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Avoiding the Pitfalls in Implementing the Measured Mile Method

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Abstract— The measured mile method, a widely accepted approach involved in lost productivity claims, compares the productivities of identical or similar work between non-impacted or least impacted and impacted segments of a project. The procedures to implement a measured mile study usually include data processing, productivity measurement, measured mile identification, cause and effect analysis, and loss of productivity calculation. Despite the popularity of the measured mile method, incorrect implementation can cause failures in proving and quantifying loss of efficiencies for claims that resulted from the impacts legitimately assignable to other parties. This article discusses some common errors and pitfalls in implementing the measured mile method in loss of efficiency claims, which should be avoided. A case study, demonstrating how to turn a loss of efficiency claim from implausible and counterintuitive to well supported with causation by correcting a few subtle errors in implementing the measured mile method, is also presented.

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Introduction

Though loss of productivity (efficiency), or disruption claims are common in construction disputes, proving lost productivity is one of the most challenging areas in construction claims. Loss of productivity occurs on a project when the contractor is prevented from achieving its otherwise attainable level of productivity for the same type of work. There are numerous circumstances and events on construction projects that impact productivity, which may be attributed to the owner, the contractor itself, or a third party. For a contractor to successfully recover damages due to lost productivity from a responsible party, the contractor will need to demonstrate the cause of the lost productivity and the cause and effect relationship between the impact events and the declined productivity. Among various methods available for quantifying lost productivity, the measured mile method (including its variation, such as the baseline method) is by far the most accepted approach [1].

The wide acceptance of the measured mile method does not overshadow the challenge in its implementation. Quantifying lost productivity using the measured mile 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 solid measured mile analysis. Just labeling an analysis a measured mile analysis does not make it so. This paper will discuss common pitfalls in implementing the measured mile method, and then a case study is used to demonstrate how a difference can be made by correcting the subtle mistakes in measured mile analyses.

The Measured Mile Method

The original measured mile method relies on a comparison of identical activities in unimpacted and impacted periods of the project. The advantage of the measured mile method over other approaches is that it relies on performance actually achieved on the same project. Whether the actual performance is better or worse than what the contractor estimated, effectively becomes irrelevant. The underlying assumption that a measured mile analysis relies on is that if all else is essentially the same, except for the identifiable impact, then the impact caused the loss of productivity. If the impact events are proven to be the responsibility of the owner or other parties, then the lost productivity associated with the events are compensable to the claimant.

Successfully implementing the original measured mile analysis can be a formidable challenge, because it requires an impact free period as the measured mile, which often may not exist. In order to overcome this shortcoming, Thomas and his collaborators introduced the “baseline” concept and made various applications [2] [3] [4] [5] [6] [7] [8]. When an unimpacted segment of the project cannot be found, a baseline may be defined using lightly impacted segments. Since this method compares severely impacted productivity to lightly impacted productivity, the result is conservative from the claimant's perspective. Recent court decisions have signaled the acceptance of the baseline method as a means to quantify lost labor productivity [1].

In this paper, we use the broad meaning of the measure mile method, which includes the original method and its variations, such as the baseline method.

Pitfalls in Implementing the Measured Mile Method

In this section, common pitfalls of implementing the measure mile method to prove and quantify lost labor productivity are discussed along with suggestions on how to deal with these vulnerabilities.

Flawed or erroneous data

It is not uncommon to see some measured mile analyses performed without verifying that the claimant's data was reasonably accurate. A measured mile analysis based on erroneous data will be unreliable and severely discredited.

The errors or inconsistencies in contractor records of some projects can be significant. A plot of productivity may 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 also 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 preclude the anomalous data points, which cannot be corrected and reconciled with contemporaneous project record and reasonably explained, from the analysis.

Inappropriate productivity measurement

Productivity is a measure of the rate of output per unit of time or effort usually measured in labor hours [1]. There are two primary methods for measuring the output, using percentage complete or using physical units of work completed. The percentage complete method relies on periodic estimates of the percentage of work completed. This information is commonly available in the pay applications and progress reports. The physical units of work completed method is more detailed and may be more precise, however the data needed for that method is not as commonly available.

In some measured mile analyses, earned value or the requested amount on payment applications for the completed work was used to measure output. If the earned value or requested payment has a good proportional relationship with the completed quantities, it may be viewed as a measurement equivalent to the physical units of work completed. However, requested payments or earnings do not always have a proportional relationship with the completed quantity, because earning may include non-labor related items, such as material, engineering, and subcontract amount. Therefore, if a good proportional relationship between earned value or requested amount and the actual completed quantity cannot be established, then an analysis relying on such data would be more appropriately viewed as an earning analysis, but not a measured mile labor productivity analysis.

<u>Incomparable or dissimilar items</u>

A common mistake in the measure mile analyses is that incomparable or dissimilar work has been compared. A measured mile analysis for labor productivity requires that [8]:

- 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;
- The work environment should be similar.

A fundamental basis for a measured mile analysis is that all else is essentially the same, except for the impacts. Therefore, it is imperative that similar work be compared. A good practice for a claim consultant is to make sure that the data points in the measured mile analysis were from similar work, and eliminate those that were not.

<u>No or inappropriate cause and effect analysis</u>

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. This is untrue, and only a measured mile analysis that is properly done meets a standard of proof.

In some measured mile analyses, all inefficiencies during the impacted periods were assumed to be the result of a single disruption event. This is almost seldom the case as it is common that there are multiple disruption events occurring during the course of the project. Some of them are attributable to the owner or third party while others may be self-inflicted. If the self-inflicted impacts in the impacted period are different than those in the baseline period, then they have to be excluded from the damage calculation.

If productivity loss can be demonstrated to be concurrent with an alleged cause, a causal link between the two may be established. A graph of productivity depicting the productivity evolution over time on the project, along with a time line of potential impact events, is commonly used. A visual illustration of the relationship between the period of low productivity and impact is usually an indispensable part of the expert's ability to prove causation.

Similar to time dependency, it is possible to demonstrate that the productivity at an impacted location is worse than the productivity at an umimpacted location, demonstrating the impact caused productivity loss. The work in the locations should be substantially similar in type, nature, and complexity; and the crew that performed the work at the different locations should be comparable.

<u>Failure to understand the premises of existing procedures</u>

A measured mile or baseline can be unobvious, especially when disruptions are pervasive during construction. Therefore, it can typically be identified in conjunction with a cause and effect analysis. Construction researchers and professionals, including D. A. Zink [9][10], H. R. Thomas [2][3][4][5][6][7][8], R. Gulezian and F. Samelian [11], and W. Ibbs and M. Liu [12], have developed various procedures to aid the identification of a measured mile or baseline. Each of the methods has its underlying premises and assumptions. Applying these procedures without considering the underlying premises and assumptions may lead to erroneous measured mile calculation.

In Zink's method, the curve of actual labor hours versus percentage of completion for the work is plotted and then the buildup and tailout sections of that plot are excluded. A linear or near linear portion of the chart showing the most efficient rate of progress is identified to be the measured mile. The measured mile must be free or essentially free of disruptions and continuous in time.

Thomas and his collaborators introduced the baseline concept. A baseline period is defined as a period of time when the best productivity is achieved, but Thomas's baseline procedure requires the baseline to be selected from the reporting periods with highest production. Thomas's baseline procedure then selects the 10% of the total reporting periods with the highest production or output as the baseline productivity period. This may result in a baseline that is intermittent, thus requiring a regression analysis to quantify the influence each of multiple disruptions had, according to Thomas [8]. Thomas' assumption is that the disruption impact per output unit is relatively lower in the periods in which best production is achieved. This assumption may be valid in some cases, however the production achieved on construction projects can be influenced by many factors which leaves the analysis vulnerable. For example, when the input in each reporting period is not uniform, it is possible to find reporting periods with high production, yet they also happen to be heavily impacted. In that case Thomas's approach could select a baseline that includes significant productivity loss, which could be unfavorable and unfair to the claimant. Another vulnerability in the Thomas approach was highlighted by Ibbs and Liu, when they noted that the 10% criteria is unsupported and highly subjective.

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. When the disruptions are pervasive throughout the project, the contractor's normal operating performance is affected. In such a case the data points would be evenly spread across the mean and the method would return a meaningless baseline so close to the mean that it would result in a determination that no productivity loss occurred.

In an attempt to overcome the shortcomings of having a subjective percentage used in selecting the baseline, Ibbs and Liu proposed a K-means clustering based method to separate the productivity data into different groups. The average value for the group with the best productivity would serve as the measured mile or baseline. Although Ibbs and Liu's method could select the best baseline based on the available data, and was claimed to be more objective and neutral, the baseline selected by Ibbs and Liu's method may include data points that do not represent the best-sustained productivity. Other issues in using the means clustering based method to identify a productivity baseline include the possibility of having multiple solutions even with the same *K* value, and the difficulty of communicating such a complicated calculation process.

Case Study

An accurate calculation of loss of productivity by contractors is usually complex and a challenge for project management, especially in large scale projects. The advances in measured measure methodologies, as well as court decisions attesting their reliability, have strengthened the ability of cost engineers and claim professionals to prove lost labor productivity, if those methodologies are properly applied. Below a case study is used to demonstrate how errors in implementation of the measured mile analysis can yield implausible and counterintuitive results that render the analysis ineffective. We show that even though a contractor had a valid claim, their mis-application of the measured mile study caused it to be rejected. Then we demonstrate how to correct those errors and properly implement the measured mile calculation such that it would be effective.

The XYZ project in this case study is a multi-hundred million dollar design-bid-build transportation project, involving underground utility relocations, road and bridge expansion, and rail and station construction. Although the data is based upon an actual claim, for confidentiality reasons, productivity data used here was scaled and altered from the actual.

In the initial request for equitable adjustments (REA) submitted to the owner, the contractor asserted the project experienced multiple owner responsible impacts, which caused tremendous cost overrun. The contractor provided a list of over 1,000 impact events, such as utilities conflicts and unidentified utilities, and provided various measured mile calculations for utility work, site preparation, road work and track work. The contractor asserted that the impacts were pervasive throughout the project, and thus adopted Thomas's baseline procedures, i.e.

- 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 5;
- The contents of the baseline subset are the reporting periods that have the highest production or output;
- The baseline is the average productivity using the total labor hours and installed units in the baseline subset [8].

For the purpose of demonstration, only one of the many measured mile calculations performed by the contractor is discussed here. The contractor's productivity calculation for an underground pipe installation is summarized in Table 1. Using Thomas's baseline procedure, the contractor selected months 1 and 9 as the baseline set, and calculated the baseline productivity to be 1.40 hr/ft. The baseline productivity was then compared to the productivity in all the other reporting periods, and the productivity loss per unit quantity was determined to be 1.54 hr/ft. Then the lost productivity per linear foot was applied to the total impacted quantities asserted by the contractor, and the total productivity loss on the underground pipe installation was determined to be 13,478 hrs, as shown in Table 2. As a part of Thomas's baseline method, a regression analysis is recommended for the intermittent baseline; thus the contractor performed a regression analysis between the number of impact events and the labor productivity, as shown in Figure 1.

Month	1	2	3	4	5	6	7
Quantity(ft)	1,381	586	897	1,010	1,005	1,296	-
Labor Hours	945	3,794	4,474	3,893	1,326	3,000	1,557
Productivity (hr/ft)	0.68	6.47	4.99	3.85	1.32	2.31	#DIV/0!
No. of Impacts	16	5	15	17	4	8	2
Month	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Quantity(ft)	572	1,558	213	121	1,182	89	543
Labor Hours	136	3,158	410	-	1,265	130	712
Productivity (hr/ft)	0.24	2.03	1.92	0.00	1.07	1.46	1.31
No. of Impacts	4	13	8	2	4	0	0
Month	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Quantity(ft)	234	255	-	-	274	457	n/a
Labor Hours	688	-	745	-	3,020	521	n/a
Productivity (hr/ft)	2.94	0.00	#DIV/0!	#DIV/0!	11.02	1.14	n/a
No. of Impacts	0	0	0	0	0	0	n/a

Table 1 – Productivity Data for Underground Pipeline in Contractor's REA

	Baseline M. 1&9	Impacted Other M.	Lost Productivity per ft	Lost Productivity
Quantity(ft)	2,939	8,734		1.54hr/ft × 8,734 ft = 13,478 hrs
Labor Hours	4,103	25,671		
Productivity (hr/ft)	1.40	2.94	1.54	

Table 2 – Contractor's Productivity Loss Calculation for Underground Pipeline

The productivity loss claim on the underground pipeline was rejected by the owner for failing to establish the causal nexus between the claim and the asserted impacts and flaws in productivity calculation, though some merit for a productivity loss claim was acknowledged.

Among the basis for rejection by the owner were the following flaws:

- There were obvious reporting errors in productivity data used by the contractor. Installed quantities without labor hours were found in some reporting periods, while labor hours with no installed quantities were found in others.
- Anomalous productivities, such as 0 hr/ft, were calculated in some reporting periods. The contractor also mistakenly used "#DIV/0!" as zero in the regression analysis.
- The selected baseline periods have more impact events than most of the other periods that were asserted to be impacted.
- The contractor did not account for its own productivity impacts.
- No significant correlation is shown between productivity and number of impact events. After the data points with infinite productivity were eliminated from the regression analysis as shown in Figure 2, the regressed line indicates a trend that the productivity slightly improves as the number of impact events increases, which is counterintuitive.

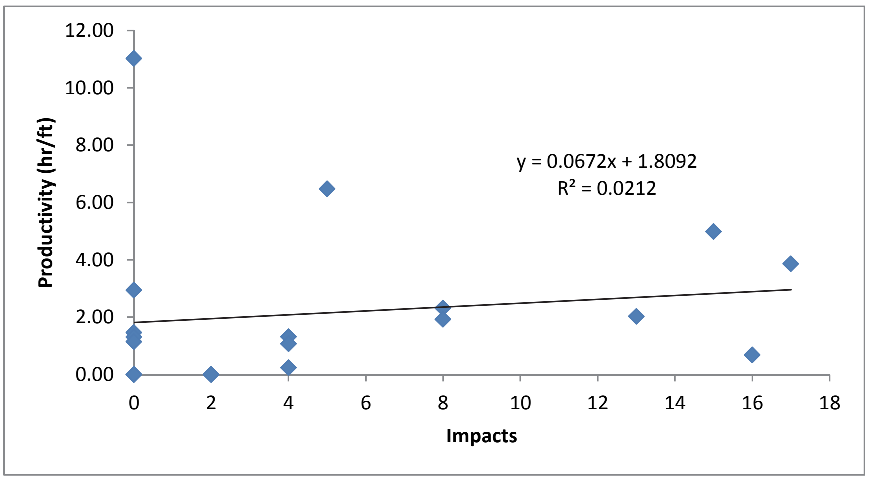

Figure 1 – Contractor's Regression Analysis between Productivity and Impacts

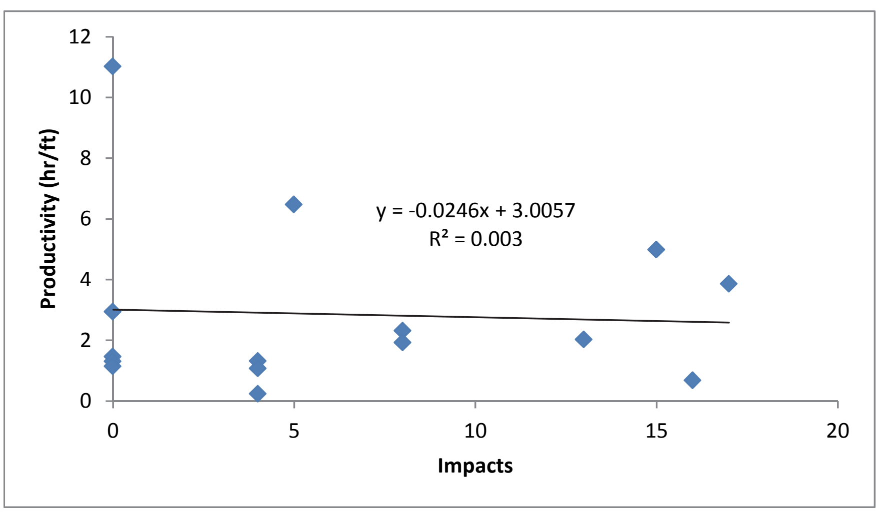

Figure 2 – Regression Chart after Eliminating Data Points with Infinite Productivity

To address these flaws a thorough review of contemporaneous project documentations was necessary to correct the anomalous data and an independent lost productivity calculation for underground pipeline was performed along with a cause and effect analysis.

- It was determined that due to the timing of data reporting, the output was not always directly associated with the output in a given month which was contributing to the anomalous data points. For example, some quantities were mistakenly reported in month 1 before they were actually completed. Also, most of the impact events claimed in month 1 actually occurred at the very end of the month and would not have affected the productivity in month 1. Therefore, due to the timing of the data reporting, months 1 and 2 were combined as a single reporting period to provide a more accurate data point.
- Likewise, the input and output data reporting in months 7 and 8 and months 10 and 11 were found to be mis-matched, so each of those two months were combined as a single reporting period to obtain a more accurate productivity data point.
- At the end of month 9, it was determined that the engineer of record issued a bulletin to address the procedures to deal with the impact events related to the underground pipeline installation. The procedures significantly streamlined the process of dealing with the various utility conflicts and unmarked utilities, thus minimizing the impact to the contractor. As a result, the impact events in subsequent months 10, 11, and 12 were dissimilar in severity to those reported prior to the bulletin, and thus they were not considered as impacts in the regression analysis.
- The project records documented that the contractor installed deficient pipes in month 15, which required significant re-work to correct in months 15 through 20. Since these periods involved contractor self-inflicted impacts, they were excluded from the productivity loss calculation.

The corrected productivity calculation is summarized in Table 3. The months following the bulletin and before the self-inflicted impacts, i.e. months 10 through 14 were selected as the baseline.

The baseline productivity was calculated to be 1.17 hr/ft. The baseline productivity was then compared to the productivity in months 1 through 9, and the productivity loss per unit quantity was determined to be 1.51 hr/ft. Then the lost productivity per linear foot was applied to the total impacted quantities in months 1 through 9, and the total productivity loss on the pipelinwas determined to be 12,551 hrs, as shown in Table 4. Note that months 15 through 20 have been excluded from productivity loss calculation for contractor self-inflicted impacts.

The lost productivity calculation results between the contractor and Delta appear to be close, but the two calculations were fundamentally different in terms of whether a causal nexus was established between the impacts and the lost productivity. The baseline Delta selected reflects a less impacted subset compared to the impacted reporting periods. Also Delta has redone the regression analysis between the impacts and the labor productivity, as shown in Figure 3. The correlation coefficient is about 0.4, which is much higher than what were shown in Figures 1 and 2. A strong correlation between impacts and productivity indicates that although impact events varied in magnitude and significance, as the number of impacts increases, the productivity likely would decline.

Month	**1 & 2**		**3**	**4**	**5**	**6**	**7 & 8**
Quantity(ft)	1,967		897	1,010	1,005	1,296	572
Labor Hours	4,739		4,474	3,893	1,326	3,000	1,693
Productivity (hr/ft)	2.41		4.99	3.85	1.32	2.31	2.96
No. of Impacts	21		15	17	4	8	6
Month		**9**	**10 & 11**		**12**	**13**	**14**
Quantity(ft)		1,558	334		1,182	89	543
Labor Hours		3,158	410		1,265	130	712
Productivity (hr/ft)		2.03	1.23		1.07	1.46	1.31
No. of Impacts		13	~~8~~	~~2~~	~~4~~	0	0
Month	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Quantity(ft)	~~234~~	~~255~~	~~-~~	~~-~~	~~274~~	~~457~~	~~n/a~~
Labor Hours	~~688~~	~~-~~	~~745~~	~~-~~	~~3,020~~	~~521~~	~~n/a~~
Productivity (hr/ft)	~~2.94~~	~~0.00~~	~~#DIV/0!~~	~~#DIV/0!~~	~~11.02~~	~~1.14~~	~~n/a~~
No. of Impacts	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~n/a~~

Table 3 – Corrected Productivity Calculation for Underground Pipeline

	Baseline M. 10-14	**Impacted M. 1-9**	**Lost Productivity per ft**	**Lost Productivity**
Quantity(ft)	2,148	8,305		1.51hr/ft × 8,305 ft = 12,551 hrs
Labor Hours	2,517	22,283		
Productivity (hr/ft)	1.17	2.68	1.51	

Table 4 – Corrected Productivity Loss Calculation for Underground Pipeline

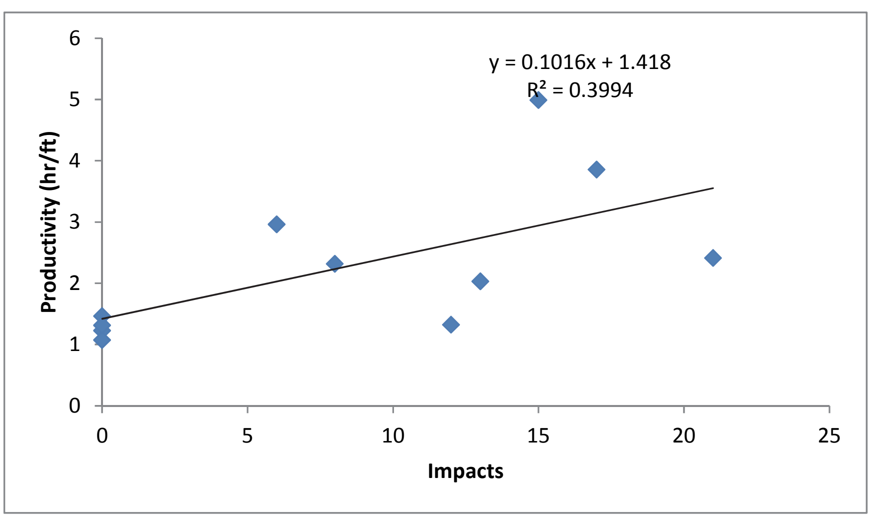

Figure 3 – Regression Chart after Correcting Productivity Calculation

Conclusion

This paper discussed the pitfalls in implementing the measured mile method to calculate lost labor productivity in construction claims. Avoiding these pitfalls can help cost engineers and claim professionals properly calculate labor productivity, identify baseline, analyze causation and calculate lost productivity. On the flip side, if your measured mile analysis falls in the pitfalls discussed in this paper, the claim based on that analysis is unlikely to go far in the dispute resolution processes, and arbitrations and litigations.

References

1. AACE International, Recommended Practice No. 25R-03, *Estimating Lost Labor Productivity in Construction Claims,* AACE International, Morgantown, WV (2004)
2. Thomas, H.R., and I. Zavrski, *Construction Baseline Productivity: Theory and Practice*, Journal of Construction Engineering and Management, Vol. 125, No. 5, ASCE, Reston, VA (1999): p 295-303
3. Thomas, H.R., D.R. Riley, and V.E. Sanvido, *Loss of Labor Productivity Due to Delivery Methods and Weather*, Journal of Construction Engineering and Management, Vol. 125, No. 1, ASCE, Reston, VA (1999): p 39-46
4. Thomas, H.R., and V.E. Sanvido, *Quantification of Losses Caused by Labor Inefficiencies: Where is the Elusive Measured Mile?,* Construction Law and Business, Vol. 1, No. 3, Aspen Law & Business, New York, NY (2000): p 1-14
5. Thomas, H.R., and V.E. Sanvido, *Role of the Fabricator in Labor Productivity*, Journal of Construction Engineering and Management, Vol. 126, No. 5, ASCE, Reston, VA (2000): p 358-365
6. Thomas, H.R., M.J. Horman, R.E. Minchin, and D. Chen, *Improving Labor Flow Reliability for Better Productivity as Lean Construction Principle*, Journal of Construction Engineering and Management, Vol. 129, No. 3, ASCE, Reston, VA (2003): p 251-261
7. Thomas, H.R., R.E. Minchin, and D. Chen, *Improving Role of Workforce Management in Bridge Superstructure Labor Productivity*, Journal of Management in Engineering, Vol. 19, No. 1, ASCE, Reston, VA (2003): p 9-16
8. Thomas, H.R., *Quantification of Economics Losses Caused by Labor Inefficiencies*, Construction SuperConference, San Francisco, CA (2007)
9. Zink, D.A., *The Measured Mile: Proving Construction Inefficiency Costs*, Cost Engineering Journal, Vol. 28, No. 4, AACE International, Morgantown, WV (1986):p 19-21
10. Zink, D.A.; *Impacts and Construction Inefficiency*, Cost Engineering Journal, Vol. 32, No. 11, AACE International, Morgantown, WV (1990):p 21-23
11. Gulezian, R., and F. Samelian, (2003), *Baseline Determination in Construction Labor Productivity-loss Claims*, Journal of Management in Engineering, Vol. 19, No. 4, ASCE, Reston, VA (2003): p 160-165.
12. Ibbs, W., and M. Liu, *Improved Measured Mile Analysis Technique*, Journal of Construction Engineering and Management, Vol. 131, No. 12, ASCE, Reston, VA (2005): p 1249-1256.

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