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Proving Lost Productivity in International Construction Claims

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Introduction

A contractor's ability to meet its planned productivity is an essential element of a successful project, and failing to do so could result in significant cost overruns for the contractor and create additional challenges to the contractor's ability to maintain the project schedule. A contractor's productivity or efficiency is simply a ratio of how many labor hours[1] will be required to perform a certain quantity of work. Depending upon the status of the design at the time of the price estimate, contractors can generally determine with reasonable reliability the quantity of work. The associated hours necessary to perform that defined quantity of work is more subjective and often relies upon the contractor's historical performance on other projects or other available estimating data, which the contractor then often adjusts to reflect any unique factors specific to the project at hand.

When a contractor is unable to achieve its planned productivity, the contractor can experience overruns in labor hours and corresponding labor costs. If the contractor believes that a labor overrun was due to disruptions and other causes beyond its control, then the contractor may attempt to recover that cost overrun through an adjustment in the contract price. For this reason, a claim for loss of productivity is sometimes referred to as a disruption claim.

This claim effort can be met with difficulty because proving lost productivity is one of the most contentious and controversial areas in construction claims and disputes, especially in international projects. This can be readily understood because a decline in productivity can occur in many circumstances on construction projects, which may be attributed to the owner, the contractor's estimate, the ability of the contractor to execute as estimated or to a third party.

Productivity is typically the ratio between work effort and work quantity. Thus, when the actual labor hours needed to accomplish a particular quantity of work exceed the estimated or "should have been" effort, then a loss of productivity occurs. As the number of hours needed to perform a certain unit of work increases, the productivity decreases.

For a contractor to recover damages due to lost productivity from factors beyond its control, the contractor will need to demonstrate that it is entitled to the damages by proving that there is a direct cause and effect relationship between the impacting events and the decline in productivity. Once entitlement is established, the contractor must quantify the damage. In this article we do not directly address the issue of entitlement; rather, we focus on the challenge of quantification.

In preparing loss of productivity quantifications in international venues, special attention may be required for factors such as the legal framework in which the claim is founded, the nature and extent of records maintained by each of the parties and the dispute resolution process. Many international construction contracts contemplate a three-step dispute resolution process, including amicable negotiation, alternative dispute resolution, such as the use of a dispute adjudication board (DAB) or a dispute resolution board (DRB), and arbitration.

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This article will first review various methods to quantify the lost productivity and explain why the measured mile method (including its variation, the baseline method) is the most accepted approach. Then we will discuss common pitfalls in performing loss of productivity analysis, especially when implementing the measured mile method. We will conclude by explaining our recent contribution to the advancement of the available methods to calculate loss of productivity in our peer reviewed article titled, "Improved Baseline Method to Calculate Lost Construction Productivity" published in the *Journal of Construction Engineering and Management*.

Methods to Quantify Lost Productivity

A construction project is a very dynamic process where thousands of custom-crafted pieces that make up the project are assembled by trade workers in an environment often exposed to changing weather conditions. Such an undertaking is subject to numerous factors that can affect productivity. Therefore, the challenge of quantifying the loss of productivity caused by a specific factor or factors, which are not within the contractor's control, can be quite daunting. Fortunately, many courts and other triers of fact have recognized that the quantification of lost productivity does not have to be shown with exact mathematical precision. Acceptance of any analysis of lost productivity will be dependent, however, upon the degree of certainty of the results. As mentioned above, the number of variables that can affect productivity at a specific project site can be extensive. As methods of analysis become less project specific and involve the comparison of separate projects, the number of potential variables that can affect the results increases and the certainty of the results decreases. As the methods of analyses become even less project specific, such as in empirical studies, the degree of certainty is even further diminished. In general, proofs of causation and lost productivity are most preferred if they are based on contemporaneous project specific documentation.

The Association for the Advancement of Cost Engineering International (AACE International) Recommended Practice 25R-03: *Estimating Lost Labor Productivity in Construction Claims* (RP No. 25R-03) has summarized and ranked common methods to quantify lost labor productivity claims from most to least reliable based on professional acceptance, case law

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and construction claim literature.[2] AACE International divides various methods into five categories: (1) project specific studies; (2) project comparison studies; (3) specialty industry studies; (4) general industry studies; and (5) cost-based methods. Project specific studies are generally preferred to project comparison studies, which are likely to be given greater weight than specialty industry studies. Specialty industry studies are generally considered more reliable than general industry studies. Among the five categories, cost-based methods are the least preferred.

1. Project Specific Studies

Project specific methods focus on the project at hand and typically rely on contemporaneous productivity data. The project specific "measured mile" approach, including its extension, the baseline method, is widely acknowledged as the most acceptable method for calculating lost productivity costs internationally. This is validated by international organizations, AACE International and the Society of Construction Law (SCL) of the United Kingdom.[3] The measured mile method compares the productivities of identical or similar work between non-impacted or least impacted work segments to impacted segments of a project based on project specific data.

A project specific productivity benchmark, or "should have been" productivity, can also be obtained through work sampling during the course of construction, and the lost time because of certain disruptions for craft labor can be sampled using questionnaires. Although the sampling methods are typically simple and inexpensive to perform, their reliability is usually challenged on how representative the sampling is.

Earned value analysis is another project specific approach identified in RP No. 25R-03. This approach compares actual hours of the affected work to earned hours for that work, without relying on specific quantity information, while demonstrating no such loss was present absent the asserted impacts. When using the earned value analysis technique, it is cautioned that the budget used to generate the earned value calculation should be carefully reviewed and verified for reasonableness.

2. Project Comparison Studies

RP No. 25R-03 identifies project comparison studies, including comparable work study and comparable project study, to determine the "should have been" productivity. To perform a comparable work study, the analyst can use information from the same project to either:

1. Estimate the lost productivity on the impacted period and then locate an analogous work activity, on the same project, that was non-impacted or lightly impacted, and could be in a different trade, and calculate its productivity; or
2. Compare productivities during the impacted period of similar but non-impacted work performed by another contractor on the same project.

Comparable project studies are used to compare the productivities of similar work activities on the project at issue and a similar project. The work selected for the comparison benchmark or similar project should be sufficiently comparable for use in the determination of the "should have been" productivity of the impacted work that cannot be calculated otherwise. Obviously, the more similar the comparisons between impacted work and the benchmark work or the impacted work on the project at issue and a similar project, the more reliable the analysis. Since the definition of similar work across trades or a similar project is rarely agreed upon by project parties, the successful use of project comparison studies can be hard to secure.

3. Specialty Industry Studies

Specialty industry studies refer to certain subject specific studies and papers on factors affecting labor productivity, such as acceleration, changes, cumulative impact and rework, learning curve, overtime and shift work, project characteristics, project management and weather. Compared to the general industry studies, the specialty industry studies are subject specific, often limited to a specific industry, and generally are based upon a small number of specific projects rather than a generalized survey of the industry.

4. General Industry Studies

Certain industry and trade associations have published studies regarding the effect of various project circumstances that can potentially reduce labor productivity. RP No. 25R-03 refers to the studies published by the Mechanical Contractors' Association of America (MCAA), National Electrical Contractors of America (NECA) and United States Army Corps of Engineers (USACE). Additionally, SCL, in its delay and disruption protocol, refers to the studies published by International Labor Organization and Chartered Institute of Building. For international projects, relevant sources of information also include general industry studies that relate to the country where the international project was located.

Unlike the subject specific studies, these general industry studies often address the potential collective productivity impact of more than one factor. Studies published by trade associations, such as MCAA and NECA, provide the impact of specific factors, but these studies are industry specific.

5. Cost-Based Methods

RP No. 25R-03 identifies three cost-based methods: (1) Total Unit Cost; (2) Modified Total Cost; and (3) Total Cost, and ranks them as the least preferable methods. Despite their low preference, they can still be accepted as viable methods to quantify lost labor productivity, provided that certain tests are passed:[4]

1. The impracticability of proving the claimant's actual losses directly;
2. The reasonableness of the claimant's bid;
3. The reasonableness of the claimant's actual costs; and
4. No responsibility for the increased costs.

Additional Considerations to Choose Quantification Methods for Lost Productivity

Although the order of preference issued by AACE International is one of the important criteria to consider when selecting the quantification methods for lost productivity, other factors also need to be considered.

Data Availability and Quality

The availability of project productivity data and the quality of data affect the choice of a method of quantifying lost productivity and the reliability of corresponding results. To perform a measured mile analysis, it is preferable to have project specific data detailing the quantities of work and the corresponding effort to complete those quantities of work. Ideally this data was collected in various areas of the project and summarized in multiple reporting periods. This will afford the analyst sufficient productivity data to compare segments of the project.

Time and Effort for the Analysis

Although the measured mile study method is the most preferred, it can be very costly. A cost benefit assessment may preclude the contractor from performing a measured mile analysis and therefore opting for a lesser preferred but less costly analysis.

Causes of Lost Productivity

When it is not possible to perform project specific studies and project comparison studies, case-specific circumstances usually influence the damage quantification method selection. The analyzer needs first to determine if the issue causing the decrease in productivity is relevant to any of the available specialty industry studies, and if not, whether it can be addressed by one of the available general industry studies. If both specialty and general industry studies are not applicable to address the issue causing lost productivity, cost-based approaches may be considered.

Prospective vs. Retrospective Analysis

It is more common that loss of productivity analyses are conducted retrospectively. It is not uncommon, however, that the project owner and contractor agree that a change in the anticipated conditions at the project has occurred, such as increased work difficulty and complexity, adverse weather conditions, work re-sequencing and/or overtime, which caused a loss of productivity. In these situations, the owner and the contractor may negotiate a change order for an anticipated loss of productivity based on a prospective estimate. Specialty and general industry studies are often used in pricing change orders. Project comparison studies can also be used if the owner accepts the contractor's supporting information on comparable work or projects.

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Required Level of Certainty

In litigation and arbitration, it is the claimant's burden to prove the lost productivity to the level of certainty, meeting the judge's, jury's or arbitrator's expectations. In a non-litigation situation, such as change order negotiations or settlement discussions, the level of certainty required for quantifying lost productivity depends on the acceptance and support needs of the opposing party.

Pitfalls in Implementing the Measured Mile Method

The original measured mile concept relies on a comparison of identical activities in non-impacted and impacted periods of the project. This is done to quantify the lost productivity resulting from the impact of the disruption events that were beyond the claimant's control. The advantage of this concept over other approaches is that it relies on actual performance achieved on the same project. Successfully implementing the original measured mile method can be a formidable challenge because it requires an impact-free period as the measured mile, which might not exist at all in many cases. In order to overcome this shortcoming, the "baseline" concept was introduced. When a non-impacted segment of the project cannot be found, a baseline may be defined using the lightly impacted segments. Since this baseline productivity may still be lightly impacted by disruption events, it is a conservative benchmark from the claimant's perspective. In this article, we use the broad meaning of measured mile method, which includes the original concept and its variations, such as the baseline method.

Quantifying lost productivity using the measured mile

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approach involves processing and reconciling data for input (usually measured in labor hours) and output (usually measured in the quantity of completed work), calculating productivity, identifying the productivity benchmark, analyzing the cause and effect relationships and measuring labor inefficiencies. There are various pitfalls in each of the steps, which may create formidable hurdles for a credible measured mile analysis. Below are the common pitfalls in implementing the measured mile method:

Flawed or Erroneous Data

A basic step in the process of preparing a measured mile analysis is to check the claimant's source level data for accuracy. There may be data entry errors and other reporting errors, such as those caused by data update delays. A plot of productivity can help reveal errors or anomalies in the data where reconciliation is necessary. Reviewing the original records, such as daily reports from all the relevant parties, may help correct data entry errors and other reporting errors. In order to maintain the reliability of the measured mile analysis, the claim consultant may need to exclude the anomalous data points, which cannot be corrected and reconciled with contemporaneous project records and reasonably explained, from the analysis.

Inappropriate Productivity Measurement

Productivity is a measured rate of output or work quantity per unit of time or effort, usually measured in labor hours. There are two primary methods for measuring the output, using percentage of work completed or using physical units of work completed. The percentage completed method relies on periodic estimates of the percentage of work completed and can be commonly seen in the pay applications and progress reports. The accuracy of the asserted percentage completed can be compromised if, for example, the contractor billed the owner ahead of its actual progress to reduce its burden on working capital or if the percent completed is skewed due to non-labor related progress billings. The physical units of work completed method is more detailed and more accurate, but relies upon the contractor accurately and consistently measuring the quantities of work performed.

Incomparable or Dissimilar Items

A common mistake in the measured mile analysis is that dissimilar work has been compared. A measured mile analysis for labor productivity requires that:

- The work performed in the measured mile and the impacted period should be substantially similar in type, nature and complexity;
- The composition and skill level of crews should be comparable;
- The measured mile should represent reasonably attainable levels of productivity; and
- The work environment should be similar.

Inadequate Cause and Effect Analysis

Since damage awards based on a measured mile analysis have been made by many judicial forums, some people mistakenly assume that any analysis labeled a measured mile analysis meets a standard of proof for lost productivity. In this article we have not focused directly on the entitlement aspect of proving loss of productivity, but any quantification method must pass the test of cause and effect analysis.

A causal link between the impacts alleged to be beyond the contractor's control and the corresponding damage quantification should be established. One common approach to demonstrate this causal link is a graph of productivity depicting the productivity evolution over time on the project, along with a correlation of potential impact events.

Similar to time dependency, it is sometimes possible to show that the productivity at an impacted location is worse than the productivity at a non-impacted location, demonstrating that the impact caused productivity loss. The work in the locations should be substantially similar in type, nature and complexity, and the crews that performed the work at the different locations should be comparable.

Failure to Understand the Premises of Existing Procedures to Determine the Measured Mile Could Lead to Unreliable Results

In some cases, identifying a measured mile through a cause and effect analysis is not readily observable. In order to aid the identification of a measured mile or baseline, construction researchers and professionals, including Zink,[5] Thomas,[6 7 8 9 10 11 12] Gulezian and F. Samelian,[13] Ibbs and Liu[14] and Zhao and Dungan,[15] have developed various procedures. Each of the methods has its underlying premises and assumptions. Applying these procedures without considering the underlying premises and assumptions may lead to an erroneous measured mile calculation.

Zink's Measured Mile Procedure

The procedures Zink proposed include:

- Plot the actual labor hours expended versus corresponding percentage of completion for the work;
- Exclude the first and last 10% from the analysis because the productivity during them may be impacted by "build up" and "tail out" effects; and
- Identify a linear or near linear portion showing the most efficient rate of progress in the 80% of the curve as the measured mile.

The measured mile selected by Zink's procedure is a continuous period of time in which the most efficient productivity is uniform or nearly uniform. In many projects, however, a measured mile period or segment with uniform or nearly uniform productivity may not exist due to the pervasive disruptions.

Thomas's Baseline Method

The original measured mile method requires the measured mile to be free or essentially free of disruptions and continuous in time, which limits its application. The baseline concept was introduced by Thomas and his collaborators in order to overcome this limitation. They asserted that a baseline period is a period of time when the contractor performs at its best, and it does not have to be a continuous, non-impacted time frame. The steps to determine a baseline proposed by Thomas and his collaborators can be summarized as follows:

- Determine the total number of reporting periods;
- The size of the baseline subset is selected as 10% of the total number of reporting periods and should not be less than five;
- The contents of the baseline subset are the reporting periods that have the highest production or output; and
- The baseline is the median of productivity value per period or the productivity average in the baseline subset.

Note that Thomas's procedure uses production instead of productivity to identify the baseline, and when the baseline is intermittent, a regression analysis may be necessary to quantify the influence of multiple disruptions. Thomas's procedure is more applicable when the input in each reporting period is uniform or almost uniform and when the reporting periods with highest production would be among the ones with best productivity. When the input in each reporting period is not uniform or the reporting periods with highest production happen to be heavily impacted, Thomas's approach could fail to determine a viable baseline or could generate a baseline that includes significant productivity loss. This could generate results that are unfair to the claimant. In addition, Thomas's procedure has also been noted for the subjective 10% size of the baseline set.

Gulezian and Samelian's Control Chart Based Method

Gulezian and Samelian proposed a statistical approach based on a process control chart for establishing a productivity baseline that reflects a contractor's normal operating performance. A control chart consists of:

- Points representing a statistic of measurements in samples taken from the process at different times;
- The mean of this statistic using all the samples is calculated;
- A center line is drawn at the value of the mean of the statistic;
- The standard deviation of the statistic is also calculated using all the samples; and
- Upper control limit (UCL) and lower control limit (LCL) that are drawn typically at three standard deviations from the center line.

To use the control chart to determine a productivity baseline, the metric on the vertical axis is productivity value, and the metric on the horizontal axis is time. The individual productivity values in corresponding reporting periods are plotted on the chart to create a time-series plot of productivity values for corresponding report periods. Since a portion of the data points may fall out

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of control with respect to the control limits, they are eliminated and the control chart is reapplied with a recalculated center line and control limits. The process repeats until no points fall out of the control limits. Then the mean productivity of the points falling within the control limits after the last iteration is used to define the baseline productivity level.

This method returns a very conservative baseline that may not reflect the attainable sustained productivity, especially when the disruptions are pervasive, and thus it would diminish the productivity loss claim. When the majority of the data points are in disruption sections, this method is not likely to determine the baseline because all data points may fall within the control limits.

Ibbs and Liu's K-Means Clustering Technique Based Procedure

K-means clustering is a method of cluster analysis that aims to partition observations into K clusters in which each observation belongs to the cluster with the nearest mean. Using the K-means clustering technique, the productivity data can be divided into two clusters, good productivity cluster and bad productivity cluster. The good productivity cluster, which may not be continuous in time, is the baseline subset determined by Ibbs and Liu's method, and the mean of the baseline subset is then selected as the baseline productivity.

One issue with the K-means clustering technique is that it does not guarantee a unique solution for baseline productivity. Another drawback of this method is the complicated calculation process, which renders it impractical for general construction professionals with no access to commercial statistical software packages.

Zhao and Dungan's Improved Baseline Method

In order to address many of the weaknesses in the above methods, Zhao and Dungan proposed an improved baseline method. In the improved baseline method, the basic principle of labor productivity loss calculation, i.e., comparing the attainable and sustained labor productivity during the non-impacted or lightly impacted periods to the productivity in the impacted periods, is central to the analysis. The baseline subset is defined as the periods in which the productivity reflects the contractor's normal attainable and sustained operating performance, which is not necessarily continuous in time. The proposed approach for determining baseline productivity comprises the following general steps:

- Segregate the data into a "good" productivity group and "bad" productivity group using the overall average productivity; and
- Determine the baseline subset from the good productivity group using basic statistical techniques, such as process control chart, and then the baseline productivity is calculated as the average productivity of the baseline subset.

An advantage of the improved baseline method is that the underlying assumption is very straightforward and easy to communicate, i.e., the more severe the disruptions, the worse the productivity. The data points

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with good productivity are normally encountered when no disruptions or light disruptions are experienced. It is reasonable to infer that the productivity observed in the sections of the work without any assignable disruptions or with light disruptions should be better than the overall average productivity, the impacted and non-impacted combined. The method can also be implemented to determine the baseline/measured mile that does not need to be continuous or non-impacted, relies on productivity and not production, does not rely on a subjective data set, generates consistent results and is relatively simple to communicate.

Conclusions

Proving and quantifying lost labor productivity in construction claims is a difficult and challenging task. As recognized by AACE International and SCL, measured mile study is the most preferred approach for estimating lost labor productivity in construction claims. In order to implement the measured mile method properly, due diligence needs to be performed to address flawed data, to select correct productivity measurement, to avoid comparing “apples to oranges,” to determine a convincing measured mile and to establish causation by demonstrating a causal nexus between lost productivity and the asserted disruptions. When data availability and other constraints make a measured mile study or other project specific studies inapplicable for a given project, the expert should try to find the most preferred method from the remaining methods listed by AACE International.

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Endnotes

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