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QUANTIFYING DISRUPTION IN POWER PROJECTS

Using the Measured Mile Analysis

DISPUTE RESOLUTION

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ABSTRACT

Power plant projects involve huge capital investment employing the services of multiple trades. In addition, power plant project complexity and scale are prone to change that often disrupts the resource utilization plan resulting in lost productivity. The more preferable method of measuring and quantifying lost productivity is the Measured Mile Analysis. However, the complex, intertwined, and interdependent nature of power projects make it difficult to identify a clean and non-impacted benchmark or measured mile. Lack of proper records, information, data and documentation can prevent analysts from preparing a proper measured mile.

Accordingly, this paper describes the fundamental concepts of the measured mile analysis with recent trends in its use. In addition, the paper outlines the approach used by the authors in their professional practice to assist in quantifying lost productivity in a power plant project due to worksite disruptions. These results were subsequently used to substantiate a successful disruption claim. Finally, the paper provides suggestions to improve the implementation of the measured mile analysis.

INTRODUCTION

Global energy needs are growing with rising population and consumption trends worldwide leading to an increase in power projects. The US Energy Information Administration (EIA) forecasts an increase of 56% in global energy consumption between 2010 and 2040 [1]. Power plants require massive capital investment with EIA data estimating an average overnight capital cost of $4,240/kW for the construction of various US based power plants including coal, natural gas, nuclear, biomass, wind, solar, geothermal, municipal solid waste and hydroelectric [2]. The costs include labor and craft overtime among other direct and indirect construction costs.

From a construction perspective, the involvement of multiple disciplines, long lead equipment, heavy civil work, and the use of skilled labor, complicate power plant project delivery and increase project costs. Power projects involve the deployment of considerable labor resources that need to be utilized efficiently to maintain profit margins; control costs ensure the smooth flow of construction activity. Therefore, effective project communication plays a key role in increasing labor productivity.

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However, project complexity and unforeseen conditions coupled with insufficient front end planning can often lead to change that disrupts the resource utilization plan leading to lost productivity. Ibbs et al displayed in their research [3] that change can lead to disruptions and cumulative impacts that eventually lead to lost productivity. Labor productivity is also affected by timing [4] and quantum of change [5]. Late and a greater quantity of changes will have a more adverse effect on labor productivity. The relationship between lost productivity and change is not simple and straightforward, it is often convoluted, complex, and involves a combination of factors. Understanding and clarifying the association between lost productivity and change events is essential for the preparation of a change order request or claim that is coherent in expressing entitlement, liability, and quantifying damages. At the core of an effective disruption claim is a technically sound and intelligible identification, measurement and quantification of damages; augmented by a clear illustration depicting the causal relationship between change events and disruption impacts.

DISRUPTION, RIPPLE EFFECTS, CUMULATIVE IMPACT, AND LOST PRODUCTIVITY NEXUS

Disruptions prevent the affected party from completing their scope of work as planned or as bid [6]. Association for the Advancement of Cost Engineering International (hereinafter AACE) [7] defines disruption as “An interference (action or event) with the orderly progress of a project or activity(ies). Disruption has been described as the effect of change on unchanged work and manifests itself primarily as adverse labor productivity impacts.” Factors that can cause labor productivity loss [8] [9] include but are not limited to the following:

+ Change in work or work sequence
+ Scheduled overtime
+ Low morale
+ Poor training
+ Poor supervision
+ Absenteeism
+ Inadequate planning and project management
+ Adverse weather conditions

The above list is by no means exhaustive and labor productivity can be affected by various other factors. AACE published Recommended Practice No. 25R-03 Estimating Lost Labor Productivity in Construction Claims lists 25 possible causes [10] for dips in labor productivity. Lost productivity often results from the project stakeholders' actions and/or inactions. Lost productivity can have single or multiple causes. Depending on the nature of the activity impacted and its predecessor and successor relationship(s), other activities can be impacted as a consequence of lost productivity. Change is a common cause of disruption that leads to lost productivity which in turn can cause further change. The complex nexus of change, disruption, and lost productivity can be explained further by cumulative impacts and ripple effects.

The negative influence an activity or event exerts on a succeeding downstream activity is known as ripple effect. For instance, a change in scope of work for a main contractor can adversely affect the execution of a subcontractor's scope of work [11]. Ripple effects from individual disruptions can combine and amplify the negative impacts [12]. At this point it becomes a challenge to distinguish individual impacts from the combined impact of all events put together. A direct causation analysis connecting the change event (cause) with resulting damages (impact) becomes difficult to perform [13]. Hence such impacts should be viewed as a 'cumulative impact' that may exceed the sum of discrete individual impacts [14] [15]. Cumulative impacts are hidden and invisible initially, but eventually reveal themselves through lost productivity and lower margins [16].

THE MEASURED MILE ANALYSIS

Labor productivity estimates are generally prepared by bidding teams during the project bid phase. These calculations are based on company records, labor productivity rates from similar work performed, historical databases or a combination of various methods [17]. However, labor productivity is an intrinsically variable component of an estimate susceptible to the negative influence of several factors. Labor productivity can vary with location, trade, experience and complexity of the work among other factors [18]. The variable nature of labor productivity makes it difficult to establish standard rates of production and estimated labor productivity. Claims based on estimated labor productivity are usually successful only when actual labor productivity data is unavailable [15]. Whenever possible, it is recommended that a disruption claim be based on actual labor productivity records [19].

The preferable method for measuring and quantifying lost productivity is the measured mile analysis [6]. The measured mile analysis is based on the use of project records. It is widely considered as an acceptable means of quantifying lost productivity due to disruption. The measured mile analysis estimates disruption damages resulting from lost productivity by comparing an activity(ies) during the disrupted period of performance with identical or substantially similar activity(ies) during a period of unaffected performance.

The objective of the measured mile analysis is to analyze the labor productivity of an impacted activity throughout the project and identify a benchmark or 'measured mile' when the project progressed without any or limited negative influence. This measured mile will then serve as a basis for comparing impacted labor productivity and determining lost man-hours for the impacted activity. A generic process for the development of a measured mile analysis is as follows:

> ***The objective of the measured mile analysis is to analyze the labor productivity of an impacted activity throughout the project and identify a benchmark or 'measured mile' when the project progressed without any or limited negative influence.***

IDENTIFICATION AND TRACKING OF IMPACTED ACTIVITIES

For any given project once a potential disruption event is identified, responsible site personnel should monitor activities that could be potentially impacted. Key personnel involved could be project controls engineers, construction managers, superintendents, and project managers. By adopting a proactive approach and maintaining thorough records, trends in labor productivity can be observed and deviations identified on a timely basis.

COMPILATION AND ANALYSIS OF LABOR PRODUCTIVITY DATA

Once disruption events and impacted activities are identified, labor productivity data should be compiled and analyzed. Labor productivity data can be extracted from contemporaneous project documents such as daily reports, weekly reports, progress records, payment applications and certified payroll [21]. Analysis of labor productivity data should include the validation and reconciliation of project documentation.

IDENTIFICATION OF MEASURED MILE

Once labor productivity data is compiled and analyzed, results should be scrutinized to identify trends over a project's timeline. Non-impacted periods of a project should be marked and labor productivity during these time periods calculated. The measured mile is the progress of an activity, or production recorded, over a non-impacted period of a project. The labor productivity of the measured mile is a benchmark for comparing labor productivity recorded during a disruption impacted period. Figure 1 depicts a labor productivity graph and measured mile for an example construction project.

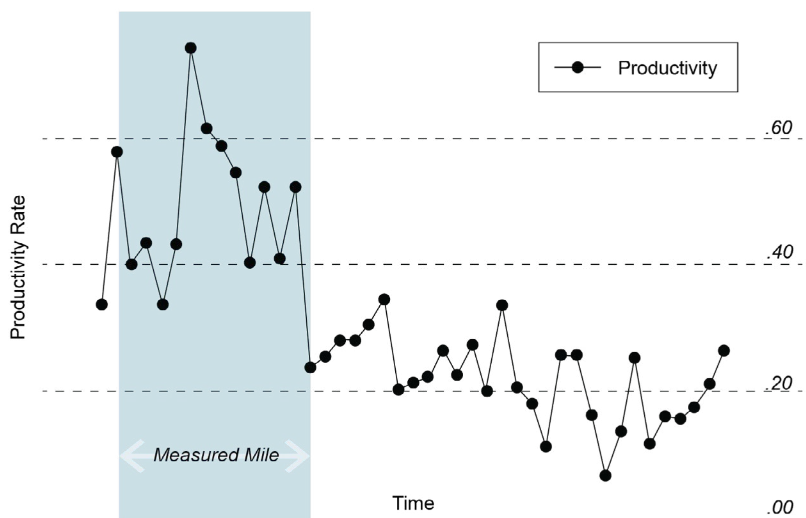

Figure 1 - Labor Productivity and Measured Mile Identification Example

Utmost care should be taken to ensure that the measured mile is technically sound. The measured mile should have limited or no negative influence arising from disruption events. Learning curve effects should also be accounted for, and the initial variability in labor productivity associated with learning a new task should be worked out.

It is recommended that the measured mile be based off a reference period of unaffected performance. However, it is often difficult to obtain a clean and non-impacted measured mile that extends over a sufficiently long reference period [22]. In such situations, a measured mile that is least impacted by disruption events can be identified and used as a basis for determining lost productivity [20]. Occasionally identifying benchmark labor productivity for identical work is challenging due to unavailability of project records. Responsible personnel should ensure that the lost productivity calculations are based on similar, if not the same activity. For example, labor productivity for the installation of 3" diameter piping should not be compared with labor productivity for the installation of 84" diameter piping. In certain exceptional cases, triers of fact, such as a court or arbitration board, considered claims that calculated lost productivity based on a measured mile dissimilar to the impacted activity [23]. In a case that involved the construction of military facility [24] [25], the court declared that "That loss of productivity of labor resulting from improper delays caused by defendant is an item of damage for which plaintiff is entitled to recover admits of no doubt; nor does the impossibility of proving the amount with exactitude bar recovery for the item". There are several similar examples where dispute resolution forums have permitted estimates based on incomplete information, which in these cases, was the best possible information available [26]. The paradox that plagues lost productivity claims is that the very factors responsible for a decrease in labor productivity can also make it difficult to maintain project records considered as satisfactory evidence for dispute resolution boards [27].

CALCULATION OF LOST MAN-HOURS

Once a measured mile is determined, labor productivity during the impacted period of performance can be compared to the labor productivity of the measured mile. A graphical representation of labor productivity throughout the project is helpful to determine the impacted and the non-impacted periods of performance. Figure 1 depicts an example of a labor productivity graph for a construction project.

The timing of disruption events can be marked on this graph to provide a more distinct indication of the impacted phase of the project. Labor productivity data should be used for the calculation of 'lost' hours of productivity or Lost Man-Hours. This information is compiled for each impacted activity corresponding to each disruption event(s). Some useful formulas for calculating labor productivity and lost productivity are as follows:

EQUATION 1

$$\text{Productivity} = \frac{\text{Units}}{\text{Work - Hours}} \quad \text{OR} \quad \frac{\text{Total Output}}{\text{Total Work Hours}} \quad [10]$$

For a project with activities impacted by disruption event(s), labor productivity for the impacted and non-impacted periods should be calculated separately. The non-impacted labor productivity pertains to the measured mile.

$$\text{Productivity for Non-Impacted period} = P_{MM}$$

$$\text{Productivity for Impacted period} = P_{IP}$$

The PMM and PIP labor productivity values can be used to calculate the Productivity Factor.

EQUATION 2

$$\text{Productivity Factor, P. F} = \frac{P_{IP}}{P_{MM}}$$

Using the Productivity Factor, the lost man-hours for an activity can be determined,

EQUATION 3

$$\text{Lost Manhours} = TH_{IP} * (1 - P.F)$$

TH_{IP} is the total hours of the impacted activity where labor productivity is P_{IP}.

SUMMARIZATION OF LOST PRODUCTIVITY INFORMATION AND CORRESPONDING TOTAL DAMAGES

A summary depicting the impacted activities and corresponding Lost Man-hours is prepared. The labor hourly rates are then factored in to quantify the total damages incurred as a result of lost productivity. The summary should include two more sections that will precede the quantification of damages. These are the Liability and Causation sections [29].

The Liability section explains entitlement of the affected party on the basis of particular contract clauses that justify the application for damages. The Causation section of the summary explains the relationship nexus between disruption impacts and disruption events, which occurred as a result of the other party's actions. This section is essential to apportion responsibility based on the actions and/or inactions of stakeholders.

CASE STUDY: DISRUPTION CLAIM FOR A GLOBAL POWER PLANT PROJECT

The case study is based off a multi-million dollar power plant construction project completed on December 2010 (hereinafter the Project). The Project was located in Central America and involved stakeholders from multiple countries. The Project scope of work included construction of a 200 MW diesel power plant and related buildings. Figure 2 summarizes the scope of work.

SCOPE OF WORK

- ☐ Power House
- ☐ Boiler Room
- ☐ Radiator Areas
- ☐ Stack System
- ☐ Exhaust Gas Area
- ☐ Pump House
- ☐ Chemical Laboratory
- ☐ Tank Farm
- ☐ Transformer Station
- ☐ Guard House

Figure 2 - Project Scope of Work

The scope of work was divided into three contracts:

+ Civil Works Contract
+ Mechanical Work Contract (hereinafter Mechanical Contract); and
+ Tankage Contract

For the purpose of the case study, we focused solely on the Mechanical Contract. The Mechanical Contract was awarded to a subcontractor as a fixed price contract. As part of the Mechanical Contract, the subcontractor was required to perform piping installation throughout the Project. Piping installation consisted of installation, welding, and grinding of pipe elements. The subcontractor was responsible for the provision of construction labor and associated supervision per contractual requirements. Hence, achieving and maintaining a consistent level of labor productivity was essential to the successful and profitable completion of the contract.

Based on project records, the subcontractor assigned crews comprised of piping foremen, pipe fitters, welders, grinders, and helpers to perform piping installation. In order to keep track of piping installation progress, the subcontractor maintained daily piping installation reports. Piping installation progress was measured in diameter-inches. A diameter-inch is a unit used to measure welded joint quantities, and is obtained by multiplying the number of welded joints by pipe diameter [30]. For example, two joints welded on a ten inch diameter pipe equal twenty diameter inches.

After issuance of the Notice to Proceed, the Project was impacted by several disruption factors due to the actions and/or inactions of the main contractor. Consequently, piping installation labor productivity was severely impacted resulting in large quantities of unproductive man-hours. The factors that impacted piping installation labor productivity included:

+ Drawings and Design Deliverables – Late deliveries did not comply with the Project schedules and introduced changes during, and very late into construction.
+ Material Deliveries – Untimely deliveries by the main contractor did not comply with the Project schedule and Mechanical Contract schedule provisions.
+ Change Work – Revisions, additions, and deletions to the Mechanical Contract scope of work.

The timing of drawing submissions and design deliverables varied greatly from the contract schedule. In addition, the drawing deliverables exceeded the original count per the Mechanical Contract by approximately 105%. Furthermore, the drawings and design deliverables increased the piping installation quantities by approximately 42%.

Material deliveries were approximately six (6) months late having a highly disruptive impact on labor productivity. In addition, as a result of the extensive and untimely changes to the Mechanical Contract scope of work, the contractor increased its planned man-hours to perform the piping installation by approximately 51%. The combined effect of the aforementioned disruption events impacted the piping installation labor productivity resulting in large quantities of unproductive man-hours. As the piping installation activity was not on the Project's critical path, there was no impact to overall project duration.

The Measure Mile analysis was used to evaluate and quantify lost man-hours. The steps taken to analyze, evaluate and quantify the disruption impacts were as follows:

IDENTIFICATION AND TRACKING OF IMPACTED ACTIVITIES

As a result of late design and material deliverables, and excessive change associated with the piping installation, the subcontractor's labor productivity was impacted during the Project. The subcontractor was able to identify these impacts during the early stages of the Project. Therefore, Project personnel were proactive in recording labor productivity.

COMPILATION AND ANALYSIS OF LABOR PRODUCTIVITY DATA

The daily piping installation reports included critical information such as type of pipe, pipe diameter, and number of welds done per day. Based on that information, the subcontractor was able to calculate the total diameter-inches installed per day. In addition, the subcontractor maintained weekly reports that included the number of hours worked by the piping installation crews. The weekly reports listed the number of hours spent installing pipe on a weekly basis. The hours were listed against crew profession such as piping foremen, piping workers, welders, grinders, and helpers. The weekly report man-hours were reconciled to the contractor's certified payroll. Based on the daily piping installation reports, weekly reports, and certified payroll, the labor productivity rate for piping installation during the Project was calculated. Figure 3 depicts the piping installation labor productivity rate throughout the Project.

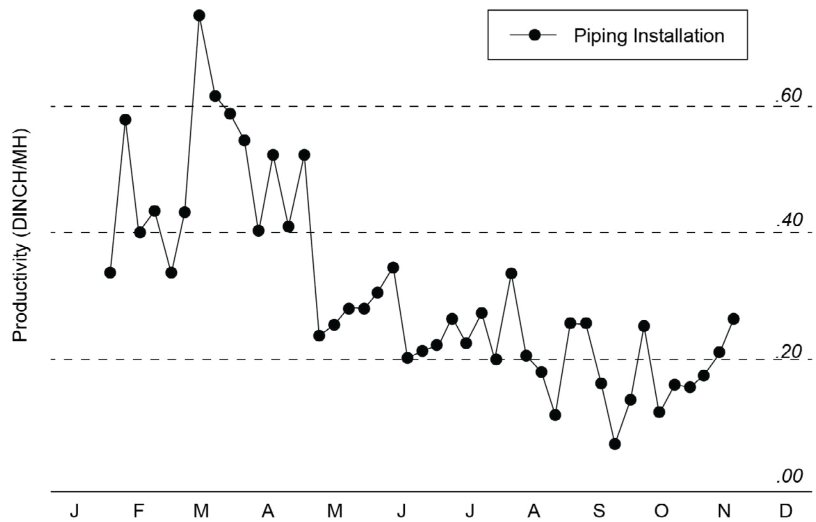

Figure 3 - Piping Installation Labor Productivity Rate

Based on Figure 3, it was evident that labor productivity was significantly impacted on and after May 2010.

IDENTIFICATION OF MEASURED MILE

The evaluation and analysis of Project records indicated that labor productivity was impacted throughout the project as a result of late design deliverables, late material deliverables and changed work. The effects of these disruption events can be seen in decreased labor productivity after May 2010. Therefore, labor productivity from the end of January 2010 to the beginning of May 2010 was used as the measured mile. Figure 4 summarizes the measure mile analysis performed.

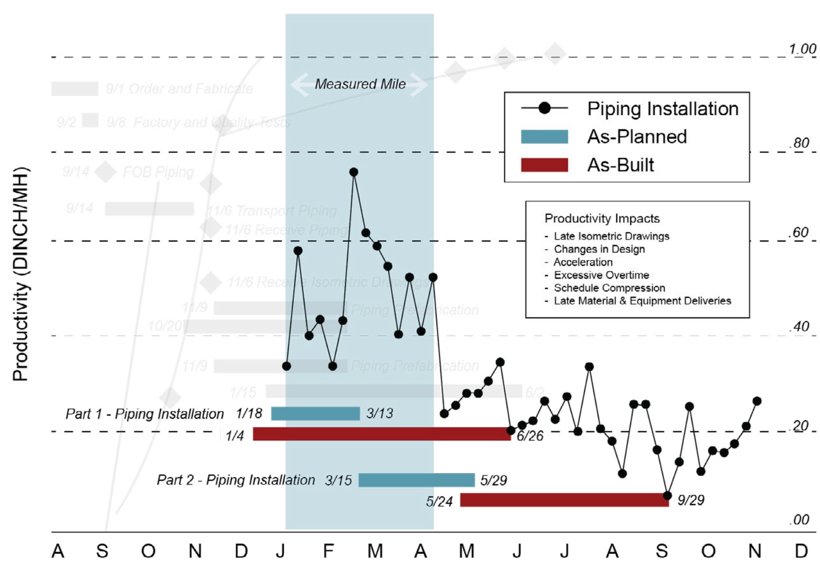

Figure 4 - Measured Mile Analysis

The measured mile extended for over three (3) months, which was approximately 10% of the total project duration and approximately 32% of the total piping installation duration.

CALCULATION OF LOST MAN-HOURS

The disrupted period began immediately after the measured mile period. From Figure 4, it is evident that the labor productivity rates for the piping activity decreased during the impacted period. A study was done to compare the labor productivity rates of the impacted period to that of the measured mile period to determine the total number of lost man-hours. The average labor productivity rates for the measured mile and the impacted period of performance were the following.

Productivity for Non-Impacted period = P_{MM} = 0.25 DINCH/MH

Productivity for Impacted period = P_{IP} = 0.16 DINCH/MH

The PMM and PIP labor productivity values were subsequently used to calculate the Productivity Factor.

Productivity Factor,P.F = P_{IP}/P_{MM} = 0.16 / 0.25 = 0.64

Finally, the lost man-hours during the impacted period of performance were calculated using the Productivity Factor and the total man-hours during the impacted period,

Lost ManHours = TH_{IP} * (1 - P.F) = 182,411 * (1 - 0.64) = 65,668 MH

Based on the measured mile analysis performed, it was determined that approximately 65,650 man-hours were lost as a result of the main contractor’s actions and/or inactions. Same process was performed to identify the man-hours lost per craft. Figure 5 summarizes the man-hours lost per craft.

CRAFT	MAN-HOURS LOST
Piping Foreman	387
Pipe Fitters	16,889
Welders	9,806
Grinders	34,322
Helpers	4,264
Total Lost Man-Hours	65,668

Figure 5 – Total Man-Hours Lost per Craft

SUMMARIZATION OF LOST PRODUCTIVITY INFORMATION AND CORRESPONDING TOTAL DAMAGES

The combined effect of the disruption events severely impacted labor productivity resulting in large quantities of lost man-hours. Based on the measured mile analysis performed, it was determined that approximately 65,650 man hours were lost as a result of the main contractor’s actions and/or inactions. In order to price the damages, the lost man-hours per craft were multiplied by their corresponding hourly rate as per the Mechanical Contract.

In addition, a summary was prepared substantiating the measured mile analysis. The summary included a causation analysis substantiating the disruption events and the impacts they had on the contractor's piping installation work performance. The summary report included but was not limited to the following information:

+ Contract Review and Analysis
+ Design Deliverables (Mechanical Contract/Baseline vs. Actual)
+ Drawing Count (Mechanical Contract/Baseline vs. Actual)
+ Material Deliverables (Mechanical Contract/Baseline vs. Actual)
+ Changed Quantities (Mechanical Contract/Baseline vs. Actual)
+ Man-hours (Planned/Baseline vs. Actual)
+ Man-hours Validation Analysis
+ Measured Mile Analysis
+ Entitlement Analysis
+ Mechanical Contract Hourly Rates per Craft

After several months of negotiation, an agreement was reached between all parties prior to the commencement of mediation.

RECOMMENDATIONS: USING THE MEASURED MILE ANALYSIS FOR LOST PRODUCTIVITY CLAIM

The measured mile analysis continues to be the most widely accepted method used to quantify damages resulting from lost productivity [10]. However, it is important to avoid the erroneous use of the method that could yield inaccurate results that are bound to be rejected. Common mistakes while performing a measured mile analysis include but are not limited to the following:

+ Wrong formulas to calculate productivity
+ Use of inappropriate units of measurement
+ Use of dissimilar activities
+ Lack of clear records
+ Insufficiently long reference period for measured mile
+ Lack of adjustment for contractor caused disruptions

A robust measured mile analysis begins with the adoption and implementation of best practice project controls systems for a particular project or company-wide for a contractor or sub-contractor. An advanced system that utilizes modern day monitoring technologies will also assist responsible supervisors in identifying negative trends or changes in labor productivity [31]. The project controls system must use a clear work breakdown structure that employs suitable units to measure production for various activities. The measured mile analysis draws heavily from the production data and calculated labor productivity rates recorded during the course of a project, which in turn affects the quality of the analysis [11] [20]. Hence, the presence of accurate and comprehensive project records greatly contribute to the success of disruption claims that use the measured mile analysis to quantify damages.

ASTM E2691 Standard Practice for Job Productivity Measurement offers a starting point for contractors to develop a robust system to record and monitor labor productivity [32]. Standardization of project records should be based on recommended practices that are tweaked to suit specific company and project requirements. In addition, the development of a proactive change management mindset will also assist in the maintenance of project records. This helps by conveying the significance of project records to project management teams. It is recommended to use documents that are less likely to be tampered with, and whenever possible, use documents that are certified by more than one project stakeholder [29]. The use of resource loaded schedules also helps in determining the labor productivity for various activities [11].

A prerequisite for the preparation of a successful measured mile analysis is a correct and thorough understanding of the method. Project records alone cannot ensure a successful claim, and a fair and knowledgeable analyst with a proven track record should be a part of the claims preparation team [19]. An expert can provide useful recommendations for any lost productivity claim by combining knowledge of construction processes, cost accounting, and construction law. It is essential to select the best suited strategy for the identification of the measured mile; decide whether the measured mile should be based on contemporaneous project records, or past performance of the contractor on similar work, or industry reports on labor productivity [19].

CONCLUSIONS

Disruption is defined as “An interference (action or event) with the orderly progress of a project or activity(ies). Disruption has been described as the effect of change on unchanged work and manifests itself primarily as adverse labor productivity impacts.” [7]. Factors than can cause labor productivity loss include but is not limited to change in work, scheduled overtime, low morale, poor supervision, poor training, absenteeism, inadequate planning, late deliverables and adverse weather conditions.

The measured mile analysis has proved to be a useful method for the quantification of lost productivity due to disruptions. However, it should be carefully used to quantify damages and support claims successfully. The intent of this paper is to describe the fundamental concepts of the measured mile analysis. In addition, the paper outlines the approach used by the authors in their professional practice to assist in quantifying lost productivity in a power plant project due to worksite disruptions. These results were subsequently used to substantiate a successful disruption claim.

BIBLIOGRAPHY

1. U.S. Energy Information Administration. EIA projects world energy consumption will increase 56% by 2040. U.S. Energy Information Administration Official Website. [Online] July 25, 2013. [Cited: October 18, 2013.] http://www.eia.gov/todayinenergy/detail.cfm?id=12251.

2. US. Energy Information Administration. Updated Capital Cost Estimates for Electricity Generation Plants. [Online] April 2013. [Cited: September 9, 2013.] http://www.eia.gov/forecasts/capitalcost/pdf/updated_capcost.pdf.

3. Quantified Impacts of Project Change. Ibbs, M.ASCE, William, Nguyen, Long D. and Lee, Seulkee. 1, s.l. : Journal of Professional Issues in Engineering Education and Practice, 2007, Vol. 133. ISSN: 1052-3928/2007/1-45-52.

4. Impact of Change's Timing on Labor Productivity. Ibbs, William. 11, s.l. : Journal of Constructiong Engineering and Management, 2005, Vol. 131. ISSN: 0733-9364/2005/11-1219-1223.

5. Quantitative Impacts of Project Change: Size Issues. Ibbs, William. 3, s.l. : Journal of Construction Engineering and Management, 1997, Vol. 123..

6. Cushman, Robert F., et al., et al. Proving and Pricing Construction Claims. New York, NY : Aspen Publishers, 2001. ISBN-13: 978-0-7355-1445-4.

7. AACE International. Cost Engineering Terminology. s.l. : AACE International Recommended Practice No. 10S-90, 2013.

8. Action-Response Model and Loss of Productivity in Construction. Halligan, David W., Demsetz, Laura A. and Brown, James D. 1, s.l. : Journal of Construction Engineering and Management, 1994, Vol. 120. ISSN: 0733-9364194/0001-0047.

9. Intergraph. Factors Affecting Construction Labor Productivity. s.l. : Hexagon, 2012.

10. AACE International . AACE Recommended Practice No. 25R-03 - Estimating Lost Labor Productivity in Construction Claims . 2004.

11. Pickavance, Keith. Delay and Disruption in Construction Contracts. London, UK : Thomas Reuters, 2010. ISBN 978 0414 045 200.

12. Thinking about Delay, Disruption, and the Cumulative Impact of Multiple Changes. Ibbs, William. s.l. : Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 2013, Vol. 5.

13. Lost Productivity: Claims for the Cumulative Impact of Multiple Change Orders. Jones, Reginald M. 1, s.l. : Public Contract Law Journal, 2001, Vol. 31.

14. Dealing with Cumulative Impact Claims. Martinez, Emelyn Warde. CDR.12, Dubai, UAE : AACE International Transactions, 2010.

15. Long, Richard J. and Carter, Rod C. Cumulative Impact Claims. Littleton, CO : Long International, Inc. , 2013.

BIBLIOGRAPHY (CONTINUED)

16. Nelson, Derek. The Analysis and Valuation of Disruption. s.l. : Hill International, Inc, 2011.

17. Federal Highway Administration. Guidelines on Preparing Engineer's Estimate, Bid Reviews and Evaluation. U.S. Department of Transportation Federal Highway Authority. [Online] January 20, 2004. [Cited: November 5, 2013.] http://www.fhwa.dot.gov/programadmin/contracts/ta508046.cfm#s4.

18. Dell'Isola, Michael D. Detailed Cost Estimating. [book auth.] American Institute of Architects (AIA). Architect's Handbook of Professional Practice. s.l. : Wiley, 2003.

19. Measured-Mile Principles. Ibbs, William. 2, Oakland, CA : Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 2011, Vol. 4.

20. Practical Issues in Loss of Efficiency Claims. Dieterle, Robert A. and Gaines, Thomas A. s.l. : AACE International Transactions, 2010, Vol. CDR.07.

21. Measured Mile Labor Analysis. Calvey, Timothy T. and Zollinger, William R. s.l. : AACE International Transactions, 2003, Vol. EST.03.

22. Improved Measured Mile Analysis Technique. Ibbs, William and Liu, Min. 12, Berkeley, CA : Journal of Construction Engineering and Management, 2005, Vol. 131.

23. P.J. Dick Inc. v. Veterans Affairs. VABCA No. 6080, 2001.

24. Luria Brothers & Company, Inc. v. The United States. 177 Ct. Cl. 676; 369 F. 2d 701, 1966.

25. Cushman, Kenneth M. Advanced Construction Claims Workshop: The Law, Analysis, and Pricing of Delays and Disruptions. New York, NY : Practising Law Institute, 1990.

26. Clark Concrete v. General Services Administration. GSBCA No. 14340, 99-1 BCA 30,280, 1999.

27. Shea, Thomas E. Proving Productivity Losses in Government Contracts. Public Contract Law Journal. Washington, D.C. : Ropes & Gray, 1988-1989.

28. Measured Mile Analysis and International Mega-Projects. Crowley, Dan and Livengood , John C. s.l. : AACE International Transactions, 2002, Vol. CDR.05.

29. Update on Proving and Pricing Inefficiency Claims. Jones, Reginald M. s.l. : The Construction Lawyer, 2003.

30. Project Baseline Consultants. Piping Progress Measurement (In Dia and in Meter). Project Baseline Consultants. [Online] 1999. [Cited: November 23, 2013.] http://www.projectbaseline.in/downloads/Piping-Progress-Measurement-(In_Dia_and_In_Meter).pdf.

31. Promoting Power Plant Construction Project Productivity. Picard, Dr. Johannes E. and Hutcheson, John. s.l. : AACE International Transactions, 2008, Vol. PM.11.

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