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Finding the Elusive Measured Mile: Unconventional Case Studies

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Abstract—The measured mile method (including the baseline method) is generally the most preferred approach to prove and quantify lost productivity in construction projects, yet applying the method can be challenging. The measured mile method uses project specific data to compare the actual productivities on identical or similar work between unimpacted or least impacted and impacted periods or segments of a project. The application of the measured mile method is often abandoned due to the lack of suitable productivity data, difficulties in proving similar work, and sometimes unclear distinction between the unimpacted or least impacted and impacted periods or segments. This paper demonstrates, through case studies, the techniques used by the authors to apply the measured mile method when it may intuitively appear inapplicable. It is hoped that practitioners will be inspired by the ideas discussed in this paper and learn innovative applications for the measured mile method.

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Introduction

It is not uncommon for a contractor to experience productivity loss on construction projects. It occurs when the contractor is not accomplishing its anticipated achievable rate of production per unit of input normally measured as work hours. Labor productivity is susceptible to various factors, and it is often challenging to contemporaneously track productivity such that the root causes of lost labor productivity can be ascertained.

According to AACE®, the measured mile method is the most preferred approach to quantify lost labor productivity. The measured mile method and its variations compare the productivity for the work impacted by certain causes assignable to another party to the same or similar work when the asserted impact was minimal, or not present. The advantage of this comparison is that it relies on actual performance achieved which minimizes the reliance on bid estimate. Additionally, since the analysis compares productivity actually achieved on the same or similar work from the same project, any productivity factors caused by the claimant are neutralized because those factors would be equally considered in both data sets.

The application of the measured mile method is sometimes discouraging due to the lack of suitable productivity data, difficulties in proving similar work, and sometimes unclear distinction between the unimpacted or least impacted and impacted periods or segments. In some instances even though the application of the measured mile method or similar approaches may appear unfeasible, the principles of the comparative methodology can still be employed to perform a meaningful and plausible productivity analysis. This paper will use case studies to demostarte how to implement the measured mile method when it may intuitively appear infeasible, and the authors hope that practitioners will be inspired to be creative in finding a reasonable measured mile or baseline for productivity loss analysis.

The Measured Mile Method

The concept of the measured mile method has been applied in industry much earlier than the adoption of the term of "measured mile". It was sometimes called a "differential method" [1]. For example, the D. C. Court of Appeals accepted that kind of analysis in *U. S. Industries, Inc. v. Blake Const. Co., Inc.* [2] by stating that it was a "well established" methodology for proving damages on lost labor productivity, even though it was not called a "measured mile" analysis at that time.

Application of the terminology of "measured mile" to lost productivity quantification was first formally used by Zink, when he proposed his "measured mile" procedure in 1986 [3]. Since then, the measured mile approach has been adopted in many courts and Boards of Contract Appeals. For example, in *DANAC, Inc*. [4], the Armed Services Board of Contract Appeals (ASBCA) reached its conclusion that a "good period vs. bad period" analysis based on comparing the labor productivity during periods both affected and unaffected by disruptive events "is a well-established method of proving damages" by citing the Blake decision.

In the original concept of the measured mile method, the comparable work has to be identical or same. According to Zink's measured mile procedure, the measured mile is required to be impact free or continuous in time. These requirements limited the application of the measured mile method [5] [6].

The Broader "Measured Mile"

Similar Work

Although the original measured mile comparison concept asserts a comparison on same work and requires that the measured mile has to be impact free and, the measured mile may not be available for many projects. Some court decisions have broadened the measured mile calculation to include the comparison of similar work. In *Clark Concrete Contractors vs. GSA*, the General Services Administration Board of Contract Appeals (GSBCA) stated that it "will accept a comparison if it is between kinds of work which are reasonably alike, such that the approximations it involves will be meaningful" [7].

According to the GSBCA, as long as both the impacted and unimpacted work was "reasonably alike," a comparison could be performed to quantify lost productivity, provided that such "approximations" were "meaningful." Although no case law has been found to define the extent of the similarity between the measured mile and the impacted, an acceptable measured mile analysis usually requires the similarity in the type, nature and complexity of the work in comparison, the composition and sill level of crews, and work environment; and the selected measured mile productiivty should be reasonably attainable [6].

The Baseline Concept

Finding a perfectly unimpacted period could be a formidable challenge, because it might not exist at all on many projects. In order to overcome this obstacle, a baseline may be defined using the lightly impacted periods/segments, when an unimpacted period/segment of the project does not exist [6]. Since this baseline productivity may still be lightly impacted by disruption events beyond the claimant's control, it is a conservative benchmark from the claimant's perspective. Although the ascertainment of damages for labor inefficiency using a conservative baseline would not result in the full damage due the claimant, it provides a reasonable, meaningful and quantifiable approximation of the damage, as the criteria acknowledged by GSBCA in *Clark Concrete Contractors vs. GSA*.

Integration of Earned Value and the Measured Mile Approach

In cases where only records for labor hours are kept, but not the quantity for output achieved, then labor efficiency may be evaluated based upon the bid estimates and percentage complete per progress payment applications, or earned values and its variations. The percentage complete in the payment applications is usually estimated to represent the ratio of what was completed vs what was in the bid estimate or budget. Since it still relies on bid estimates or earning based on budget, this kind of analysis deviates from the traditional measured mile analysis which completely eliminates the reliance on the bid estimate and budget. This earned value based "measured mile" analysis needs to demonstrate the reasonableness of the bid estimate and the appropriateness of the percentage completed from payment applications.

The case of *P.J. Dick v. Principi* [8], a modified measured mile analysis was accepted by Veterans Affairs Board of Contract Appeals (VABCA). In the accepted analysis, productivities were not compared directly to find the loss of efficiency within similar work. Instead, an "efficient factor" was determined as the ratio of actual labor hours and budgeted labor hours for the similar work in the unimpacted period. The "should-have-been" labor hours for the impacted work are calculated by multiplying the budgeted labor hours with the "efficient factor." The lost labor hours is then calculated as the difference between the actual and "should-have-been" labor hours for the impacted work.

In the case of *Bell BCI Company v. United States* [9], the measured mile calculation accepted by the court was essentially the same as that in *P.J. Dick v. Principi*; the difference is that the "efficient factor" used in *P.J. Dick v. Principi* was called "reasonable productivity level" in *Bell BCI Company v. United States*. The lost productivity portion in *Bell BCI Company v. United States* was not challenged in a later appeal [10].

In the case of *James Corporation d/b/a James Construction v. North Allegheny School District*, et al. [11], the court accepted a so-called "measured mile" analysis, despite that the School District challenged it "as nothing more than the disfavored total cost approach, which subtracts the estimated costs under the contract from the actual costs incurred." In the accepted analysis, the expected labor hours in the impacted period is estimated based on the actual labor hours in the unimpacted period adjusted by the ratio between the percent complete in the two periods. Then the lost productivity is calculated as the difference between the expected and actual labor hours in the expected period. In its ruling, the court noted the following:

> "Contractor's witness, an expert in project controls and claims analysis (claim expert), explained his measured mile analysis included an earned value factor since the Project was delayed from the beginning and the work could not be easily compared. N.T. Vol. III at 157, 231. According to claim expert, this comports with industry standards. Id. at 158.
>
> Claim expert then described his methodology. Dividing the Project into two time periods, claim expert compared the percentage of work completed in each period to the number of labor hours utilized. During the first period, Contractor expended 4,279 hours to complete 41.76% of the Project. Had Contractor been able to work at the same pace during the second period, it would have expended an additional 5,967 hours [*51] to complete the remainder of the Project. However, the Project's total hours equaled 19,645 hours; therefore, Contractor used 15,366 hours to complete the second period (19,645 -5,967 [*sic*: 4,279]). Thus, the inefficient labor hours amounted to 9,366 [*sic*: 9,399] (15,366 - 5,967 = 9,366 [*sic*: 9,399]). To arrive at an earned value factor of 61%, claim expert divided the inefficient labor hours by the number of hours worked in the second period (9,366 [*sic*: 9,399] / 15,366 = 61%).

> Utilizing the earned value factor, claim expert then determined the number of inefficient labor hours Contractor and its subcontractor each experienced. The results were multiplied by the applicable hourly rates of pay. In total, claim expert valued Contractor's damages at $ 294,000."

In spite of the acceptance of these quantification methods in courts and boards, proof of entitlement and causation is still necessary. The ability of the claimant to prove entitlement depends largely on the availability of contemporaneous project documentation and the level of pervasiveness of disruptions.

Further, when necessary contemporaneous project documentation is available, the order of preference is recommended as follows:

- It is more preferable to use an impact free measured mile than a baseline that was subject to certain light impacts;
- A comparison based on same work is preferred to a comparison based on similar work;
- Productivity measurement based on physical units of work completed is more preferable than the one based on percentage complete or earned value.

Unconventional Measured Mile and Case Studies

Despite the acceptance of the measured mile method and its variations by courts and boards, it is still a challenge to properly implement them. It is not uncommon that there is insufficient contemporaneous documentation to support a measured mile study, or that the disruption was so pervasive throughout the project that a measured mile or baseline is not readily available to allow a reasonable comparison. In those instances, the measured mile appears to be nonexistent or counterintuitive, and the methodology is often abandoned.

In this section, three case studies are presented to demonstrate the selection of the measured mile/baseline, which initially appeared to be elusive. The case studies came from real projects, but for confidentiality purpose, the data was scaled and altered from the actual and the names of the involved parties have been replaced with generic names.

Case Study 1: Parking Lot Re-paving
In a shopping center renovation project, a subcontractor, "ABC," was awarded from the general contractor, "DEF," a subcontract to replace the pavement for the parking lot area. When it prepared its proposal and entered the subcontract with DEF, ABC reasonably expected that ABC would have suitable work areas to efficiently perform its work. In particular, ABC anticipated in its proposal that it would be allowed to place at least 830 tons of asphalt per day. ABC's expectations were confirmed by DEF prior to bid and were actually required in order for ABC to perform its work within the time constraints set out in the subcontract schedule. DEF was required by its subcontract to consult with ABC in the preparation of the progress schedule and

to provide ABC with project schedules as the work progressed and ABC was to work in accordance with those schedules.

During the course of construction, DEF did not obtain ABC's input into the project schedules or provide ABC with Project schedules such that ABC could plan its work efficiently; rather DEF directed ABC's work on a daily basis. The contemporaneous records document that DEF released work to ABC sporadically, in small restricted areas that were scattered at various locations around the project site. ABC's daily production was plotted over time for the period in which ABC performed the non-continuous and non-contiguous paving work, as shown in Figure 1.

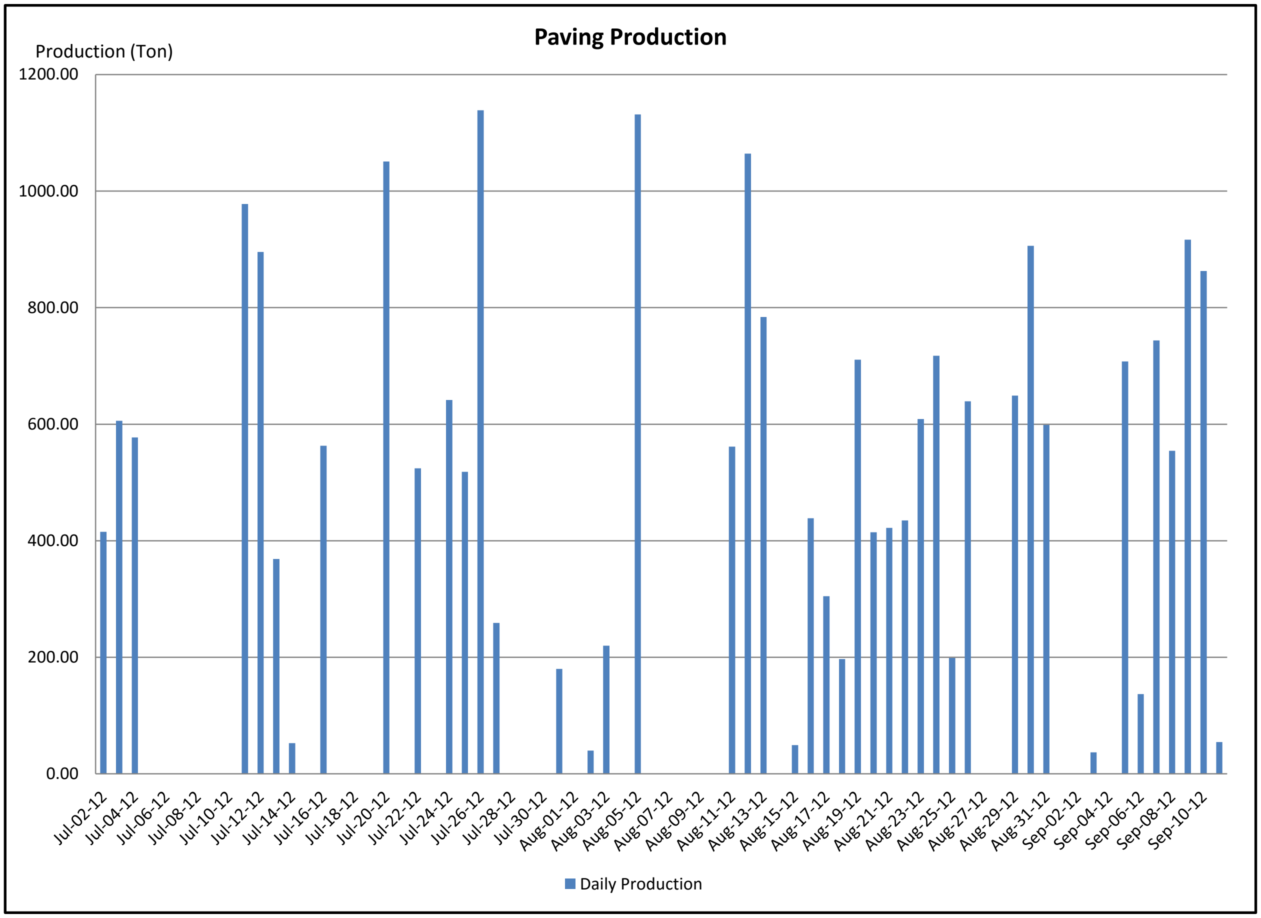

Figure 1 – Case Study 1: Paving Production

Disruptions are known to impact output of the work [6]. As shown in Figure 2, on the days that had higher production, the productivity in general was better. The days that had higher production were in general the days on which larger work areas were available to ABC. The paving productivity varies with different daily production or the size of work areas available. Therefore, the productivity from one day cannot be directly compared to the productivity from another day to measure lost productivity, because the productivity achieved could be based on different size of work areas.

Because of the non-continuous and non-contiguous work, ABC suffered lost productivity, since the as planned average productivity for paving is 7.1 ton/hour, while the actual average productivity is only 5.1 ton/hour, as shown in Figure 2.

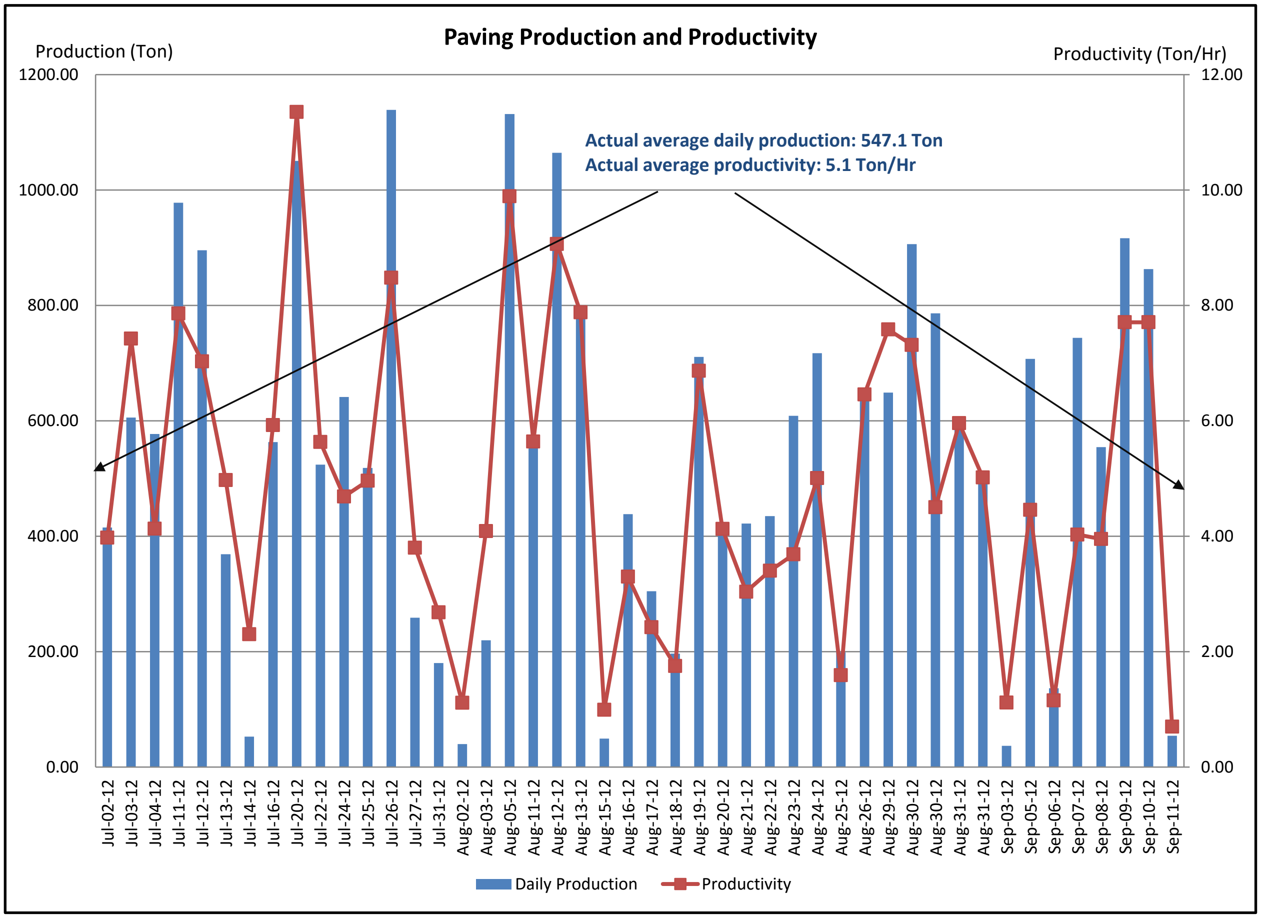

Figure 2 – Case Study 1: Paving Productivity on the Non-Zero Production Days

DEF agreed to compensate ABC for any lost productivity that ABC could reasonably prove was caused by DEF. ABC, however, was not able to readily determine a measured mile or baseline from which to quantify their damage and show entitlement. The authors were engaged by ABC to establish a reasonable and plausible productivity baseline using the production data on the project.

Since it is common for paving work to be performed in a combination of small and large areas, even without disruptions, ABC would have experienced certain high production days and certain low production days. Therefore, it is infeasible to select a productivity baseline by comparing day to day productivity, because the productivity achieved on a day to day basis was based on "dissimilar" size of work areas.

To overcome this hurdle, the authors of this paper recognized that since both ABC and DEF agreed that ABC would be able to achieve a daily average production of 830 ton without DEF's disruption, the actual productivity for the work days with an average of daily production of about 830 ton would represent a reasonable baseline to measure lost productivity. Therefore, the authors of this paper:

1. Sorted the data based on production, from highest to lowest rather than in chronological order
2. Selected the work days, from the highest production data, that when averaged best represented the planned 830 tons per day. This was established as the Baseline productivity set.
3. Calculated the average productivity in the baseline set and established that as the baseline productivity.

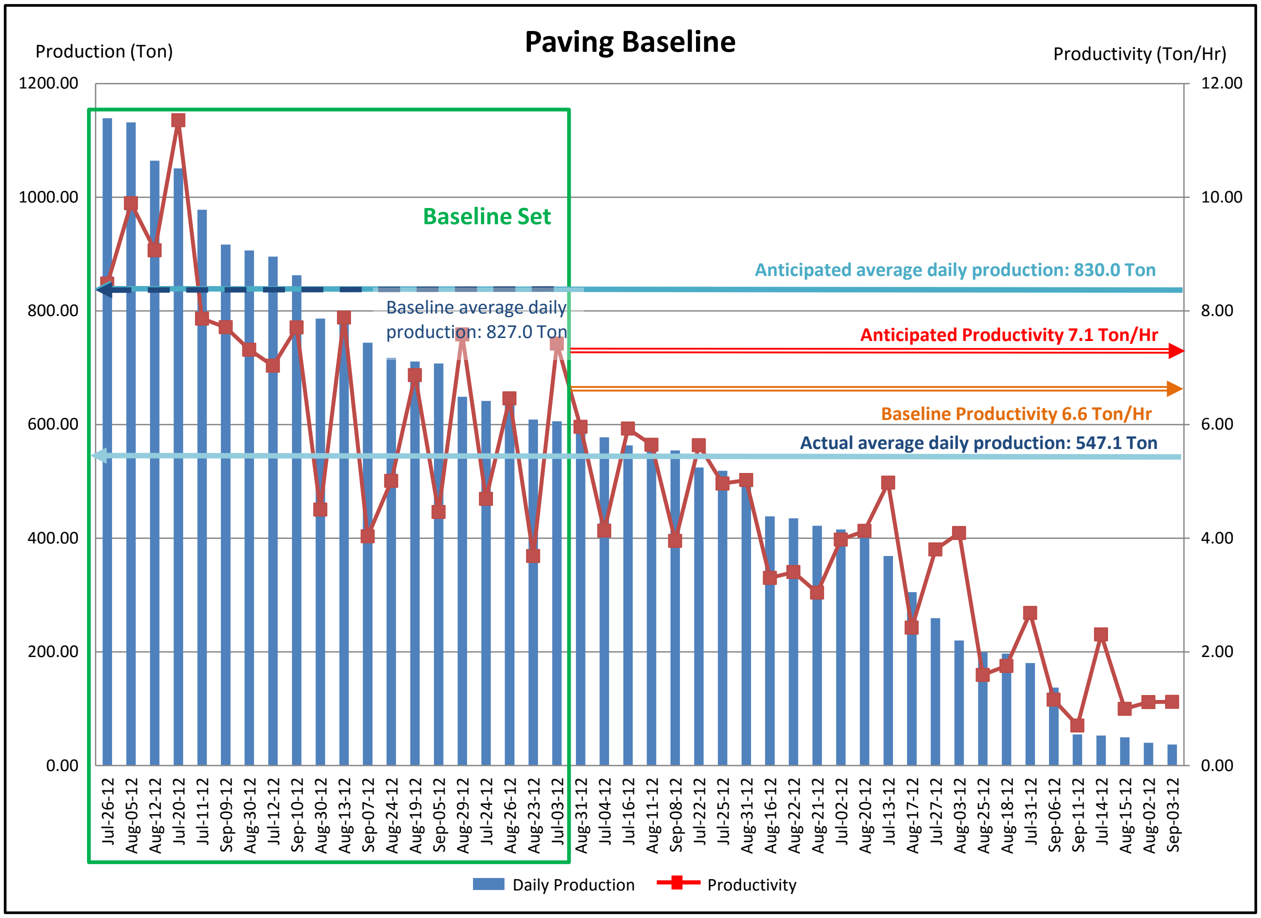

Figure 3 – Case Study 1: Paving Baseline

Following the above procedures, a baseline set was selected, which has an average daily production of 827.0 tons, as demonstrated in Figure 3. The baseline productivity is calculated to be 6.6 Ton/Hour, which is higher than the overall average productivity of 5.1 Ton/Hour, but still lower than the originally anticipated productivity of 7.1 Ton/Hour. This baseline productivity was held out as a reasonable benchmark to measure lost productivity. The authors calculated

ABC's productivity loss and further offered evidence that the work days outside the baseline set were indeed impacted by events outside of ABC's control. As a result, ABC and DEF successfully negotiated a satisfactory settlement.

Case Study 2: Piping Installation

A mechanical subcontractor "GHI" entered a subcontract with the general contractor "JKL" to install piping in different sections of the project. The sections were anticipated to be identical or extremely similar and productivity was planned to be the same throughout. At the beginning of the installation, GHI was able to perform the work as anticipated. Later, GHI's installation was disrupted by changes in routing that resulted from differing site conditions. GHI maintained detailed records for its piping installation. Based on contempraneous project information, the GHI prepared the following chart of productivity plotted over time.

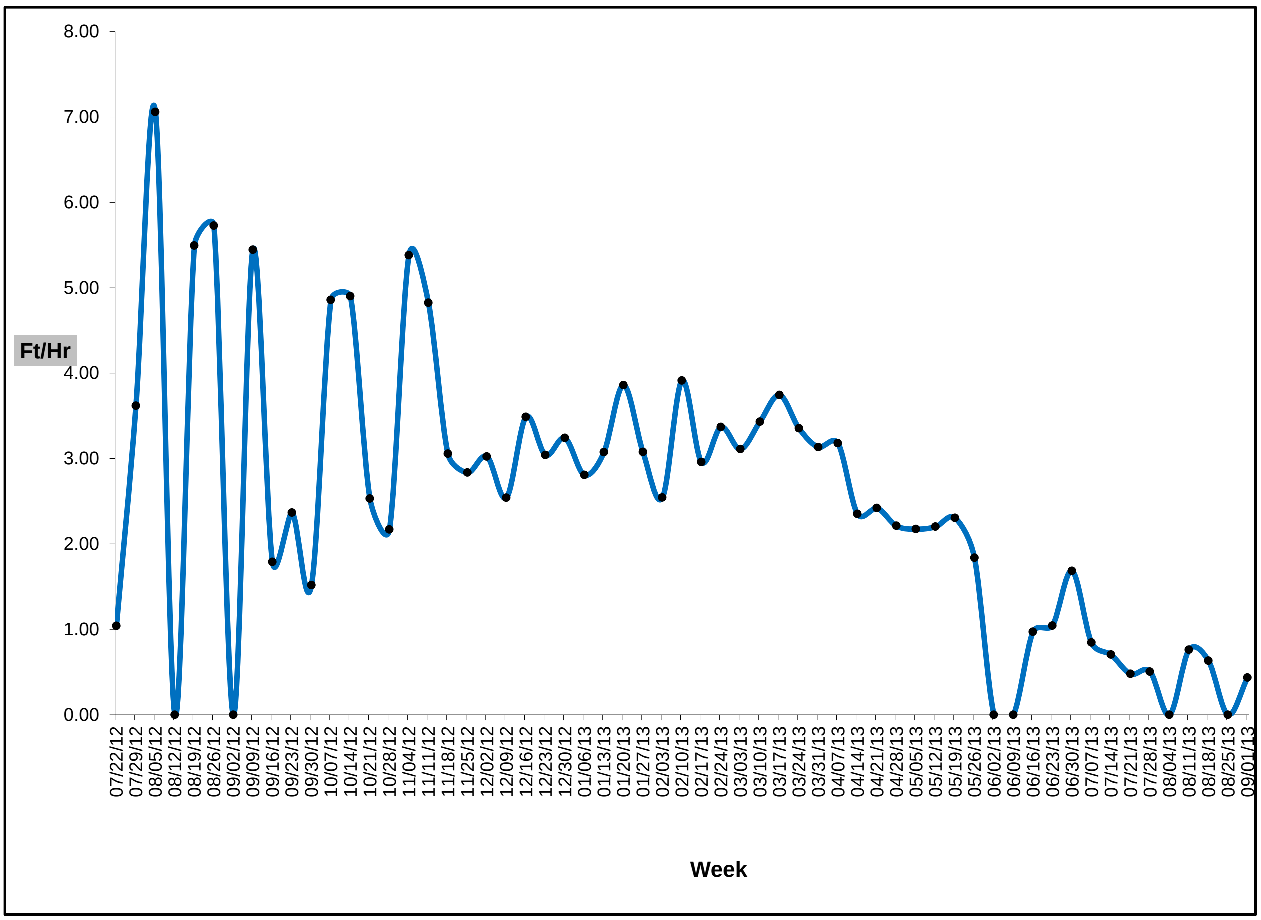

Figure 4 – Case Study 2: Piping Productivity

The declining productivity trend shown in Figure 4 generally alligned with evidence that the disruption events became more pervasive as the project advanced. The productivity fluctuation, however, was counterintuitive and GHI could not readily identify a baseline and engaged the authors to assist them.

After researching the contemporaneous data, the authors learned that the work hours used to calculate piping productivity included both the hours for the installation of the pipe hangers as well as the actual piping. GHI's piping crew installed pipe hangers first, then the installation of the actual pipe followed. GHI, however, only measured work in place based in lineal feet of pipe installed. In certain weeks, GHI's crews were expending work effort, but only installing hangers, so no units of work were measured. It was then determined that the valleys in the chart were periods when GHI was only or mostly installing hangers, while the peaks were when GHI was only or mostly installing piping.

In order to obtain a reasonable and plausible baseline to measure lost productivity, the authors considered two options:

1. Segregate the work hours of installing pipe hangers from installing pipe, and perform separate productivity analysis between piping and pipe hangers.
2. Combine the effort to install the hangers with the effort to install the corresponding pipe to match the reported quantity, and then calculate the productivity of the combined work.

GHI did not track the work hours for pipe hangers separate from piping, therefore, option 1 was not feasible. It was possible, however, using the data and contemporaneous recording of work put in place to combine the work effort. Using this combined effort, a baseline was calculated and entitlement analsyis performed that helped GHI successfully negotiated a favorable settlement.

Case Study 3: Engineering Work

In a multi-hundred million dollar international project, "MNO" was the EPC contractor to design and build a process plant. The project experienced numerous design changes that affect virtually all disciplines of the engineering work. Although the owner issued extensive change orders based on forward pricing, the EPC contractor still suffered tremendous cost overrun for cumulative impacts for the design changes, which were not, and could not be captured in the forward priced change orders. The owner recognized its liability, and was willing to negotiate a settlement with MNO based on a measured mile type method, but would reject a cost proposal based on a total cost or modified total cost aproach. The authors were engaged to perform an engineering productivity analysis and quantify lost engineering productivity.

In order to quantify lost engineering productivity, one must determine how to measure engineering productivity, i.e engineering input versus engineering output. MNO kept very good records of its engineering input by tracking the hours its engineers expended, but those hours were not directly associated with the output. In general, there are three ways to measure engineering output [12]:

- Quantities of engineering documents;
- Installed quantities or the Issued for Construction (IFC) quantities;

- Quantifiable design elements for the scope of work, such as the number of structural elements for a structure, or the number of pipe runs in a mechanical system.

The nature and characteristics of engineering work varies by discipline, and the work between various disciplines can be very different. In addition, contempraneous documentation is also a significant factor governing the choice of productivity measurement. Therefore, the authors performed different productivity measurements and comparisons for different engineering disciplines.

For example, in the structural discipline on this project, the productivity was measured as engineering hours per engineering deliverable. There were two major building structures on the project. On one of the two buildings, significant design changes were made to address differing site conditions and to incorporate owner elected changes. On the other building, only minor design changes were made. The building with less design changes was then selected as the baseline and used to measure the lost engineering productivity on the building with more design impacts.

Another example is the piping discipline. The productivity was measured as engineering hours per pipe run. A pipe run is the piping connecting two different pieces of equipment. The following exercises were performed to quantify lost productivity in the piping discipline:

1. Segregate the scope of piping engineering work into different systems;
2. Quantify engineering hours for each system;
3. Quantify pipe runs for each system;
4. Calculate piping engineering productivity for each system, measured as engineering hours per pipe run;
5. Identify unimpacted or lightly impacted systems based on the magnitude of changes, modifications, or review oversight initiated by the owner or third parties, and the engineering effort required to address them;
6. Compare the baseline productivity to the productivity in the impacted systems to quantify lost engineering productivity.

The above baseline analysis was found convincing by both MNO and the owner, which helped them successfully reach a settlement agreement.

Conclusions

The measured mile method is the preferred approach to prove lost productivity. It can sometimes be discouraging to implement when the measured mile or baseline is elusive. The authors used three case studies in this paper to demonstrate how to establish a reasonable and plausible productivity analysis when the measured mile or baseline is not readily apparent.

References

1. Revay, S. G., 1985, Impact Costs - The Validity and Calculation of Costs Related to Reduced Productivity, The Revay Report, Vol. 4, No. 2
2. *U. S. Industries, Inc. v. Blake Const. Co., Inc.,* 1982, 671 F.2d 539, 547 (D.C. Cir. 1982)
3. Zink, D. A., 1986, The measured Mile: Proving Construction Inefficiency Costs, AACE International Cost Engineering Journal, 28(4), Pages 19-21, AACE International, Morgantown, WV
4. *DANAC, Inc.,* 1997, ASBCA No. 33394, 97-2 BCA ¶ 29,184 (1997).
5. Ibbs, W., and Liu, M., 2005, Improved Measured Mile Analysis Technique, Journal of Construction Engineering and Management, 131(12), Pages 1249-1256, ASCE, Reston, VA
6. Thomas, H. R., 2007, Quantification of Economics Losses Caused by Labor Inefficiencies, Proceedings of 2007 Construction Super Conference, San Francisco, CA
7. *Clark Concrete Contractors, Inc. v. GSA,* 1999, GSBCA No. 14340, 99-1 BCA ¶ 30,280, 149,746-9.
8. *P.J. Dick v. Principi,* 2003, VABCA Nos. 5597, 5836-37, 5839-50, 5951-65, 6017-24, 6483, 01-2 BCA ¶ 31,647.
9. *Bell BCI Company v. United States,* 2008, 81 Fed. Cl. 617; 2008 U.S. Claims LEXIS 116, (April 21, 2008).
10. *Bell BCI Company v. United States,* 2009, 570 F.3d 1337 (Fed. Cir. 2009).
11. James Corporation d/b/a James Construction v. North Allegheny School District, et al., 2007, No. 1268 C.D. 2007 Pa. Commonwealth. November 30, 2007.
12. Zhao, T., and Dungan, J. M., 2012, Proving Engineering Productivity Loss, AACE® International Transactions

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