2015, p.21.

<sup>9</sup> Ibbs, William and Vaughan, Caroline. *Change and Loss of Productivity in Construction: A Field Guide*. Oakland, CA: The Ibbs Consulting Group, 2015, p. 48.

answers. Anytime a contractor is impacted by defective design, the defects and their effect on the project must be documented for potential recovery.

**Dilution of Supervision** – When original work and multiple change order work is progressing simultaneously, or additional craft crews are added, unless extra supervision is accounted for, the original supervision will be diluted and labor productivity may be reduced. Additionally, equipment, tools, supplies, and materials may be in short supply, and there may be a need for extra planning. Dilution of supervision is generally non-recoverable and should be accounted for if change orders make such dilution necessary.

**Excessive Overtime** – Multiple studies over many years have documented that labor productivity typically declines as overtime work is performed. The most commonly stated reasons for this loss of productivity include fatigue, increased absenteeism, decreased morale, reduced supervision effectiveness, poor workmanship resulting in higher than normal rework, and increased accidents.<sup>10</sup> According to various overtime impact studies cited by Dr. William Ibbs, “the overall efficiencies for fifty, sixty and seventy hours per week are 90%, 83% and 71% respectively of the standard schedule efficiency.” Ibbs concludes by stating, “As a rough approximation when trying to predict what kind of efficiencies to expect, there is approximately a **10% decrease in efficiency for every 10 hours of week added to the work schedule.**”<sup>11</sup>

**Failure to Coordinate Subcontractors and/or Vendors** – If the contractor fails to provide subcontractors and/or vendors within its scope of work with necessary equipment, materials, supplies, and/or additional crews, delays may occur that may affect productivity and slow production. Crews may not have the necessary resources to accomplish their work. There may not be recovery of any costs that result from one’s coordination failure.

**Fatigue** – Fatigue may not be caused by overtime alone. Working in hazardous conditions, hot or cold weather, or other demanding environments may cause fatigue to craft labor, which can lead to accidents, poor workmanship, and mistakes that result in lost productivity and extra cost.

**Labor Relations** – Many different labor relations issues may occur on the project, including union/non-union disputes, strikes, and/or walkouts that are not directly the responsibility of management, but cause productivity losses. Other self-imposed labor issues such as poor or unsafe working conditions, late access or lack of access, and/or poor communications may all lead to loss of productivity and non-recovery of extra costs.

**Late Crew Build-up** – If management is slow or late to man the craft crews, efficiency is reduced. Late crew build-up could be caused by the unavailability of labor, competition for resources, or other factors not originally planned.

**Learning Curve** – Every new project will experience a learning curve as crews become familiar with the project location, site conditions, availability of tools and equipment, management of

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<sup>10</sup> “Recommended Practice No. 25R-03 Estimating Lost Labor Productivity in Construction Claims,” *AACE International*, April 13, 2004, p 5.

<sup>11</sup> Ibbs, William and Vaughan, Caroline. *Change and Loss of Productivity in Construction: A Field Guide*. Oakland, CA: The Ibbs Consulting Group, 2015, p. 44.

the project, and quality standards. However, the original budget should have accounted for the initial learning curve. What is not accounted for are more or longer learning curves caused by a work stoppage, or loss and replacement of craft labor. After the initial learning curve has been completed, the craft labor has a greater familiarity with the task at hand, more efficient and effective use of tools and equipment, standardization of the procedure, and better coordination and teamwork within the crews.<sup>12</sup> Any need for additional learning curves may cost the contractor additional costs, unless a stoppage of work was caused by the owner or other third party.

**Materials, Tools, and Equipment Shortages** – The contractor is responsible for providing materials, tools, and equipment to its crews timely and at the proper location, or idle time will occur and result in lost productivity. The same applies to the proper sequencing of materials, tools, and equipment for subcontractors. Additionally, the proper quantity and quality of materials, tools, and equipment must be provided.

**Overmanning** – Overmanning is similar to crowding, in that it often creates limited crew space. Overmanning is often an attempt to recover from slow production or to compensate for a lack of skilled craft labor, but productivity may be further affected due to crowding. Overmanning may also be nonproductive if sufficient materials, tools, and/or equipment is not available. Additionally, there may be a need for supplementary training of the additional labor, and overmanning will dilute overall supervision. However, if the space, materials, tools, and equipment are available, overmanning may increase production, but at the non-recoverable cost of the extra labor.

**Poor Morale** – Many factors can contribute to poor morale of craft labor and may include poor management, over inspection, constant rework requirements, excessive extra work, low pay, hot or cold weather, unsafe working conditions, labor disruptions, and poor communications. Each of these has the potential to affect the productivity of the craft labor and add extra non-recoverable costs.

**Project Management Factors** – Of all the factors that affect labor productivity, project management is the one over which the contractor has the most control. Proper scheduling and coordination of the craft labor, material, and equipment is paramount to good labor productivity. Proper planning prior to commencing construction can be invaluable to productivity. This includes jobsite access; site planning; open communications between all parties; appropriate and sufficient materials, tools, and equipment; proper supervision; and sufficient and convenient storage areas.

**Out of Sequence Work** – When work is not performed in a logical and orderly sequence, productivity suffers. If a craft crew is required to construct an item in an area that is not ready for that item, problems may result. When follow-on work precedes its predecessor work, both items may require extra work and/or rework. Productivity will suffer and time is lost. If the out-

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<sup>12</sup> Ibbs, William and Vaughan, Caroline. *Change and Loss of Productivity in Construction: A Field Guide*. Oakland, CA: The Ibbs Consulting Group, 2015, p. 61.

of-sequence work is the result of the owner or other third parties, extra costs may be recoverable.

**Rework and Errors** – There is no question that rework or correcting a construction error will cost time and money. Extra labor and equipment will be necessary, and repair of materials and/or equipment or the purchase of new materials may be required. **Schedule Compression** – Compression of the project schedule may cause a loss of labor productivity. If the need to compress the schedule is caused by a party other than the contractor, recovery of the loss may be available to the contractor. Any compression of the schedule will require extending work hours or increasing the manning levels of the craft crews. Each of those activities may affect the craft labor and possibly the timing of the arrival of materials and equipment. For schedule compression to be necessary, the critical path must have been disrupted, as any other non-critical activity will contain float, or the amount of time a task can be delayed without delaying the project, that could be absorbed. The compression of a non-critical activity may not shorten the length of the project. The need for schedule compression is generally the result of a delay.

**Shift Work** – Craft labor crews working second and/or third shifts are going to be less productive than crews on the day shift. This is due to the fact that a second or third shift requires time to evaluate and understand what the previous shift accomplished and what the current shift needs to accomplish. Start-up and shut-down of each shift causes lost time. A competent contractor will plan its budgeted labor productivity accordingly and account for this lost time, though this is not always the case.

**Site or Work Area Access Restrictions** – During budgeting for the project, the site must be examined for access. Additionally, the type of project must be understood, as there may be work access problems due to the nature, location, and complexity of the construction. Working on a project or site with inconvenient access may make receiving materials and equipment in a timely manner difficult, and challenge the craft crews' ability to work effectively, thus impairing productivity. The contractor is responsible for accounting for the cost of the known project site access problems when budgeting the project.

**Skilled Labor Availability** – A construction budget is likely to be developed based on a known level of skilled labor for the area. If that skilled labor is not available, the contractor's productivity may suffer. This is typically a contractor's problem and, therefore, should have been planned for prior to execution of the contract. Regardless, if this situation occurs, the contractor's cost may increase either because the available labor will need additional training or the skilled labor will have to be hired at a higher rate. The availability of skilled workers could also be affected by competition from other contractors seeking to employ skilled labor; this could cause the contractor to pay higher wages to keep the skilled labor at the project and lead to excessive and unanticipated costs.

**Stacking of Trades** – If crew members are in too close proximity to the work of other crews, interferences will occur and each affected crew will suffer loss of productivity. As in the crowding of crews, each crew member requires an adequate amount of space to perform its work. Additionally, some craft crews must complete their work before a follow-on crew can effectively perform its own work. When crews are stacked together, previously scheduled work and/or follow-up work may be disrupted.

**Start and Stop Work (See Learning Curve)** – When the contractor stops a productive craft crew from finishing a work assignment and shifts that crew to another work area, it causes a disruption, for the stopped work will take additional time to restart once the craft crew returns. Not only will it take time to relocate the craft crew to the new assignment, it will take additional time to overcome the learning curve for the new work. Additionally, it will take time to return the craft crew to the stopped work, as well as time to restart the work. Part or all of the restarted work may require modification in order to finish the assignment. The start, stop, and restart of work causes lost labor productivity.

**Untimely Approvals and Responses** – When the project owner, designer, and/or construction manager fails to timely respond to questions regarding submittals or requests for information, the productivity of the craft crew may be affected. Generally, the contract will define the response time for questions and/or submittals and the contractor must plan for that response time. Any delay must be noted and the delaying party notified of the impact of that delay. However, the contractor must create proper and acceptable submittals and requests for information, as any defective submittal or request for information will delay a proper response from the appropriate party.

**Weather (Adverse or Severe)** – A contractor must plan for typical adverse weather, but if the work is subjected to severe unexpected weather conditions, labor productivity may be affected. Most construction contracts address whether or not a contractor may be compensated for unexpected severe weather. Many times, the contract will define the standard or average number of rain days that are anticipated to occur at the project site. If the average number of rain days is exceeded, the contractor should be entitled to an extension of time and/or additional compensation, provided the owner/designer/construction manager is properly notified.

## **Lost Productivity Cost Recovery**

Loss of productivity can be interpreted as “the increased cost of performance caused by a change in the contractor’s anticipated or planned resources, working conditions or method of work.”<sup>13</sup> The request to be compensated for costs associated with loss of productivity caused by others must demonstrate entitlement and price the delay reasonably. According to AACE International, “The resulting damages (cost) are an outgrowth of the change in Output/Input. Lost productivity is the difference between baseline productivity and that actually achieved.”<sup>14</sup>

$$\text{Lost Productivity} = \text{Productivity}_{\text{Baseline}} - \text{Productivity}_{\text{Actual}}$$

AACE International’s *Practice No. 25R-03* continues, “Baseline productivity can be determined by measurements of input and output in unimpacted or the least impacted periods of time on

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<sup>13</sup> Jones, Reginald M. and Driscoll, Thomas J., *Cumulative Impact Claims*, (Falls Church, VA: Federal Publications, 2002), p. A-5.

<sup>14</sup> “Recommended Practice No. 25R-03 Estimating Lost Labor Productivity in Construction Claims,” *AACE International*, April 13, 2004, p. 7/29.



the project. When this data is not available, estimated or analytically determined baseline productivity may be substituted.”<sup>15</sup>

Depending on the details of the contract, AACE International’s *Practice No. 25R-03* describes the following issues that the contractor must demonstrate to be entitled to recover damages:<sup>16</sup>

- ❖ Compliance with the notice requirements of the contract.
- ❖ Events occurred during the performance of the work, which were unforeseeable at the time of contract execution or a preceding change order(s).
- ❖ The events were beyond the control of the contractor seeking compensation, whether it is the contractor, its subcontractors, vendors or suppliers, at any tier.
- ❖ The events were caused by the owner or some entity for whom the owner is responsible (i.e., the design professional, construction manager or an independent prime contractor, etc.). Or, in the alternative, the events were caused by situations for which the owner assumed contractual liability (i.e., a force majeure situation or differing site condition, etc.).
- ❖ Recoverability for the resulting damages is not barred by the terms of the contract (e.g., exculpatory clauses such as no damages for delay clause which may be upheld in the jurisdiction or overcome by events beyond the contemplation of the parties or intentional, willful, or grossly negligent conduct of the party seeking enforcement of such a clause).
- ❖ The events caused a change in the performance of the work and resulted in increased costs and/or time required to perform the work (i.e., work was resequenced, means and methods were changed, it took longer to perform the work, the work cost more due to performing work in bad weather, etc.).

There are several approaches a contractor may take to develop these time and monetary costs. The most effective and acceptable approach is to develop a cost coding and tracking system that quantifies the impact based on actual data. Rarely will a contractor have the ability to foresee that a tracking system is necessary before it is too late to develop an effective one.

Recommended methods for estimating lost productivity can generally be grouped based on availability of project information, articles, and/or relevant publications. AACE International’s *Recommended Practice No. 25R-03 Estimating Lost Labor Productivity in Construction Claims* describes and details various methodologies for estimating lost productivity.

According to AACE International’s *Recommended Practice No. 25R-03*, the various methodologies are categorized as follows:<sup>17</sup>

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<sup>15</sup> “Recommended Practice No. 25R-03 Estimating Lost Labor Productivity in Construction Claims,” *AACE International*, April 13, 2004, p. 7/29.

<sup>16</sup> *Ibid.*

<sup>17</sup> “Recommended Practice No. 25R-03 Estimating Lost Labor Productivity in Construction Claims,” *AACE International*, April 13, 2004, pp. 8-9/29.

- ❖ **Project Specific Studies**
  - Measured Mile Study
  - Earned Value Analysis
  - Work Sampling Method
  - Craftsmen Questionnaire Sampling Method
  
- ❖ **Project Comparison Studies**
  - Comparable Work Study
  - Comparable Project Study
  
- ❖ **Specialty Industry Studies**
  - Acceleration
  - Changes, Cumulative Impact and Rework
  - Learning Curve
  - Overtime and Shift Work
  - Project Characteristics
  - Project Management
  - Weather
  
- ❖ **General Industry Studies**
  - U.S. Army Corps of Engineers Modification Impact Evaluation Guide
  - Mechanical Contractor's Association of America
  - National Electrical Contractor's Association
  - Estimating Guides
  
- ❖ **Cost Basis**
  - Total Unit Cost Method
  - Modified Total Labor Cost Method
  - Total Labor Cost Method
  
- ❖ **Productivity Impact on Schedule**
  - Schedule Impact Analysis

A Cost Basis method is generally utilized if it is possible to demonstrate entitlement and causation but there is insufficient project documentation to support damage calculations using any of the above techniques.

AACE International's *Recommended Practice No. 25R-03* does not recognize Productivity Impact on Schedule as a recommended method for estimating lost productivity, but discusses the fact that "there is a relationship between a lost labor productivity analysis, lost labor productivity's impact to a project schedule, and, possibly, the critical path of that project."<sup>18</sup> Therefore, schedule analysis often plays a major role in analyzing entitlement and impact of productivity loss. Generally, the categories described above, excluding Cost Basis and Productivity Impact on Schedule, are listed in order of preference from most to least reliable. Each category, from least favored to most favored, is discussed below.

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<sup>18</sup> "Recommended Practice No. 25R-03 Estimating Lost Labor Productivity in Construction Claims," *AACE International*, April 13, 2004, p. 17/29.

## **General Industry Studies**

General Industry Studies are the least favored methodologies for estimating lost productivity, because they are based on industry-wide studies and are not job specific. These studies, or methodologies, were generally developed to price future work and not to analyze past work. Two of the better-known industry-published productivity studies are promulgated by the Mechanical Contractor's Association of America (MCAA) and the National Electrical Contractors Association (NECA). The MCAA publication entitled *Labor Estimating Manual Appendix B, Factors Affecting Productivity*, Rockville, MD, August 1998, itemizes and ranks by potential impact many productivity factors, such as added work, crowding of work space, supervision, and manpower availability. The NECA publication *Manual of Labor Units*, Bethesda, MD, 1976 and 2003, gives job factors for consideration that under certain circumstances may affect labor costs. However, as can be determined by the publishing organizations, the MCAA and NECA studies are specialized craft documents that should not be utilized for other craft disciplines.

In 1979, the U.S. Army Corps of Engineers published the *Modification Impact Evaluation Guide*, which discussed the effect that contract modifications have on materials, equipment, and labor, and was used as a guide to assess inefficiency claims; however, the Corps officially rescinded the guide on 14 June 1996.<sup>19</sup> Therefore, owners would probably be reluctant to accept claims based on this guide. However, this guide would be useful for a contractor to use as the basis for an analysis of its own loss of productivity, relative to the specific crafts referenced in the Corps of Engineers' manual.

RS Means and other estimating guides are used to price work in advance and, as such, do not account for the impact of delayed or disrupted work. It is not likely an owner would recognize a loss of productivity claim based on an estimating guide. Nevertheless, unlike the above listed general study guides that list percentage factors to calculate productivity loss under certain situations, the estimating guides can be used to establish a baseline budget.

## **Specialty Industry Studies**

Specialty Industry Studies are specialized studies of specific types of problems. These studies involve activities such as acceleration, changes, learning curve, overtime, and others; most of the studies are articles and papers written by individuals on actual construction projects. However, some specific studies are published by recognized associations such as Construction Industry Institute (CII), which is based out of The University of Texas at Austin; Business Roundtable; and the American Society of Civil Engineers.

AACE International's *Recommended Practice No. 25R-03* has identified numerous Specialty Industry Studies, as listed below; there have been multiple studies on each of these topics.<sup>20</sup>

- ❖ Acceleration
- ❖ Changes, Cumulative Impact and Rework
- ❖ Learning Curve Overtime and Shift Work

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<sup>19</sup> Reginald M. Jones, "Update on Proving and Pricing Inefficiency Claims," *The Construction Lawyer*, Summer 2003: p.8.

<sup>20</sup> "Recommended Practice No. 25R-03 Estimating Lost Labor Productivity in Construction Claims," *AACE International*, April 13, 2004, pp. 19-25/29.

- ❖ Project Management Factors
- ❖ Weather

### **Project Comparison Studies**

Project Comparison Studies are utilized in situations for which there were either no unimpacted portions of the specific work, or costs cannot be separated between impacted and unimpacted periods of time. In other words, if one trade contractor's work was impacted throughout the project, a comparison can be developed by analyzing a similar trade contractor's work on the same project or a comparable project.

#### Comparable Work Studies

For comparable work studies, one must find similar work (generally by similar or comparable crafts at similar locations) on the same project that has been impacted the least when compared to the most impacted. It is important when comparing both periods of time that the same site conditions occurred, such as size, location, labor, and/or weather conditions in order for these two comparisons to be compatible. The type of work that is being analyzed is also important, in that comparing plumbing and fire sprinkler system work, or electrical and instrumentation work, is acceptable; however, comparing mechanical work with structural work is not reasonable. The similar trades or crafts should be compared during the least impacted period of time and most impacted period of time.

If there were no unimpacted periods of time on a project performed by specific trade contractors, it may be practical to evaluate similar work on the same project constructed by a different contractor. Obviously, it is rare to have two separate contractors of the same discipline on the same project, but for this type of evaluation to be undertaken, the conditions should be similar on the project, such as timing, weather, and crew size, and the trade contractors should be performing relatively similar work.

#### Comparable Project Study

Should comparable work activities not exist, it is possible to compare similar work on another project. It is difficult, at best, to identify similar work on a similar project that has the same circumstances, such as location, size, configuration, labor, and weather conditions. However, if two similar projects exist and costs can be developed for similar work, this method is generally acceptable if presented effectively.

### **Project Specific Studies**

Project specific studies are the most reliable method of computing loss of labor productivity. In project specific studies, impacted periods of time and unimpacted periods of time are calculated and compared. Costs can be determined based on either the percentage of units of work completed or actual units of work completed as compared to the total units of work to be done. Generally, the units of work completed are converted to labor cost per unit for both the impacted and unimpacted periods of time. These methodologies will also be discussed in the order of least reliable to most reliable.

#### Craftsman Questionnaire Sampling Method

The Craftsman Questionnaire Sampling (CQS) method is the least desirable method of describing the loss of productivity on a specific project as the "numerical results of CQ

[Craftsmen Questionnaire] lack validity, which creates a skepticism on the part of the construction industry regarding its use. Moreover, the data collection of CQ, which requires the craftsman to go to a preassigned location away from the work area, not only takes time but also interrupts the ongoing construction activities.”<sup>21</sup>

CQS is essentially the same process as the Work Sampling method discussed next, with the exception that instead of an independent sampler, the craftsman assigned to the work fills out the questionnaire. It is believed that the assigned craftsman will have more knowledge of the delays than a random sampler. The two methods (CQS and Work Sampling) are similar in execution, using a similar questionnaire, conducting random sampling of crews and timing, and the results are similarly tabulated. The execution is different from the Work Sampling method in that either the foreman or sampler gathers the foreman’s crew into a specific location and distributes the questionnaire and each craftsman provides his or her own responses.

Each craftsman completing the questionnaire is asked to identify what activity he or she was engaged in during the previous period of time (the period of time is designated by management). According to Chang and Borcharding, the questionnaire generally has five investigative activities, which are categorized as either “productive” or “unproductive.” These five categories are listed as direct work, support work, traveling, waiting, and unrelated work. Once a craftsman has indicated a productive category, that category is subdivided into either performing the work or helping. The productive work is further broken down into new work or rework. If the activity of the craftsman was unproductive, the reason for the unproductive activity is listed. Traveling or waiting are unproductive activities that could include waiting on material, traveling to a different area of the work site, absence, or work not available.

The results of the questionnaires are tabulated and the crew hours are developed and analyzed by management. Again, these craftsman questionnaires are randomly conducted throughout the project, and productive man-hours and unproductive man-hours are tabulated. If certain delay factors affected the working conditions, a loss of productivity cost can be established as long as there were sufficient samplings to determine a baseline and an impacted time. The next most reliable method of project specific studies is the Work Sampling method.

### Work Sampling Method

Work Sampling is more reliable than CQS because Work Sampling is conducted onsite as the work is being performed, whereas CQS is conducted away from the work being performed. In Work Sampling, management can evaluate the factors that affect unproductive work and/or compare various samples to determine the cost of labor differences in productive work and unproductive work on the project.

To conduct work sampling interviews, management develops a questionnaire similar to that of the craftsman questionnaire, but the sampling is performed by an independent sampler. Work Sampling is conducted throughout the project at various times and the results are evaluated to determine the various productivity levels of the work. Sampling is done on similar trade crews and analyzed to determine what periods of time were most productive and least productive.

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<sup>21</sup> Luh-Maan Chang and John D. Borcharding, Craftsman Questionnaire Sampling, *Journal of Construction Engineering and Management*, 112, 4 (1986), p. 543.

Work sampling not only provides information on the amount of time workers spend performing productive/nonproductive work, but also helps to identify the site-specific factors that have either a positive or negative effect on productivity.<sup>22</sup> A work sampling evaluation taken during non-impacted work will provide the baseline for comparison for an impacted period of time.

In Work Sampling, the sampler randomly visits a craft crew and completes the questionnaire during the crew's performance of the work. There is no disruption of the work, as the sampling is conducted by the sampler's observation of the crew's performance. As such, the sampler must be familiar with the contractor's means and methods to determine if productive work is being performed. If a crew member is idle or not engaged in productive work, the sampler must be able to distinguish why and what caused the crew member to be idle. At the completion of the various work sampling periods, management tabulates and evaluates the results of the questionnaires.

According to AACE International's *Recommended Practice 22R-01 Direct Labor Productivity Measurement – As Applied in Construction and Major Maintenance Projects*, work sampling procedures must be random, free of bias, and consistently carried out according to the definitions and procedures developed by the management of the organization performing the sample.

AACE International's *Recommended Practice 22R-01* further states the following advantages of the Work Sampling method:<sup>23</sup>

1. Random observations are made of overall project work activity groups of workers, collectively observed at randomly selected areas and times, not of specific individual workers.
2. Sampling causes less anxiety and tension among workers than continuous observation (such as with a stopwatch).
3. There is no, or minimal, interference with the workers' normal activities.
4. Observers with minimal specialized training can conduct random work sampling.
5. The number of observations can be adjusted to meet desired levels of accuracy.
6. Work sampling is an effective means of collecting useful facts during project execution that are not normally collected by other methods.
7. Work sampling is less expensive than continuous observation techniques.

The conclusions developed from Work Sampling determine the percentage of either direct work or delays in a given environment and operation. Generally, construction work can be divided into three categories: (1) direct work, (2) support work, and (3) delays.<sup>24</sup>

The challenge of performing Work Sampling is to define the various work activities that are to be sampled and placed into one of the three categories listed above. The activities need to be

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<sup>22</sup> Dr. James L. Jenkins and Daryl L. Orth, Productivity Improvement Through Work Sampling, *Cost Engineering*, 46, 3 (3 March 2004).

<sup>23</sup> "Recommended Practice No. 22R-01 Direct Labor Productivity Measurement – As Applied in Construction and Major Maintenance Projects," *AACE International*, April 26, 2004, p. 3/19.

<sup>24</sup> Fwu-Shiun Liou and John D. Borcharding, Work Sampling Can Predict Unit Rate Productivity, *Journal of Construction Engineering and Management*, 112, 1 (1985).

detailed enough to incorporate all the project's anticipated work activities, but broad enough so that the quantity of work activities is less cumbersome.<sup>25</sup>

The next most reliable method of project-specific studies is the earned value analysis.

### **Earned Value Analysis**

A more reliable method of determining labor productivity for a specific period of time is a comparison of the work completed (earned value) with the work planned to be completed (planned earned value) for the same time period.<sup>26</sup> When the period of time that is analyzed was impacted by a loss of productivity event, it can be compared to a period of time that was not impacted. By developing the cost of the work during the impacted and unimpacted periods of time, one can calculate the cost of the productivity loss. In this comparison, the work (earned value) must be similar and comparable in order to justify the calculation. Additionally, because the values of the costs expended are actual and not estimated, the results are as reliable and dependable as the underlying data.

There are two methods that are used to determine the earned value of a project and are described as percent complete and equivalent units.<sup>27</sup> In the first method, if there is disruption to a specific element of work, the contractor can evaluate the amount of work completed and compare that to the budgeted cost to complete the same element. During the impacted period of time, a percent complete is established at a certain status date for the specific element of the work affected. That percent complete is multiplied by the actual cost to complete the specific element and subtracted from the budgeted cost assigned to the element. The difference will be the cost of the lost productivity. The percent complete is generally used by contractors because it is easy to estimate. However, because the percent complete is subjective, the value can be challenged by the client or the project management.

The second method of determining the loss of productivity of a disrupted time frame is comparing the cost of the specific building unit or element to the budgeted cost to complete that same unit or element. The difference is the cost of the loss of productivity for that work element. Though this method is more reliable than the percent complete method, the timing to complete a building unit may be excessive and the length of time to complete the building unit may be too long to correct any loss of productivity. Therefore, the budgeted length of time for unit completion for the sampled unit should be no more than one month.

### **The Measured Mile Approach**

The measured mile calculation is favored because it considers only the actual effect of the alleged impact and thereby eliminates disputes over the validity of cost estimates or factors that may have impacted productivity due to no fault of the owner.<sup>28</sup> This method involves a comparison of actual labor performance between two periods, a normal (unimpacted) period,

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<sup>25</sup> Ricardo Viana Vargas, *Earned Value Probabilistic Forecasting Using Monte Carlo Simulation, 2004 AACE International Transactions CSC.16* (2004).

<sup>26</sup> "Recommended Practice 81-R-13 Required Skills and Knowledge of Earned Value Management," *AACE International*, May 1, 2014.

<sup>27</sup> Ricardo Viana Vargas, *Earned Value Probabilistic Forecasting Using Monte Carlo Simulation, 2004 AACE International Transactions CSC.16* (2004).

<sup>28</sup> "Recommended Practice No. 25R-03 Estimating Lost Labor Productivity in Construction Claims," *AACE International*, April 13, 2004.

referred to as the “measured mile,” and an impacted period. The measured mile period is defined as a continuous period when labor productivity is unimpacted by outside sources. The impacted period is the period during which outside sources interfere with the normal labor performance. Provided that there are two distinct, measurable periods, one being unimpacted and the other being impacted, the measured mile approach of analysis is reasonable and desirable. However, the difficulty in utilizing the measured mile to quantify damages arising from lost labor productivity is that the measured mile method is a concept, not a procedure. No rules exist regarding standard procedures to be utilized, therefore the concept relies on the judgement of the analyst performing the study. There have been numerous papers and articles describing the measured mile concept to demonstrate labor productivity losses, and most generally agree on how to quantify the work performed during the two periods.

When performing a measured mile delay/disruption analysis, the most critical factor in developing a reasonable conclusion is comparing work efforts of similar tasks. In other words, the task should be confined to measurable efforts that are not so broad that differing scopes of work are performed. As in the old saying, one should "compare apples to apples, not apples to oranges." By utilizing performance criteria, one will be able to develop reasonable comparisons of work efforts. Two papers on this topic are *Quantification of Losses of Labor Efficiencies: Innovations in and Improvements to the Measured Mile* (H. R. Thomas, 2010), and *Getting the Most out of Your ‘Measured Mile’ Approach* (M. C. Loulakis and S. J. Santiago, 1999).

These studies establish that the work performed in the measured mile period and the alleged impacted period should:

- ❖ be substantially similar in both periods;
- ❖ represent reasonable, attainable levels of productivity;
- ❖ be demonstrated to be based on a productivity definition of labor hours per unit (unit rate) or quantities of units installed;
- ❖ maintain the same productivity level during the measured mile period;
- ❖ have comparable skill levels involving work in both periods;
- ❖ be performed on the same type and complexity of work;
- ❖ be performed in a similar environment; and
- ❖ exclude from the analysis the first and last 10% of the work.

Provided that a contractor or a subcontractor is legally eligible for damages due to productivity loss, and entitlement has been established based on liability and causation, is the measured mile productivity analysis always the best approach?

To determine if the measured mile is the best approach to developing a claim for productivity loss, one must ensure that the approach is focused on a single work task. That is not to suggest that only one work task was affected by an owner/architect/engineer or third-party-caused



interference, as multiple work tasks may have been impacted. As such, each work task that was affected by the interference would be evaluated separately, and the cumulative costs (each cost code of work that was affected) would be included in the damage assessment. The foremost cause of rejection of a measured mile productivity analysis is using too large of a sample (different type of work). Most practitioners agree that the composition of the work during the periods to be compared must be appropriate and similar. If the various previously described performance criteria are not followed, the analysis may be flawed.

Once the analysis has been focused on a single task or a combination of affected individual tasks, the reliability of the available information is the next critical element. Generally, the contractor will not maintain exclusive cost records of the impacted work task, so other jobsite records must be utilized to perform the analysis.

Regarding preparation for analyzing labor productivity utilizing the contractor's jobsite records, it is necessary to understand what records are best utilized to support the analysis. First, a productivity baseline must be established if it has not already been prepared. If one does not exist or cannot be recreated, the projected manpower utilization for units of work must be obtained. Jobsite records should be available to develop this baseline. If a pre-construction baseline was established, an actual productivity sampling during construction should be performed for comparison. Actual productivity determined during construction provides a more reliable basis for comparison in the analysis, because it is based on jobsite records. Secondly, it must be understood that the initial (pre-construction) baseline may not represent the best performance that was obtained during actual construction, and one has to take advantage of a more representative sampling of productivity. Thirdly, the actual sampling is based on production, or output, not on proposed or assumed productivity. Finally, an effective sampling is the best leverage to use in determining the measured mile period as well as the impacted periods.

It is also critical to obtain production records. Work output and input (labor man-hours) must be documented and recorded during construction. Generally, jobsite daily reports detail units of work or tasks completed. With daily jobsite costs available, unit rates per man-hour can be established. If this data is not available, it is extremely difficult to reliably establish post-construction.

When establishing the measured mile, it is important that work performance represents reasonable, attainable levels of productivity and that this productivity was maintained at the baseline level during the measured mile period. Additionally, when establishing the impacted and unimpacted periods, jobsite records should be utilized to establish that substantially similar work was performed during both periods, the work crews had comparable skill levels while working in both periods, and the work was performed in a similar environment compared to the environment when the affected (impacted period) work was performed.

Another important responsibility when comparing the impacted and unimpacted periods of the project is ensuring that no self-imposed disruptions are included in one period and not included in the other. In other words, if the contractor disrupts its own work during one but not both periods, adjustments must be made to eliminate this impact to the one period. If the self-imposed disruption occurred in both periods, it cancels or compensates for the effect of the self-imposed disruption on productivity.

Lastly, evaluating the impact of overtime is not appropriate when evaluating productivity loss as a result of delays and disruptions. This is because reasonable levels of productivity may not be attained when overtime is involved. Overtime cannot be evaluated in the measured mile analysis, whether it was required by an owner/architect/engineer or self-imposed.

There is no question that certain courts throughout the country, as well as governmental boards, have allowed damage assessments utilizing the measured mile method without all the criteria discussed in this paper; however, the more accurate the facts and records, the better the results.

## **Conclusion**

For a contractor to be successful on a project, various labor productivity factors need to be controlled. This paper describes most of the factors that can disrupt a project; once the project is progressing, the actual labor utilization throughout the project should be evaluated by comparing it to the budgeted labor baselines. This is accomplished by performing a labor productivity analysis. These productivity analyses can be performed during the project or after the project's completion. If delays and disruptions occur throughout the project duration, a productivity analysis should be performed to determine the effect labor productivity had on the project. If certain delays and disruptions were caused by the owner or a responsible third party, the damages suffered because of the productivity loss may be recoverable.

If a contractor has suffered interference by an owner/architect/engineer or third party, it can develop a claim for productivity loss for that delay and/or disruption. However, the contractor has the burden to not only prove the effect of the interference or disruption and to determine the party responsible for the interference, but also to establish that the increased time and/or costs are a reasonable approximation of the costs that were incurred. As discussed in this paper, quantifying damages arising from lost labor productivity is dependent on the available project records and the timing of the effects of the productivity loss. As stated previously, no rules exist regarding the proper procedures to be utilized in developing a damage model for productivity loss. This paper has discussed the various performance criteria that may be followed (Project Specific Studies, Project Comparison Studies, Specialty Industry Studies, and General Industry Studies), and detailed the problems with each criterion that must be avoided to prevent flawed conclusions. To be successful, the preparer of the claim must utilize the best available facts and records, and ultimately package the claim in an understandable and believable format.