فرآیند جامع آنالیز تاخیرات در پروژه

جلسه دوم آنلاین:

تصدیع و کاهش بهره‌وری

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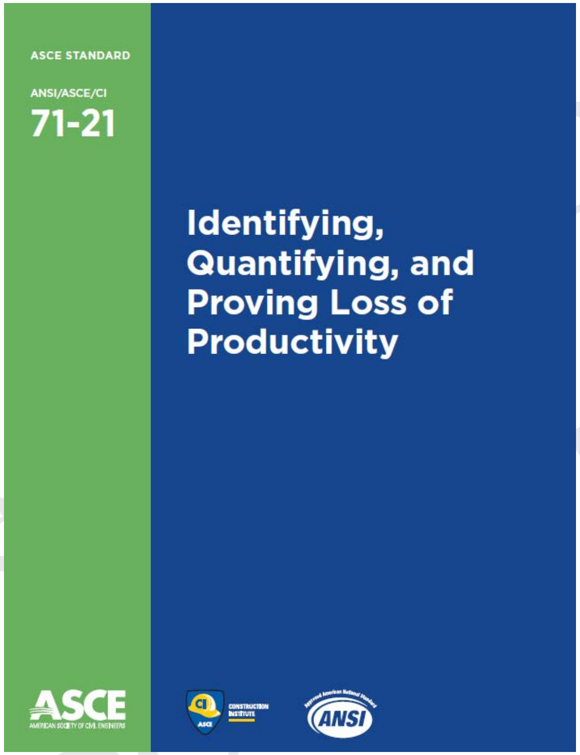
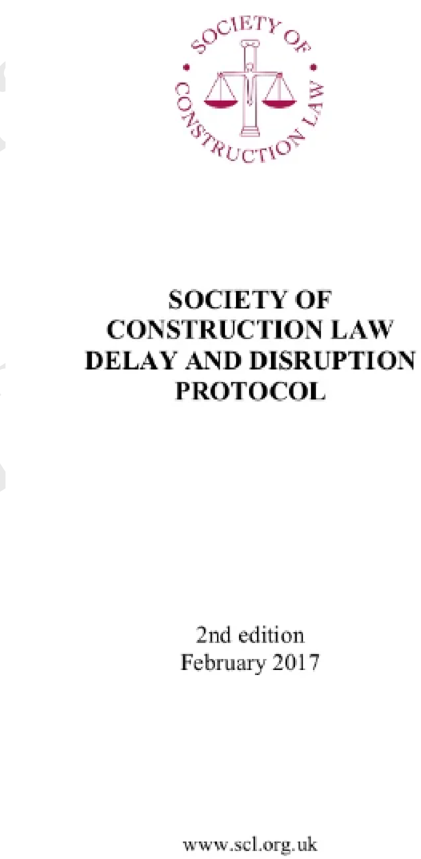
What we will learn?

- Introduction
- Inefficiency, Lost Productivity Costs or Disruption
  - Basics
  - Identifying productivity loss
  - Establishing Recoverable Loss Productivity
  - Quantifying Productivity Loss

Introduction

Primary reference





SOCIETY OF CONSTRUCTION LAW
DELAY AND DISRUPTION PROTOCOL

2nd edition
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www.scl.org.uk

Why we need this?

- ASCE

Total project cost is composed of subcosts including

- Labor,
- Materials,
- Construction equipment,
- Subcontractors,
- Design, and
- Overhead.

Which one has more variability?

Why we need this?

- ASCE

The cost of labor is typically the component with the greatest variability, and it is determined by a combination of factors including

- Work scope definition,
- Quantities,
- Design,
- Crew composition,
- Hourly crew costs, and
- Crew productivity.

Why the variability here is important?

Why we need this?

- ASCE

Because labor is such a significant portion of overall project costs, a loss of productivity typically results in a significant amount of increased costs and reduced contractor profit. The purpose and use of this standard is to help prevent, minimize, and resolve disputes over identifying, quantifying, and proving the loss of productivity on a project.

What does productivity mean?

Productivity

- ASCE

The term *productivity* is most often presented in this standard in the context of construction craft workers. However, the concepts and principles presented herein are also applicable to the productivity of designers, subcontractors, fabricators, construction equipment, and managers.

How productivity could vary?

Productivity

- ASCE

Productivity can vary from the level anticipated in the budget because actual factors encountered on the project may differ from factors anticipated at the time of bid for any number of reasons. These disruptive factors may include

- Schedule delay,
- Acceleration,
- Differing site conditions,
- Out-of-sequence work,
- Labor availability,
- Stacking of trades,
- Excessive overtime,
- Seasonal and weather conditions,
- Design changes,
- Cumulative impact of multiple changes,
- Poor project management,
- Diluted supervision, and
- Other causes.

Why is this challenging?

Productivity

- ASCE

Identifying the causes of loss of productivity is challenging if those measurements and discussions did not occur during the project. It is also challenging to identify causal factors if the project participants are no longer available to assist in reconstructing the project history. Disagreements over the quantification, cause, and liability for productivity loss may become contentious during the project and result in legal disputes and lawsuits.

Why the standard needed?

Standard

- ASCE

For these reasons, there is a need to establish processes and standards by which the causes and resultant loss of productivity can be identified, captured, documented, quantified, and supported. This standard presents such guidelines. These guidelines should, however, be viewed in the context of the industry sector, project delivery method, contract requirements and size, schedule, sophistication and normal practice of the parties, their behavior during the project, and other project-specific factors. Because one size does not fill all cases, they are advisory, not mandatory.

Who should read this document?

Intended readership

- ASCE

As stated, the purpose of this standard is to help minimize and resolve disputes over identifying, quantifying, and proving the loss of productivity on a project. The intended readership is attorneys, consultants, contractors, designers, educators, owners, researchers, and other project participants interested in the basics of identifying, quantifying, and proving loss of productivity from a construction and project management perspective. The associated contractual, legal, and accounting issues are complex, and this standard touches only lightly on those aspects from a project management perspective.

Who should read this document?

Inefficiency, Lost Productivity Costs or Disruption

(Basics)

Definition

- SCL Protocol:

18. Disruption claims

Compensation may be recovered for disruption only to the extent that the contract permits or there is an available cause of action at law. The objective of a disruption analysis is to demonstrate the loss of productivity and hence additional loss and expense over and above that which would have been incurred were it not for the disruption events for which the Employer is responsible.

Definition

- In construction, **'disruption'** may be defined as
  - An **interruption** to flow, continuity or sequence of planned work
  - A bringing of **disorder** to an activity or project

SCL Protocol:

18.1 Disruption (as distinct from delay) is a disturbance, hindrance or interruption to a Contractor's normal working methods, resulting in lower efficiency. Disruption claims relate to loss of productivity in the execution of particular work activities. Because of the disruption, these work activities are not able to be carried out as efficiently as reasonably planned (or as possible). The loss and expense resulting from that loss of productivity may be compensable where it was caused by disruption events for which the other party is contractually responsible.

And:

In the construction context, disrupted work is work that is carried out less efficiently than it would have been had it not been for the cause of the disruption.

Definition

- SCL Protocol:

18.3 That lost productivity will result in financial loss in carrying out the impacted work activities. However, not all lost productivity is subject to compensation. The Contractor may recover compensation for disruption (whether under the contract or for breach of contract) only to the extent that the contract permits or there is an available cause of action at law.

Definition

- ASCE

Key Principles

- *Production is a measure of output only.*
- *Productivity is a measure of production output per measure of input.*

What is the difference?

- Actual productivity
- Planned productivity

Which one is preferred for productivity?
Labor-hours or monetary?

Definition

- ASCE

When measuring actual productivity, actual labor-hours (input) are preferred to be used and compared with actual work completed (output). However, there may be instances where complete labor data are not available and use of monetary units or an earned value measure over time is the best alternative. Cumulative output over cumulative input at different points during the project is a measure of the calculated to-date productivity.

What methods are mentioned in ASCE?

Methods for measuring the quantity of output completed?

- ASCE

Different methods are available for measuring the quantity of output completed, including

- Physical units, where the quantity of work can be reliably measured, for example volume of concrete placed, length of conduit installed or pipe placed, or weight of duct or rebar installed;
- Money expended to date;
- Time expended to date;
- Earned value in the form of progress percent complete achieved or revenue generated; and
- Rules of credit.

❖ *Rules of Credit are **a predefined measure of progress associated with predefined milestones**; in other words progress associated with physical construction or progress against on a defined deliverable or work package.*

How to collect and store productivity data?

Collecting and storing productivity data

- ASCE

Key Principles

- *The data necessary to measure productivity should be collected and analyzed in accordance with the project requirements defined in the contract or execution plan from project beginning to end, to the extent possible.*
- *Productivity data should be collected from verifiable contemporaneous project records.*
- *The data necessary to measure productivity for a specific type of work should be stored in a cost account defined specifically for that work type.*
- *The basis of productivity data measurement should be documented and explained.*
- *Data related to change work should be tracked separately from base contract work when possible.*
- *Productivity data should be validated, and variations in those data should be corrected or explained as early and completely as possible.*

How to collect?

Collecting and storing productivity data

- ASCE
  - The **information and data necessary** to calculate productivity metrics are typically collected through a variety of **project control procedures** and software, which aggregate labor-hours, labor costs, material costs, equipment costs, and quantity tracking.
  - Data collection is being **enhanced and streamlined** by using advancing technology, enabling real-time reporting of labor-hours expended and quantities completed.

What information sources may be helpful?

Collecting and storing productivity data

- ASCE

More often the obstacle to collecting productivity data is not technology, but rather the creation of a culture that values the collection and use of productivity data and the assignment of enough trained organizational resources to use that technology and information. Information sources that may be helpful in understanding productivity and productivity problems include

- Daily progress reports,
- Payroll records,
- Time-and-material reports,
- Quality control and inspection reports,
- Ad hoc reports and notes,
- Payment requisitions,
- Photographs and videos, and
- Diaries and witness statements.

What is the relationship between cost code and data gathering?

Collecting and storing productivity data

- ASCE

Storing and analyzing the information should be done in discrete cost accounts, within reason, to help pinpoint trends and problems. For example, storing formwork productivity data for 30 bridges on a highway project in one cost code leads to difficulty in identifying problems that develop on any one of the 30 bridges. A more useful approach would be to store data in sub-accounts for each bridge or to have the ability to sort and extract data for each bridge. Alternatively, establishing a project cost control system with an excessive number of granular cost accounts may

- Increase data collection effort and cost,
- Increase the likelihood of miscoding information,
- Provide insufficient information that has meaningful value for tracking productivity, and
- Dissuade project participants from using the system.

What are four steps for successful data collection operation?

Collecting and storing productivity data

- ASCE

A successful data collection operation typically involves

- Accurately assigning planned labor-hours to discrete work activity codes,
- Accurately tracking the actual labor-hours expended,
- Identifying changes, and
- Recording and assessing the quantities of work installed.

How important scope reports are?

Collecting and storing productivity data

- ASCE

Scope reports should be developed at the outset of the project to define the scope of work contained in the labor plan and then used throughout to track the work's progress. These reports are sometimes called activity scope reports or, in US Army Corps of Engineers' work, QC reports. They may also be part of a contractor's normal daily report summary.

Let's see an example!

Collecting and storing productivity data

- **Actual labor expenditures** should then be **coded** per the scope of the report, perhaps **tracking back** to a work breakdown structure code.
- In this manner managers can ensure that the **actual labor-hours** being **charged** to an activity code are accurately assigned.

JOB Number :.................... ACTIVITY :....................

DESCRIPTION.................... DATE : / /

INSTALLATION STEPS	DWG REF	Labor Planned			Total Quantity Planned	Material Required		
		Crew Size	Days	Man Hours		Quantity	Size	Description

Equipment Rental, Totals, Scaffolding, etc.	Days Req	Cost Day	Amount

Remarks:

Activity scope reporting form.

Inefficiency, Lost Productivity Costs or Disruption

(Identifying Productivity Loss)

Key principles

- *Establish a productivity measurement control system at the outset of the project.*
- *Monitor productivity continuously throughout the duration of the project.*
- *Identify causes of productivity losses as early as possible and note those reasons in the project records.*
- *Based on a cause-and-effect analysis, evaluate options and take reasonable steps to mitigate productivity loss as early as practical.*
- *Provide notice of productivity impacts within the timing and format requirements of the contract.*

What factors can cause productivity loss?

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Factors

Many factors can cause productivity loss, including

- Missing or overlooked scope,
- Defective or incomplete design,
- Change orders (individually or collectively),
- Excessive or unplanned overtime,
- Congestion caused by stacking of multiple trades or joint occupancy in the same work areas,
- Unusually adverse weather,
- Unanticipated third-party events, such as *force majeure* events,
- Disruption and out-of-sequence workflow,
- Reassignment of crews,
- Start-stop-restart of work activities,
- Lack of site access,
- Dilution of supervision,
- Changes in crew size or shift,
- Work interruptions,
- Changes in logistics,
- Poorly trained or unmotivated work force,
- Poorly managed or unsupervised work force,
- Incorrect crew size or crew composition and skill sets,
- Inefficient sequencing of the work or procurement of materials,
- Absenteeism or turnover of labor,
- Lack of tools and equipment,
- Poor workmanship,
- Waiting for instructions or direction,
- Poor planning and scheduling, and
- Relocation of lay-down and material storage areas.

Remember the causes mentioned before?

What steps should be taken here?

Regularly reviewing

In addition to collecting productivity data, regularly reviewing productivity to identify variances between the planned and actual labor expenditures is important to identify changes to and loss of productivity. Methods of evaluating productivity include taking periodic surveillance (job walks), talking to project representatives, and reviewing labor productivity reports.

How to promptly identify potential problems and future trends?

Promptly identifying potential problems and trends

Tabular and graphical representations such as planned versus actual S-curves (common sigmoid functions) and the examples presented in Table 3-1 and Figure 3-1 are helpful for promptly identifying potential problems and future trends. They should be used in conjunction with the activity scope reports shown in Figure 2-1.

Let's see the example

Promptly identifying potential problems and trends

Table 3-1. Labor-Hour Variance Report.

Activity Code ID (1)	Activity Description (2)	Planned L-Hrs. (3)	Change Order L-Hrs. (4)	Per Plan (5=3+4)	Last % Complete (6)	Current % Complete (7)	Earned L-Hrs. (8 = 5×7)	Previous Total L-Hrs. (9)	Current Actual L-Hrs. (10)	Week-2 L-Hrs. (11)	Week-1 L-Hrs. (12)	Current Week L-Hrs. (13 = 8 –10)
7660	Inst. CHWS&R Mains	500	0	500	30	50	250	300	450	–75	–150	–200
7670	Inst. CHWS&R Branches	700	50	750	10	20	150	120	200	–40	–15	–50
7090	Connections at Mechanical Equipment	100	0	100	10	15	15	10	12	0	0	3
Total		1300	50	1350	50	85	415	430	662	–115	–165	–247

Note: CHWS&R = Chilled and hot water supply and return.

Promptly identifying potential problems and trends

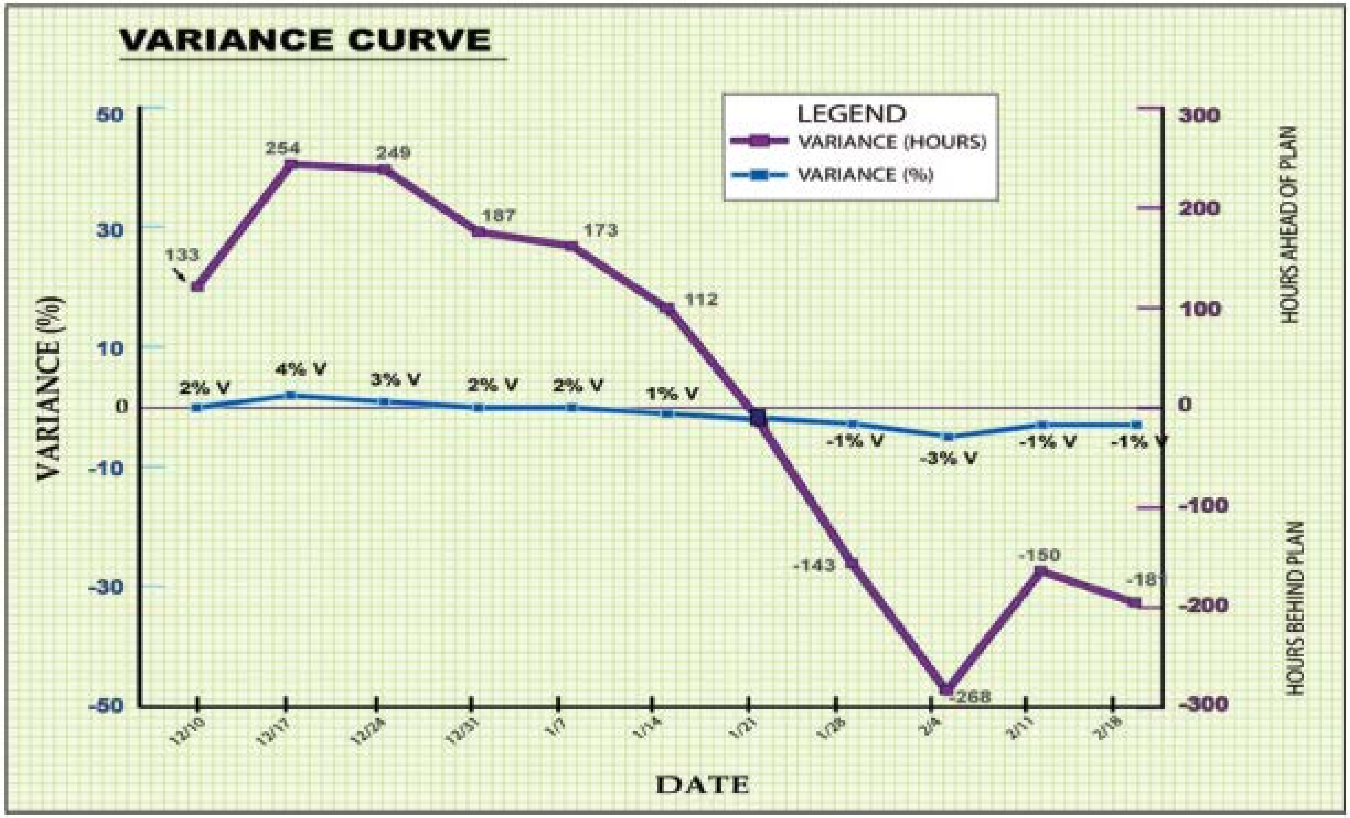

Figure 3-1. Graphical display of labor-hour variance.

Note that the data in Table 3-1 and Figure 3-1 are unrelated and are provided for illustrative purposes only.

Promptly identifying potential problems and trends

Let’s see more elaborate systems for tracking productivity used by larger companies!

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Promptly identifying potential problems and trends

Table 3-2. Detailed Labor Productivity Report.

Job #:	1234	Job Name:	Colorado River Bridge	PM's Name:	Jane Doe	Report Run for Period Ending:	January 20, 2018

Cost Account	Cost Account Description	%Qty Complete	%$$$ Complete	UOM	Data Description	Revised Budget	Forecast At Completion	Forecast To Complete	Projected Gain/(Loss)	Inception thru Date 12/16/17	Week Ending 12/23/17	Week Ending 12/30/17	Week Ending 01/06/18	Week Ending 01/13/18	Week Ending 01/20/18	Job To Date 01/20/18	Lowest Unit Cost
																Week Ending	*12/30/17*
013-020	Maintain Temporary Fiber Roll	72%	65%	LF	Quantity	61,100.0	68,404.0	19,404.0	(7,304.0)	30,400.0	2,500.0	5,000.0	5,000.0	3,400.0	2,700.0	49,000.0	5,000.0
					Labor-Hrs.	344.0	414.2	143.7	(70.2)	163.5	13.0	24.5	25.5	24.5	19.5	270.5	24.5
					Productivity in Qty/LH	177.6	165.1	135.0		185.9	192.3	204.1	196.1	138.8	138.5	181.1	204.1
					LH/Qty	0.006	0.006	0.007		0.005	0.005	0.005	0.005	0.007	0.007	0.006	0.005
					Labor $$$	17,489.00	20,710.00	7,226.71	(3,221.00)	8,135.76	649.75	1,222.48	1,259.73	1,228.00	987.57	13,483.29	1,222.48
					Labor $/LH	50.84	50.00	50.28		49.76	49.98	49.90	49.40	50.12	50.64	49.85	49.90
					Labor $/Qty	0.29	0.30	0.37		0.27	0.26	0.24	0.25	0.36	0.37	0.28	0.24
																Week Ending	*12/23/17*
013-030	Remove Temporary Fiber Roll	26%	34%	LF	Quantity	61,100.0	68,404.0	50,954.0	(7,304.0)	1,750.0	1,000.0	700.0	0.0	1,500.0	12,500.0	17,450.0	1,000.0
					Labor-Hrs.	240.0	245.0	160.5	(5.0)	6.5	3.5	2.5	0.0	7.5	64.5	84.5	3.5
					Productivity in Qty/LH	254.6	279.2	317.5		269.2	285.7	280.0	0.0	200.0	193.8	206.5	285.7
					LH/Qty	0.004	0.004	0.003		0.004	0.004	0.004	0.000	0.005	0.005	0.005	0.004
					Labor $$$	12,200.00	12,600.00	8,319.69	(400.00)	312.57	172.58	123.78	0.00	384.23	3,287.15	4,280.31	172.58
					Labor $/LH	50.83	51.43	51.84		48.09	49.31	49.51	0.00	51.23	50.96	50.65	49.31
					Labor $/Qty	0.20	0.18	0.16		0.18	0.17	0.18	0.00	0.26	0.26	0.25	0.17

How to calculate from the raw and calculated data?

Raw and calculated data

Such forecasts can be developed by **trending productivity** to date or, as in this case, by subjective estimates prepared by **knowledgeable practitioners**.

Table 3-3. Raw and Calculated Data for Cost Account 013-200.

RAW DATA FOR PRODUCTIVITY CHART						PRODUCTIVITY (LF/LH)		
WEEK ENDING	WEEKLY QUANTITY	JOB-TO-DATE QUANTITY	WEEKLY LABOR-HOURS	JOB-TO-DATE LABOR-HOURS	REVISED BUDGET	WEEKLY	JOB-TO-DATE	FORECAST AT COMPLETION
12/2/17	15,300.0	15,300.0	84.5	84.5	177.62	181.07	181.07	177.62
12/9/17	10,100.0	25,400.0	54.0	138.5	177.62	187.04	183.39	177.62
12/16/17	5,000.0	30,400.0	25.0	163.5	177.62	200.00	185.93	177.62
12/23/17	2,500.0	32,900.0	13.0	176.5	177.62	192.31	186.40	177.62
12/30/17	5,000.0	37,900.0	24.5	201.0	177.62	204.08	188.56	177.62
1/6/18	5,000.0	42,900.0	25.5	226.5	177.62	196.08	189.40	189.63
1/13/18	3,400.0	46,300.0	24.5	251.0	177.62	138.78	184.46	189.63
1/20/18	2,700.0	49,000.0	19.5	270.5	177.62	138.46	184.46	165.13
1/27/18					177.62			165.13

How to make forecast calculations?

Forecast calculations

Table 3-4. Labor Productivity Forecast Report.

FORECAST CALCULATIONS

WEEK ENDING	QUANTITY REMAINING	CONSEVATIVE REMAINING PRODUCTIVITY	CALCULATED LABOR-HOURS REMAINING	CALCULATED FORECAST PROBABILITY
		Estimate based on remaining work, actual figures, and experience of cost manager		
1/6/18	25,504.00	190	134	189.63
1/20/18	19,404.00	135	144	165.13

How to plot labor productivity trend graph?

Labor productivity trend graph

It compares:

1. Weekly productivity
2. Job-to-date or cumulative productivity
3. Revised budget productivity
4. Forecast-at-completion productivity

This graph shows the **productivity achieved** as of 1/20/18, as well as the productivity rates **forecast for the entire project** at different times since the work began.

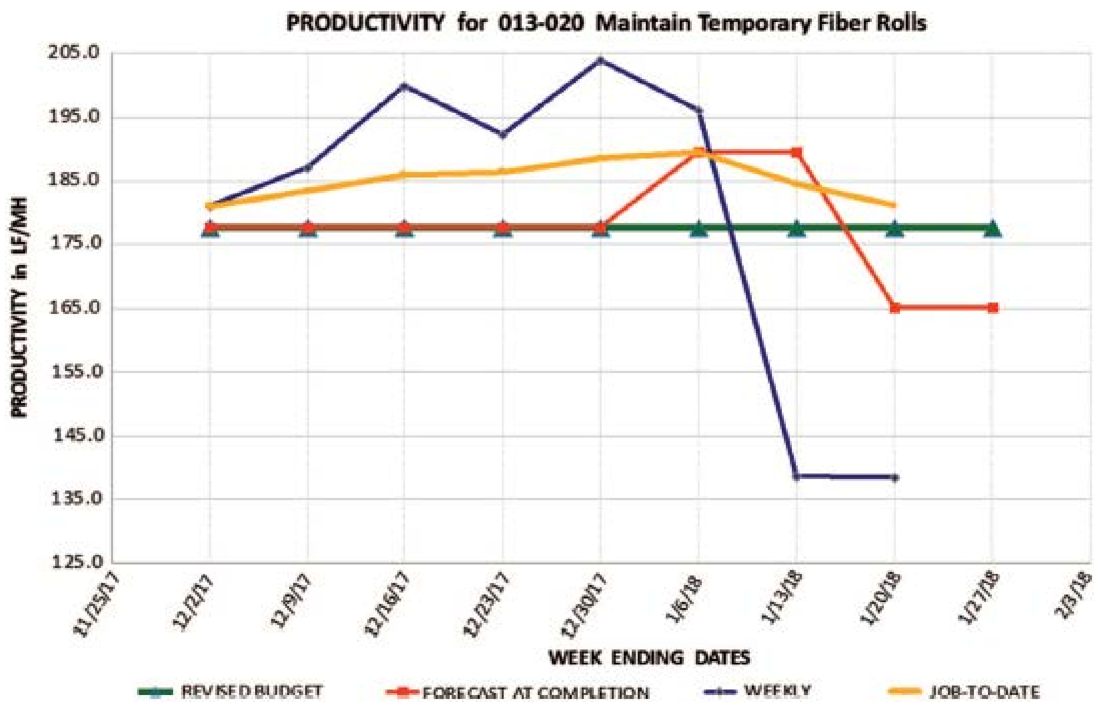

Figure 3-2: Labor productivity trend graph.

When could we say we are doing well?

Labor productivity trend graph

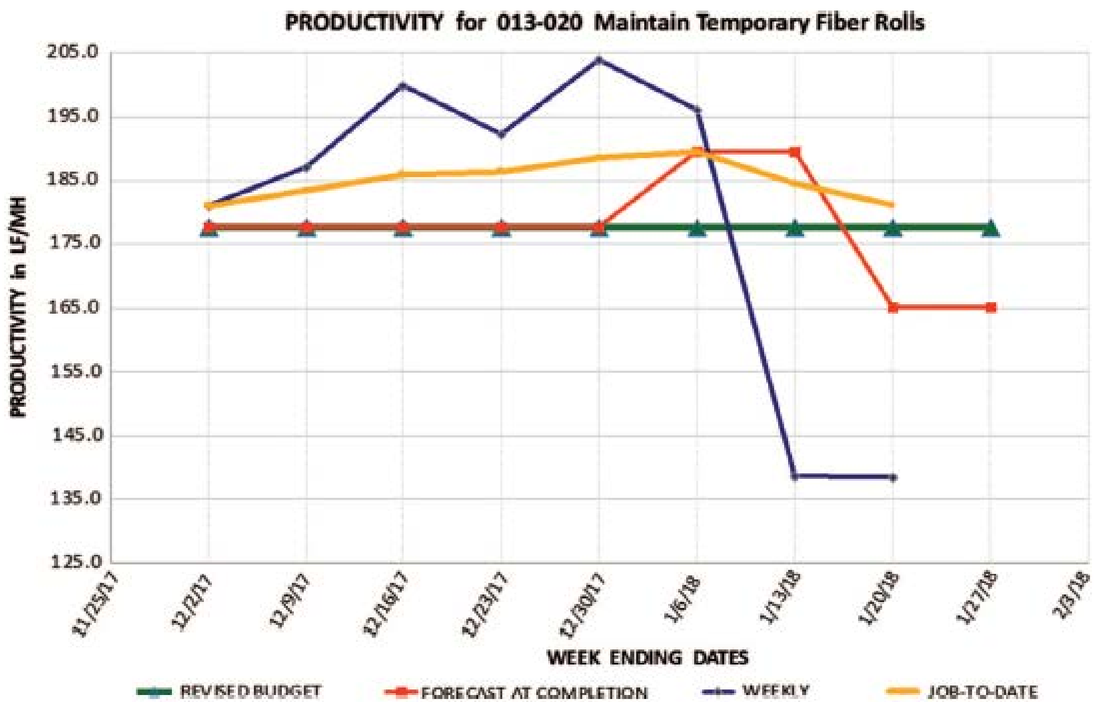

Figure 3-2: Labor productivity trend graph.

The cost account is performing well if the job-to-date productivity trend line increases over time and stays above the revised budget productivity line. Dramatic changes in weekly productivity may indicate issues in the field affecting productivity. The graph could also be used to calculate unimpacted productivity, which could be used in a measured mile analysis.

Labor productivity trend graph

To maintain balanced earned value style reporting, budgeted and actual labor-hours associated with scope changes or change orders should appear on both sides of the labor-hour tabulations, planned and actual. A detailed discussion of the earned value concept is beyond the scope of this standard.

How does this impact project management and also disruption claims?

Labor productivity trend graph

Using earned value labor reports and graphic depictions of the labor trends on a project, the management team can quickly identify areas of potential labor production impacts. This allows the team members to focus their attention on diagnosing the cause of labor overruns. Once the cause is identified, proper notice can be provided to the appropriate party and remedial actions considered and taken.

How is it in terms of the contract?

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Contract

- Many design and construction contracts include change order and payment application forms that have strict waiver language (e.g., "full accord and satisfaction"). Such language requires the contractor to include forward-priced loss of labor productivity impacts and inefficiencies in its change order proposals or face the possibility of waiving such damages. Waiver language in some contracts and change order forms may be restrictive about loss of productivity, inefficiency, cumulative impact, acceleration, disruption, and other related terms, and legal counsel in a specific jurisdiction should be consulted as necessary for compliance and/or understanding what rights are preserved or given up during the course of the project.

How is it in terms of the contract?

Inefficiency, Lost Productivity Costs or Disruption

(Establishing Recoverable Loss Productivity)

Introduction: Key Principles

- *To recover a productivity loss, one should show that the actual conditions differ materially from those that should have been reasonably anticipated.*
- *Productivity losses cannot always be determined precisely. The more supportable and precise the estimate of productivity losses by cause, the more likely the estimate will be accepted.*
- *Loss of productivity resulting from cumulative impact changes may be proved in certain circumstances even if individual change effects cannot be isolated and measured discretely.*
- *Project participants can be valuable sources of information, and their perspectives should be considered when investigating productivity loss.*
- *Ideally, project documentation should capture important information about productivity and should be reviewed.*
- *Major claims for loss of productivity prepared by productivity loss experts may be preferred because project participants may be considered biased or unable to understand the full project picture.*

Is additional cost automatically recoverable?

Recovering productivity loss

Additional cost owing to low productivity by itself is not automatically recoverable. Recoverable productivity loss occurs when the contractor expends more labor-hours to complete a given unit of work than it otherwise would have because of a disrupting event for which another party is liable.

What should be done to have successful claim?

Recovering productivity loss

To be successful, a claimant must demonstrate that the actual productivity was materially or substantially different from the productivity that should have been anticipated but for the claimable impact. In this standard, the term *claimant* is used in a general sense. It could mean either a contractor or an owner, and the situation could be either prior to or during litigation. For claimable impact, actual productivity rates should be compared to levels that were achieved or would have been achieved absent the claimable disrupting event. Cause and effect must be established to a reasonable degree of certainty for the loss to be recoverable.

How important this claim is?

Recovering productivity loss

Because there is often a significant monetary loss involved in loss-of-productivity claims, courts and other triers of fact require proof of causation and liability for the losses to be recoverable and generally require testimony by experts to help assess the issues, as project participants are often considered biased or unable to understand the project as a whole.

How important is to have contemporaneous records?

Recovering productivity loss

Measuring and identifying productivity over time can be a means to more directly identifying a claimable cause or changed condition and the resulting loss of productivity. Failing to maintain contemporaneous labor production records may lessen or preclude recovery in a loss-of-productivity claim. Maintaining contemporaneous and accurate labor reporting not only allows the contractor to quickly identify and address labor overruns, it also allows the contractor to mitigate losses and provide timely contractual notice of potentially recoverable productivity impacts arising from changed conditions, as well as to quantify possible losses. Contemporaneous notice, in turn, also provides an owner with the opportunity to consider ways to mitigate such impacts.

Do courts require claimants to prove damages with absolute certainty?

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Recovering productivity loss

Courts have also determined that claimants need not prove their damages with absolute certainty, because loss-of-productivity claims are complex. However, productivity claims can be rejected if the claimant fails to demonstrate that actions by one party caused damages to an opposing party. The relationship between cause and effect may be a significant hurdle in both meeting contract requirements for changes and delays and proving the impact in dispute resolution. Fact witnesses may be useful in identifying and providing convincing evidence for the cause and effect elements of a claim.

Do courts require claimants to prove damages with absolute certainty?

Inefficiency, Lost Productivity Costs or Disruption

(Quantifying Productivity Loss)

Introduction: Key Principles

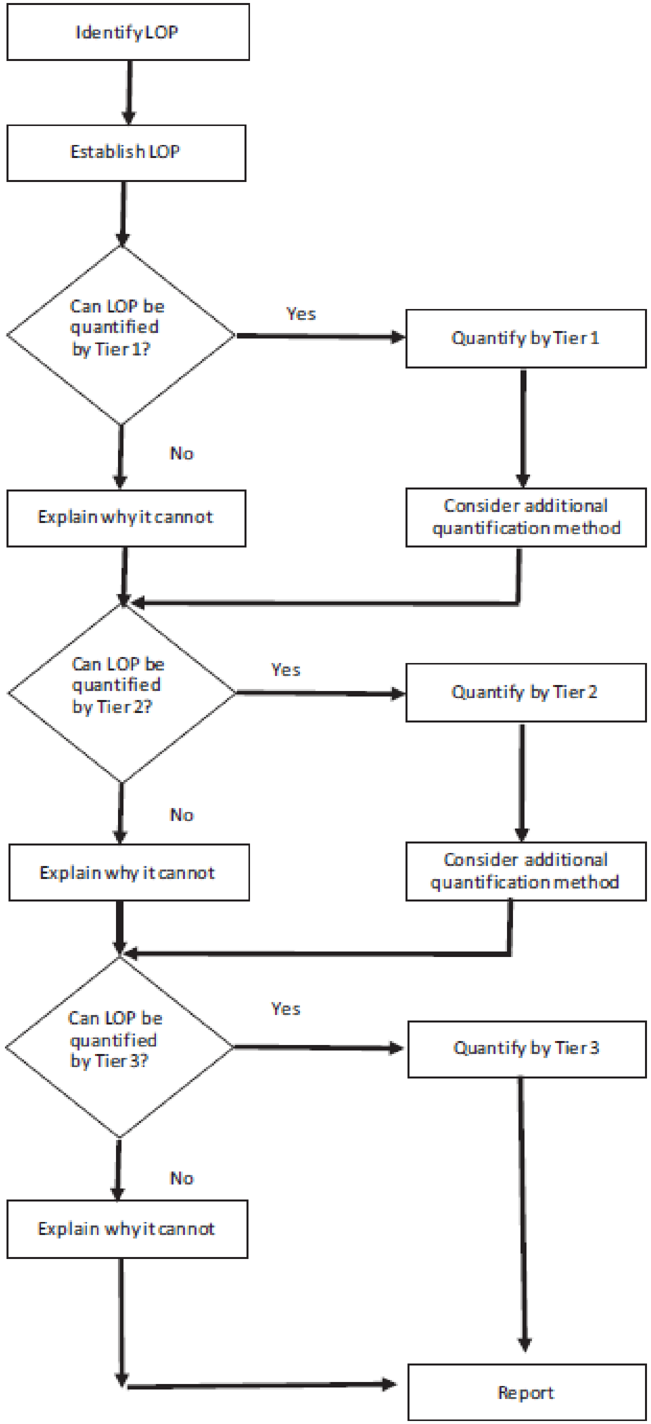
- A full review of the relevant project and the project information should be conducted and incorporated into the analysis.
- The preferred order of methods for quantifying productivity loss is
  - Tier 1: Measured Mile.
  - Tier 2: Academic and Industry Productivity Factors Studies and Modified Total Cost.
  - Tier 3: Total Cost.
- Before moving from one tier to a lower tier, reasonable degree of certainty that a higher-tier method could not be used should be shown.
- If doing so improves the overall reliability of the productivity damage estimate, separate productivity analyses should be used in different periods or areas on a project. Those separate analyses should not overlap or duplicate each other.
- Loss-of-productivity computations should be evaluated to ensure that the results are credible and sensible, and agree with job cost records.
- Productivity loss computations should be compared with the project's total cost loss and job cost records to check and support the relative reasonableness of the damage calculation.
- If several different quantification methods produce similar estimates of the loss of productivity, the quantification effort may be considered more reliable.

How to select Tiers?

Tiered approach to damage quantification methods

Although we have taught the detail of tiers previously
You could read the detail from the Standard

How to convert lost hours into <u>lost money</u> and <u>lost time</u>?



Converting lost hours into lost money and lost time

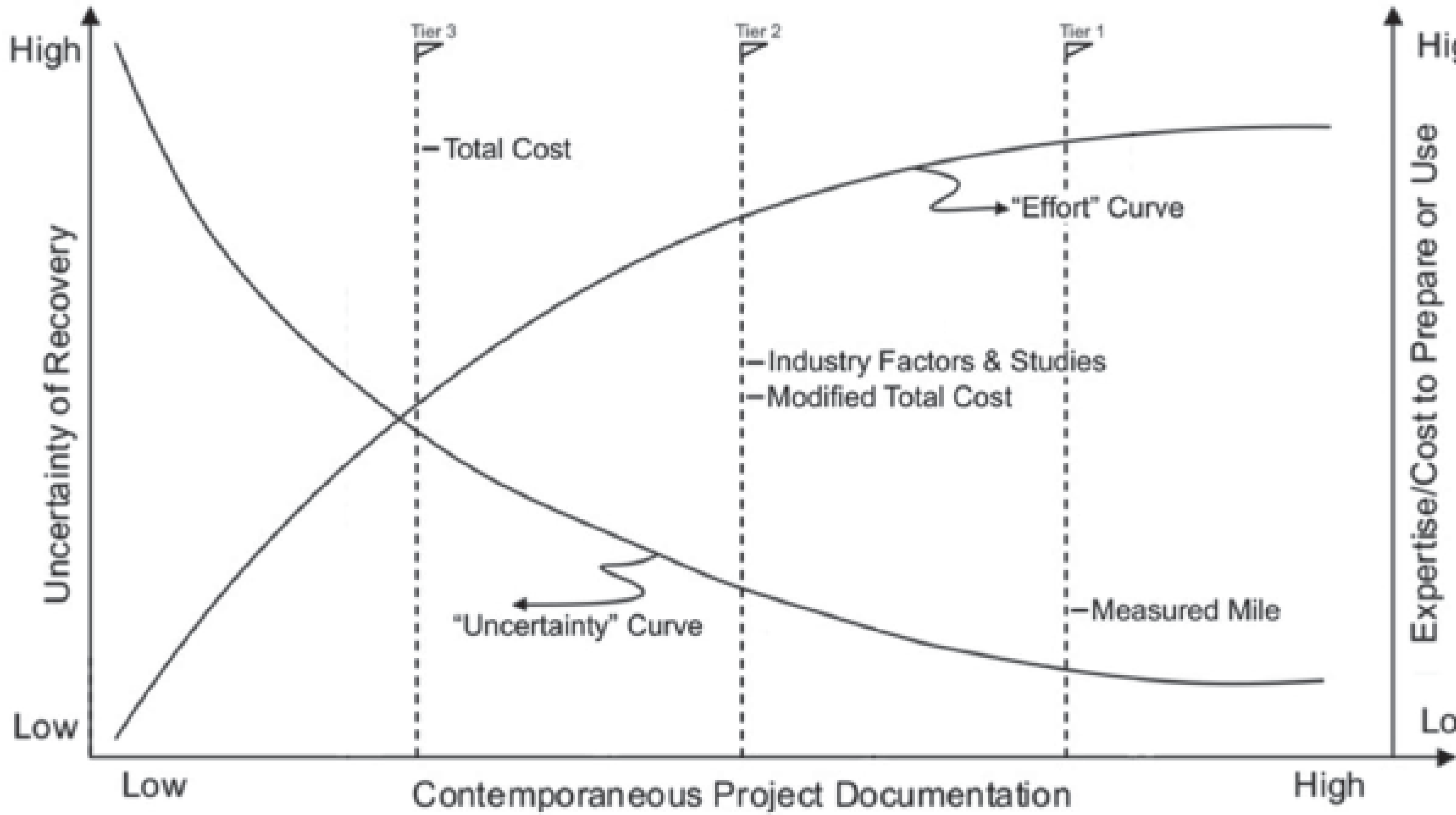
A "blended rate" is a rate of not less than one-and-a-half times the weighted average of all non-overtime rates used during that workweek.

Typically, productivity calculations reflect the difference between the planned and actual labor-hours. The result is a productivity analysis that produces a number of lost or additional labor-hours. Those lost labor-hours can then be converted into cost by confirming and applying the appropriate labor cost rate. This is normally performed by taking a total blended labor cost rate over the course of the year or years in which the labor-hours were lost.

Numerous nuances must be considered when converting labor-hours into costs. These may include exchange rates, escalation, and burden rates, all of which should be carefully considered. They are beyond the scope of this standard and may require professional accounting advice.

Let's see quantification methods summarized!

Effort and reliability of loss-of-productivity quantification methods



Let's see quantification methods summarized!

Rest of the document

How to avoid productivity loss?
Case study!

I may present these two in the next year?

موسسه مهندسی و مدیریت ساخت علوی پور (ACEMI)

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