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# ESTIMATING LOST LABOR PRODUCTIVITY IN CONSTRUCTION CLAIMS

TCM Framework: 6.4 – Forensic Performance Assessment


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## A. INTRODUCTION

One of the most contentious areas in construction claims is the calculation or estimation of lost productivity. Unlike direct costs, lost productivity is often not tracked or cannot be discerned separately and contemporaneously. As a result, both causation and entitlement concerning the recovery of lost productivity are difficult to establish. Compounding this situation, there is no uniform agreement within the construction industry as to a preferred methodology of calculating lost productivity. There are, in fact, numerous ways to calculate lost productivity. Many methods of calculation are open to challenge with respect to validity and applicability to particular cases -- thus making settlement of the issue on a particular project problematic.[1]

What is productivity in construction and how is it measured? Several authors have answered this question in the following manner.

> "…productivity refers to quantities produced per employee hour of effort…" and further is "…defined as the ratio of output to input… Productivity can be defined by any of the equations …
>
> Productivity = Output ÷ input
> = Units ÷ work-hours
> = (Total output) ÷ (Total work-hours)"[2]
>
> "Productivity is measured generally by the output per hour of input."[3]
>
> "Productivity: [A] relative measure of labor efficiency, either good or bad, when compared to an established base or norm as determined from an area of great experience. Productivity changes may be either an increase or decrease in cost."[4]
>
> "Productivity is defined as the craft hours necessary to produce a unit of finished product."[5]

Simply stated then, productivity is a measurement of rate of output per unit of time or effort usually measured in labor hours. For example, cubic yards/cubic meters of concrete placed, linear feet/meters of conduit installed or pipe placed, etc. per crew hour or some other standard measure.

Productivity loss, therefore, is experienced when a contractor is not accomplishing its anticipated achievable or planned rate of production and is best described as a contractor producing less than its planned output per work hour of input. Thus, the contractor is expending more effort per unit of production than originally planned.[5] The result is a loss of money for a contractor. Therefore, a challenging aspect of construction cost control is measuring and tracking work hours and production in sufficient detail to allow analysis of the data in order to determine the root cause(s) of poor labor productivity, should it occur.

Productivity is critically important in the context of construction contracts, both large and small. Construction contractors are typically paid for work completed in place that conforms to the terms of the contract. This is sometimes referred to as pay item work and is generally true whether the contract is lump sum/firm fixed price, cost reimbursable, target cost, unit cost or pay item work or as a percentage of previously defined categories of work, often referred to as a schedule of values or bill of quantities. That is, unlike automotive manufacturers, construction contractors are rarely paid on the basis of the entire completed product. And, unlike craft labor, construction contractors are rarely paid by hours of labor. Therefore, productivity is related to project cash flow and profitability.

 

All too often in construction, the terms “productivity” and “production” are used interchangeably. This is, however, incorrect. Production is the measure of output (i.e., things produced) whereas productivity is the measurement of the production. The following two formulas can be used to calculate these two terms.

$$\text{Productivity} = \frac{\text{Output (units completed)}}{\text{Input (work or equipment hours)}}$$

$$\text{Productivity Factor} = \frac{\text{Actual Productivity}}{\text{Baseline or Planned Productivity}}$$

Given this set of operating terms, it is therefore possible for a contractor to achieve 100% of its planned production but not achieve its planned productivity. That is, a contractor could well be accomplishing the planned rate of production of 300 linear feet of pipe/day in the ground but be expending twice the amount of labor planned to accomplish this daily production rate, for example. In this case, the contractor would be accomplishing 100% of planned production but operating at 50% productivity.

Thus, production and productivity are not reciprocal numbers. It does not necessarily follow that if a contractor is 75% productive then they are 25% inefficient. In the context of this Recommended Practice, production is the measure of output (i.e., how many feet or meters of pipe to be installed per work hour) while productivity is the measure of input (i.e., how many labors hours it takes to install a foot or meter of pipe).

Measurement and allocation of responsibility for loss of productivity can be difficult. There are a number of reasons for this difficulty.[6] Amongst them, are the following.

- Lost productivity resulting from some action which is the responsibility of the owner, may not be easily detected or observed at the outset. Unless a contractor has a good productivity monitoring plan, well known to field project management staff, all that may be known at the outset of a problem is that the field crews are not completing work activities as planned, and project schedule, costs and cash flow are suffering as a result. As a result, appropriate written notice to the project owner is often not promptly filed, kicking off more discrete and detailed project monitoring efforts.[7]

- Productivity is frequently not discretely tracked on construction projects in a contemporaneous manner. Unless a contractor uses some sort of structured earned value system for tracking output units and input units, there is no way to measure productivity contemporaneously. Thus, productivity losses can be difficult to prove with the degree of certainty demanded by many owners.

- Lost productivity is, all too often, calculated at the end of a project during preparation of a claim or request for equitable adjustment. As a result, often times only a gross approximation or a total cost estimate can be made.

- Complicating the issue even more, there are myriad ways to calculate lost productivity. There is no common agreement amongst cost professionals as to how such lost hours should be calculated. Notwithstanding this statement, there is general agreement among cost professionals that a comparison to unimpacted work on the project is generally preferred when there is sufficient data available.[8]

- The quality of some of the methods’ results is not always repeatable, leading to low confidence in the resulting analysis. Often two methods are used to compare results as a check with seemingly wide variances observed that cannot be easily understood or reconciled.

- Finally, once lost productivity is calculated, it is still difficult to establish causation. Contractors tend to blame such losses on owners and ask to be compensated. Owners, on the other hand, often blame a bad bid or poor project management and thus deny additional compensation for lost productivity. Given this situation, the root cause of lost productivity is frequently a matter in dispute between owners, contractors and subcontractors.

The key to reconstructing productivity information in support of a lost productivity claim is good record keeping throughout the entire project. From the very start of the project, the contractor ought to establish a uniform system of capturing and recording field labor productivity information on a contemporaneous basis.[9] Actual labor productivity ought to be compared on a routine basis to as-bid or as-planned labor productivity to determine how the project is progressing against the plan. The earlier productivity loss can be detected on a project, the greater the likelihood that corrective action can be implemented to mitigate damages. If progress is not per plan, analysis for causation must be made. In the event that poor productivity is, to a greater or lesser extent, brought about by some action or lack of action by the owner, then appropriate written notice should be filed. Regardless of causation, corrective action ought to be initiated as soon as the decline in labor productivity is detected.

## B. PURPOSE

This Recommended Practice focuses on identification of various methods for estimating lost labor productivity in construction claims. Often the claim is the result of one or more change order requests that cannot be fully resolved to capture their full and final effect on the entire project cost and schedule. Specifically, this Recommended Practice examines the issue in terms of claims for cost recovery of lost productivity. Therefore, the purpose of the Recommended Practice is to

- Identify Lost Productivity Estimating Methodologies: That is, survey as many of the various methodologies employed in litigation throughout North America as can be identified;

- Rank Order the Methodologies: That is, based on reliability, professional acceptance, case law and construction claims literature, rank the identified methodologies from most to least reliable with respect to documenting estimating damages in claim situations. While it may not be possible to state with certainty which methods are absolutely most or least reliable, it can be stated that under certain sets of circumstances some methods are generally considered more reliable than others. (**CAUTION**: This Recommended Practice was prepared on the basis of the author's understanding of Canadian and U.S. case law. It is recommended that anyone preparing a lost productivity claim seek appropriate legal advice on the methodology to be used. This is especially true if the claim is being pursued under national law other than Canada or the United States.)

- Define and Discuss Each Methodology: That is, discuss the method and how it is employed. Also, when possible, discuss the strong and weak points of each method;

- Identify Selected Studies Applicable to Each Methodology: Herein, identify as many studies and professional or technical papers as possible which will help the practitioner in learning more about and/or employing a particular method.

It needs to be noted that this Recommended Practice does not define in detail how one should properly perform the various analytical methods identified herein. The Recommended Practice gives a brief description of each method only in an effort to help claimants properly identify the method. That is, different claimants may have differing nomenclature for the same methodology. In this case, the brief description of each method is intended to help overcome this situation.

### B.1 Common Causes of Lost Productivity

On construction projects there are numerous circumstances and events which may cause productivity to decline. A review of two relatively recent publications results in the following list of causes which, while not all inclusive, fairly well covers the majority of situations encountered on a construction project.[10] The circumstances set forth below may all impact labor productivity. However, for a contractor to successfully recover damages due to lost productivity from a project owner, the contractor will need to clearly demonstrate that the root cause of the event or circumstance was something for which the owner or one of the owner's agents was responsible. Additionally, the contractor must be able to show a cause and effect relationship between the event and the impact to labor productivity in order to recover damages (i.e., costs and/or time). However, the recoverable damages are not limited to direct costs. They may also include ripple damages or indirect costs, to the extent that a cause and effect relationship can be established between the downstream effects and the originating event.

- **Absenteeism and the missing man syndrome** – When a crew hits its productive peak the absence of any member of the crew may impact the crew's production rate because the crew will typically be unable to accomplish the same production rate with fewer resources or, perhaps, a different mix of skill and experience levels.

- **Acceleration (directed or constructive)** – The deliberate or unintentional speeding up of a project may result in lengthy periods of mandatory overtime, the addition of second shifts, or the addition of more labor beyond the saturation point of the site or that can be effectively managed or coordinated, all of which may have distinct impacts on productivity.

- **Adverse or unusually severe weather** – Some bad weather is to be expected on almost every project. But, pushing weather sensitive work from good weather periods into periods of bad weather, or encountering unusually severe weather, may impact productivity (e.g., earth backfill and compaction operations pushed into wet weather periods).

- **Availability of skilled labor** – To be productive, a contractor must have sufficient skilled labor in the field. To the extent that skilled labor is unavailable and a contractor is required to construct a project with less skilled labor it is probable that productivity will be impacted.

- **Changes, ripple impact, cumulative impact of multiple changes and rework** – All projects encounter some change during construction. This is to be expected. Some authors believe that 5 – 10% cost growth due to changes is the expected norm.[11] However, major change (change well beyond the norm), change outside the anticipated scope of work (cardinal change), multiple changes, change's impact on unchanged work, or the cumulative impact of changes may all impact productivity. The need to tear out work already in place, the delays attendant to changes, the need to replan and resequence work, for example, may also cause productivity to decline.

- **Competition for Craft Labor –** If a nearby project(s) commences concurrently with the execution of a project that was estimated and planned to utilize a stated level of labor skill and availability, and a competition for that skilled labor base ensues, productivity may be adversely impacted. Financial incentives, work rule changes and other issues may result in labor leaving one site for another, resulting in lower productivity and increased costs for the first contactor. Further, the replacement labor may be more costly and less skilled.

- **Craft turnover** – If a crew suffers from continual craft turnover, it is unlikely that they will achieve good productivity simply because one or more members of the crew may be on the learning curve, and thus decrease the overall productivity of the entire crew.

- **Crowding of labor or stacking of trades** – To achieve good productivity each member of a crew must have sufficient working space to perform their work without being interfered with by other craftsmen. When more labor is assigned to work in a fixed amount of space it is probable that interference may occur, thus decreasing productivity. Additionally, when multiple trades are assigned to work in the same area, the probability of interference rises and productivity may decline.

- **Defective engineering, engineering recycle and/or rework** – When drawings or specifications are erroneous, ambiguous, unclear, etc., productivity is likely to decline because crews in the field are uncertain as to what needs to be done. As a consequence, crews may slow down or pace their work, or have to stop all together while they wait for clear instruction.

- **Dilution of supervision** – When crews are split up to perform base scope work and changed work in multiple locations or when work is continually changed or resequenced, field supervision is often unable to effectively perform their primary task – to see that crews work productively. Field supervision ends up spending more time planning and replanning than supervising. It is probable that productivity will decline because the right tools, materials and equipment may not be in the right place at the right time.

- **Excessive overtime** – Numerous studies over many years have consistently documented the fact that productivity typically declines as overtime work continues. The most commonly stated reasons for this result include fatigue, increased absenteeism, decreased morale, reduced supervision effectiveness, poor workmanship resulting in higher than normal rework, increased accidents, etc. One author has gone so far as to suggest that "…on the average, no matter how many hours a week you work, you will only achieve fifty hours of results."[12] The thought underlying this statement is that while overtime work will initially result in increased output, if it is continued for a prolonged period, the output may actually decline for the reasons stated earlier. Thus, long term overtime may lead to increased costs but decreased productivity. The effect of continued overtime work on labor productivity is, perhaps, one of the most studied productivity loss factors in the construction industry. The large number of studies contained in Appendix D is testimony to this fact.[13]

- **Failure to coordinate trade contractors, subcontractors and/or vendors** – If the project management team fails to get subcontractors, material or equipment to the right place at the right time, then productivity may decline as crews will not have the necessary resources to accomplish their work, various trades interfere with others or work is not available to the crews to perform.

- **Fatigue** – Craftsmen who are tired tend to slow down work, make more mistakes than normal, and suffer more accidents and injuries, thus productivity may decrease for the entire crew.

- **Labor relations and labor management factors –** When there are union jurisdictional issues, industrial relations issues, unsafe working conditions or other safety issues, multiple evacuation alarms in existing facilities, untimely issuance of permits, access issues, etc. labor productivity may be adversely impacted in multiples ways.

- **Learning Curve** – At the outset of any project, there is a typical learning curve while the labor crews become familiar with the project, its location, the quality standards imposed, laydown area locations, etc. This is to be expected and is typically included in as-bid costs. However, if the work of the project is shut down for some period of time and labor crews laid off, then when work recommences the labor crews brought back to the project may have to go through another learning curve. This is probably an unanticipated impact to labor productivity. If this happens more than once, then each time a work stoppage occurs another learning curve productivity loss impact may occur.

- **Material, tools and equipment shortages** – If material, tools or construction equipment are not available to a crew at the right location and time, then the crew's productivity will probably suffer as they may be unable to proceed in an orderly, consistent manner. Similarly, if the wrong tools or improperly sized equipment is provided, productivity may also suffer.

- **Overmanning –** Productivity losses may occur when a contractor is required to or otherwise utilizes more personnel than originally planned or can be effectively managed. In these situations, productivity losses may occur because the contractor may be forced to use unproductive labor due to a shortage of skilled labor; there may be a shortage of materials, tools, or equipment to support the additional labor; or the contractor may not be able to effectively manage the labor due to a dilution of supervision.

 

- **Poor morale of craft labor** – When work is constantly changed or has to be torn out and redone, etc. the morale (i.e., enthusiasm for their work) is likely to suffer. When this occurs, productivity may decline.

- **Project management factors** – A result of poor project management may be the failure to properly schedule and coordinate the work. Work that is not properly scheduled, shortage of critical construction equipment or labor, and incorrect mix of labor crews may result in decreased productivity because crews may not be able to work as efficiently as they would otherwise do. Improperly planned and implemented project initiation procedures may also lead to lost labor productivity. For example, mobilizing labor prior to having access to site electrical power or prior to having adequate site parking can both impact early on labor productivity. Additionally, poor site layout can contribute to loss of productivity. If, for example, crews have to walk a long way to lunch rooms, tool cribs, laydown areas, washrooms, entrances and exists, etc., then productivity may suffer as a result. In design / build or EPC projects, mobilizing to the filed prematurely before engineering is sufficiently complete to support efficient work schedules may lead to rework and inefficiencies.

- **Out of sequence work** – When work does not proceed in a logical, orderly fashion productivity is likely to be negatively impacted as crews are moved around the site haphazardly, for example.

- **Rework and errors** – When work in the field must be done more than once in order to get it right, productivity may suffer as a result.

- **Schedule Compression Impacts on Productivity –** Contractors are not legally bound to prove that contract performance was extended to recover for lost productivity. When there are delays early on in the project, the compression of the overall timeframe for later activities is often looked to as the way to make up for delays and finish the project on time. From a strict scheduling perspective this may be possible to do without accelerating individual work activities by utilizing float in the project's overall schedule. However, on many projects, schedules are not fully resource loaded. As a consequence, a properly updated schedule reflecting the delays may show the project finishing on time, without shortening individual activities. It may result in overmanning of the work by the contractor due to the shortening of the overall duration allowing the contractor to complete the total remaining work. This is known as schedule compression. Schedule compression, when associated with overmanning often results in significant productivity losses due to dilution of supervision, shortages of materials, tools or equipment to support the additional labor, increased difficulty in planning and coordinating the work and shortages of skilled labor.[14]

- **Site or work area access restrictions** – If a work site is remote, difficult to get to, or has inefficient or limited access then productivity may suffer because labor, equipment and materials may not be on site when and as needed to support efficient prosecution of the work. In addition, productivity losses may occur when access to work areas are delayed or late and the contractor is required to do more work in a shorter period of time, which may result in overmanning, dilution of supervision and lack of coordination of the trades.

- **Site conditions** – Physical conditions (such as saturated soils); logistical conditions (such as low hanging power lines); environmental conditions (such as permit requirements prohibiting construction in certain areas during certain times of the year); legal conditions (such as noise ordinances precluding work prior to 7:00 AM [0700 hours] or after 6:00 PM [1800 hours]) may all negatively impact productivity on a project.

- **Untimely approvals or responses** – When project owners, designers and/or construction managers fail to respond to contractually required submittals or requests for information in a timely manner, productivity on a project may decline as crews may not have authority or sufficient knowledge to proceed with their work.

Once the first productivity loss has been detected, the contractor should reconfirm the baseline estimate to ascertain that the project estimate is basically correct. In doing so, the contractor can insure that the productivity loss detected is not simply the result of comparing field productivity to a flawed baseline. Once this effort is complete the root cause of the productivity loss needs to be determined.[15] If the causation is found to be something for which the owner is liable, recommended practice is to follow the mandates of the contract with respect to providing written notice to the appropriate party as soon as possible. Subsequently, recommended practice is to gather all necessary supporting documentation and file the lost productivity claim as prescribed in the contract. Some contracts allow claim filing within a specified period of time after the notice of claim was filed whereas other contracts provide for claim filing within so many days after the event or circumstance has passed. Regardless, the contractor seeking to recover lost productivity costs should follow the mandates of the contract as closely as possible.

## B.2 Recovery of Lost Productivity Cost

Based upon the definition of productivity set forth at the outset of this Recommended Practice and a review of the causation factors, lost productivity can be translated to "…the increased cost of performance caused by a change in the contractor's anticipated or planned resources, working conditions or method of work."[16] While the general cause(s) of lost productivity may be easy to speculate upon (at least in hindsight), the contractor seeking to be compensated for a cost increase must first demonstrate entitlement, that is, a contractual right to recover damages, to the level of certainty required by decision makers or the trier of fact. Second, the contractor must sufficiently prove causation, the nexus between entitlement and damages.[17] The resulting damages (cost) are an outgrowth of the change in Output/Input. Lost productivity is the difference between baseline productivity and that actually achieved.

$$\text{Lost Productivity} = \text{Productivity}_{\text{Baseline}} - \text{Productivity}_{\text{Actual}}$$

Baseline productivity can be determined by measurements of input and output in unimpacted or the least impacted periods of time on the project. When this data is not available, estimated or analytically determined baseline productivity may be substituted.

While it is beyond the scope of this Recommended Practice to discuss the legal elements of entitlement and causation in detail, it is noted that to recover lost productivity costs (damages) the contractor typically must sufficiently demonstrate the following.

- Compliance with the notice requirements of the contract.

- Events occurred during the performance of the work, which were unforeseeable at the time of contract execution or a preceding change order(s).

- The events were beyond the control of the contractor seeking compensation, whether it is the contractor, its subcontractors, vendors or suppliers, at any tier.

- The events were caused by the owner or some entity for whom the owner is responsible (i.e., the design professional, construction manager or an independent prime contractor, etc.). Or, in the alternative, the events were caused by situations for which the owner assumed contractual liability (i.e., a force majeure situation or differing site condition, etc.).

- Recoverability for the resulting damages is not barred by the terms of the contract (e.g., exculpatory clauses such as a no damages for delay clause which may be upheld in the jurisdiction or overcome by events beyond the contemplation of the parties or intentional, willful, or grossly negligent conduct of the party seeking enforcement of such a clause).

- The events caused a change in the performance of the work and resulted in increased costs and/or time required to perform the work (i.e., work was resequenced, means and methods were changed, it took longer to perform the work, the work cost more due to performing work in bad weather, etc.).

 

Only after all of the above has been sufficiently documented and demonstrated, is the contractor able to present its damages (also referred to as "quantum" by attorneys) for consideration. It is the calculation of potential damages or the estimate of damages incurred due to lost productivity that this Recommended Practice is intended to address.

It must also be noted the optimal productivity is rarely if ever at the maximum production rate. Lost productivity claims must compare planned and documented productivity rates with actual productivity rates. A claim of "low productivity" is not likely to prevail. While non-optimal productivity is inefficient and costly, it may be driven by factors known at the time of bidding and thus not give rise to additional compensation. For example, a project bid with a tightly constrained schedule may dictate higher costs and poor productivity in order to accomplish the work in a shortened timeframe. But, if this is an as-known condition at the time of bidding, a claim of poor productivity is not likely to be successful.

## C. RECOMMENDED PRACTICE

### C.1 Methods of Estimating Lost Productivity

Listed below, in outline form, are various identified methods for estimating lost productivity. These methods are listed in order of preference. The recommended order of preference of the applicability of the studies and methods set forth below is based upon the weight of published literature. That is, Project Specific Studies are preferred to Project Comparison Studies. Project Comparison Studies are likely to be given greater weight than Specialty Industry Studies. Specialty Industry Studies are generally considered more reliable than General Industry Studies, and so on and so forth. Within each category, this Recommended Practice has likewise placed the methodology in order of preference. For example, properly performed measured mile studies are preferred to earned value analyses which, in turn, are considered more credible than work sampling or craftsmen questionnaires. Following this listing is a discussion of each method and a commentary of the method's utility in a claim or dispute situation.

- **Project Specific Studies**
  - Measured Mile Study
  - Earned Value Analysis
  - Work Sampling Method
  - Craftsmen Questionnaire Sampling Method
- **Project Comparison Studies**
  - Comparable Work Study
  - Comparable Project Study
- **Specialty Industry Studies**
  - Acceleration
  - Changes, Cumulative Impact and Rework
  - Learning Curve
  - Overtime and Shift Work
  - Project Characteristics
  - Project Management
  - Weather
- **General Industry Studies**
  - U.S. Army Corps of Engineers Modification Impact Evaluation Guide

 

- Mechanical Contractor's Association of America
- National Electrical Contractor's Association
- Estimating Guides

➢ **Cost Basis**

- Total Unit Cost Method
- Modified Total Labor Cost Method
- Total Labor Cost Method

➢ **Productivity Impact on Schedule**

- Schedule Impact Analysis

Inclusion of a methodology in this Recommended Practice is not intended to be an endorsement of the methodology by AACEI or those that contributed to this Recommended Practice. Rather, inclusion is simply acknowledgement that the methodology is recognized in the construction industry and has been used, with more or less success, in the legal systems in North America to estimate damages arising from certain situations.

**C.2 Recommended Practice – Order of Preference**

Prior to initiating a loss of productivity analysis, the claimant should carefully consider whether the productivity loss can be recast as an impact of specifically definable extra work. If so, then such productivity loss ought to be incorporated into the estimate of the extra work and resolved in that manner.

A review of U.S. and Canadian case law leads to the conclusion that Courts, Boards of Contract Appeals and other legal forums are more favorably impressed by damage calculations related directly to the project in dispute and supported by contemporaneous project documentation.[18] Therefore, recommended practice for one preparing a lost productivity calculation is to utilize, if possible, one of the techniques listed in the category **Project Specific Studies**. These methodologies, discussed in further detail below, are project specific and supported by people and records directly involved at the time of the dispute or the disputed work. If there is insufficient information available from contemporaneous project documentation to support one of these techniques, recommended practice then is to use one of the methods listed under the category **Project Comparison Studies**. These methodologies, too, are project specific but rely upon different forms of contemporaneous documentation.

It is recognized that contemporaneous project documentation is not always available to one tasked with estimating lost productivity. Estimated costs are, of course, recognized as a legitimate way to calculate damages once entitlement and causation are sufficiently proven. North American legal systems recognize that damages cannot always be calculated with mathematical certainty. Further, it is recognized that contractors frequently have to prepare and live with cost estimates. Therefore, in the absence of other proof of damages, the legal system may allow estimates to establish damages.[19] Estimated damages may be acceptable, under proper circumstances, but are more subject to challenge than direct project costs. Of the damage calculation and estimating methods, recommended practice is to use first, one of the studies listed in the **Specialty Industry Studies** category. These are specialty studies of specific types of problems and are, generally, based on some number of actual construction projects. Of course, to utilize one of these studies, the causation of the lost productivity should be appropriate for the particular problem studied.

If none of the specialized studies are applicable to the situation, recommended practice is to utilize one of the studies listed in the **General Industry Studies** categories. These studies are more subject to challenge because they are industry wide and not subject or project specific. Further, the basic data is sometimes derived from a non-construction environment. Finally, these studies were, by in large, intended as "forward pricing guides" and thus their intended purpose was distinctly different.

 

Notwithstanding these criticisms, in the absence of more reliable techniques, claimants have been allowed to use these studies once entitlement and causation have been sufficiently proven.

If the contractor preparing a lost productivity damage calculation can demonstrate entitlement and causation but is unable to utilize one of the techniques previously listed, recommended practice is to use one of the methods listed in the **Cost Basis** category. To successfully utilize one of these techniques, the claimant has to overcome some difficult legal hurdles, discussed in more detail below. But, if these challenges can be met, then these techniques may be allowed as a measure of lost productivity.

Finally, while it is not within the scope of this Recommended Practice to discuss the details of scheduling and schedule delay analysis, recommended practice is to feed back the results of a lost productivity analysis into a schedule to determine whether there are further impact costs that should be recoverable. Recommended practice is to utilize the approach listed in the **Productivity Impact on Schedule** category and employ an appropriate schedule delay analysis technique.

A note of caution is in order at this point. Most lost productivity claims involve situations where the loss of productivity is due to multiple causes. It cannot be emphasized enough that calculation of productivity loss is <u>not</u> a simple exercise. As a result, it is critical that the root cause of the lost productivity be determined from project records or project personnel before deciding how to proceed to estimate the labor impact. In cases where there are multiple causes of productivity loss, the individual preparing the claim may be required to perform multiple estimating analyses and then merge them together to rationalize the results, but <u>not</u> overstate the estimated productivity loss.

Most of the following methodologies have developed procedures to follow when applying the method to a situation. Claimants using one of more of these methods must, in order to maintain credibility, follow the procedures outlined in the method being utilized. Some of the more common mistakes made in estimating lost productivity include the following:

- Calculating the percentage change on a project on a cost rather than a labor hour basis;
- Applying calculated lost productivity factors to as-bid labor hours rather than actual labor hours;
- Applying calculated factors to all hours on the project rather than the hours during a certain impacted period;
- Failing to account for typical learning curve productivity factors when calculating lost productivity;
- Failing to deduct the additional labor hours already paid for in change orders or extra work orders, before applying the productivity loss factor(s) estimated: or,
- Failing to take into account and deduct other factors, which impacted productivity but which are <u>not</u> recoverable under the terms of the contract.

Errors, such as those listed above, in applying a method to the situation being analyzed must be carefully guarded against. If mistakes such as these are allowed to creep into the productivity loss analysis, then the credibility of the analysis will be undercut and the likelihood of cost recovery reduced.

Finally, it is noted that civil litigation in Canada and the U.S. rests on the “preponderance of evidence” test. That is, it is more likely than not that “x” event or occurrence resulted in “y” damages. Therefore, someone preparing a productivity loss analysis may want to employ more than one of the methods listed herein. From a practical point of view, and this is especially applicable if the productivity analysis is <u>not</u> based on contemporaneous project records, if two or more methods independently applied result in comparable results, the trier of fact (be it judge, jury or arbitration panel) is more likely to accept the results. Again, it needs to be noted that this Recommended Practice has been derived from a review of U.S. and Canadian legal decisions. To the extent that someone is pursuing a loss of productivity claim in a legal forum other than in the U.S. or Canada, legal advice should be obtained concerning how legal forums in those jurisdictions deal with the issue of lost productivity.

## C.3 Discussion of Recommended Practice

**Project Specific Studies** – As noted earlier, when a dispute arises over lost productivity, calculations based upon contemporaneously created project documentation from the project in dispute, supported by personnel who were actually involved in the project and disputed work activities are the most credible. Accordingly, when calculating lost productivity, recommended practice is to utilize one of the following techniques, when possible.

There are two primary methods for measuring completed work items. The **percentage complete method** rests upon periodic estimates of the percentage of work completed on a work item basis. For example, a monthly payment application may estimate backfill work 50% complete, underground conduit 32%, etc. The **physical units of work completed method**, however, is more detailed and more accurate.[20] Under this method, the actual units of work are surveyed for completion on a regular or periodic basis and compared to the total known number of units to be installed or constructed. Any of the project specific studies below can use either of these calculations, depending upon contemporaneous project documentation maintained by field personnel.

- **Measured Mile Study –** According to Schwartzkopf --

  "The most widely accepted method of calculating lost labor productivity is known throughout the industry as the "Measured Mile" calculation. This calculation compares identical activities in impacted and non-impacted sections of the project in order to ascertain the loss of productivity resulting from the impact of a known set of events. The Measured Mile calculation is favored because it considers only the actual effect of the alleged impact and thereby eliminates disputes over the validity of cost estimates, or factors that may have impacted productivity due to no fault of the owner."[21]

  A recent court decision has broadened the Measured Mile calculation to include comparison of similar work activities and least impacted periods versus impacted periods.[22] If sufficient work on the project is complete in an unimpacted or least impacted period and the quantity of work is known then calculations can usually be performed to ascertain a baseline level of productivity for that part of the work. Physical units of work complete divided by hours expended to complete these work items determines productivity during the least impacted or unimpacted period. A similar calculation is then performed for the period of the impact. The productivity loss can then be calculated by subtracting the unit productivity rate during the impacted period from the unit productivity during the unimpacted period. It is noted that when performing a Measured Mile calculation, other variables, which could affect productivity but are unrelated to the claimed impacts, must be accounted for and removed from the impacted period calculation to the extent these variables occurred during the least or unimpacted period. These may include weather, project mismanagement, subcontractor-related problems, voluntary acceleration, etc.[23] Numerous federal court cases have upheld use of the measured mile technique including *E.C. Ernst, Inc. v. Koopers Company,*[24] *Natkin & Company v. George A. Fuller Company,*[25] *United States Industries, Inc. v. Blake Construction Company, Inc.,*[26] *Appeal of Batteast Company,*[27] *Goodwin Contractors, Inc.,*[28] and *Clark Concrete Contractors, Inc. v. General Services Administration.*[29] Of the four methodologies listed in the project specific studies category the Measured Mile study is the method most often cited in court cases. It is probably the best of the recommended practices, assuming there is sufficient contemporaneous data to allow such an approach. This method appears to be recognized as the most credible in the legal system.[30] Additionally, unlike some other methods, the Measured Mile study can be used after the impact has occurred or as a sampling technique, while the impacted work is in progress.

 

- **Earned Value Analysis** – Productivity measurement is sometimes difficult when there is insufficient information concerning the physical units of work installed on the project. In these situations, a simplistic form[31] of the earned value analysis method can be utilized to calculate estimated labor hours.[32] The contractor's estimate or alternatively the dollar value of payment applications, contract amounts or unit prices can be used to determine labor hours, when they were expended and, possibly, on what activities.[33] Physical units of work completed multiplied by budget unit rates can be used to determine earned hours. The earned hours are then compared to the actual hours expended for the period of the impact and the difference between the two may be used to calculate the productivity loss experienced. Earned value measurement of contemporaneous project documentation, such as percentages complete from schedule updates or payment applications can assist with calculating labor productivity.[34] Additionally, the claimant may calculate the actual revenue per hour of labor versus the planned revenue per hour, as an alternative.[35] Earned value analysis may also be utilized to calculate estimated labor hours.[36] When using the earned value analysis technique, it is cautioned that the budget used to generate the earned value metrics be carefully reviewed and verified for reasonableness. Any earned value analysis based upon an unreasonable budget is highly suspect. Finally, it is noted that a fully resource loaded (labor and quantities) CPM schedule is a good source for obtaining earned value metrics and allows for like-time causation analysis.

- **Work Sampling Method –** Work sampling is a method in which the claims analyst makes a large number of direct observations of craftsmen to determine what they are doing at various points in time. Work sampling is defined as

  > "An application of random sampling techniques to the study of work activities so that the proportions of time devoted to different elements of work can be estimated with a given degree of statistical validity."[37]

  From these observations the claimant determines, on a percentage basis, how much time is spent between direct work (pay item work); support work (moving tools and materials to the work location); or delays (time when no work is being performed). By performing a number of work sampling studies, the analyst can draw comparisons of productivity before and after known events, between work activities or crews, etc. Work sampling has been offered as a means of determining productivity loss but it can only be performed during the life of the project and is not compatible with a hindsight analysis effort.[38]

- **Craftsmen Questionnaire Sampling Method** – Claims analysts estimating lost productivity frequently are not in the field, on the project, during the disruption period. However, when productivity loss is recognized by field project management staff, a questionnaire can be prepared and provided to craftsmen in the field. The questionnaire allows craftsmen to estimate the amount of lost productive time in the field on a daily or weekly basis, identifying the reason for the lost time. While, perhaps, not the most scientific of studies, this is contemporaneous documentation if administered properly. The claimant can then tie the results of such a survey to the entitlement and causation arguments.[39] A variation of this method is the use of a Craftsmen Questionnaire at the end of the job, to confirm or modify a productivity loss analysis performed utilizing another method. For example, a recent Board of Contract Appeals case allowed a Craftsmen Questionnaire to be used as a modifier of an industry-wide study and awarded lost productivity costs to a mechanical subcontractor on this basis.[40]

➢ **Project Comparison Studies –** There may be times when a claimant needs to prepare an estimate of lost productivity when circumstances affecting productivity such as project change, delay or disruption ran throughout the entire project. That is, the circumstances of the project were such that there were no unimpacted periods for the work activity in question from which one can determine baseline productivity. In these circumstances, and assuming it is possible, recommended practice is to utilize one of the following methods, assuming sufficient data exists.

 

- **Comparable Work Study –** There are two forms of this analytical technique. One form is for the contractor to estimate productivity loss on the impacted portion of the project. Once done, the analyst locates an analogous or similar work activity on the project, which was unimpacted (or least impacted) and calculates the productivity on this work. For example, a comparison of electrical conduit installation with fire sprinkler installation. The ratio of the two calculations then forms the estimated productivity loss. The difficulty in this method is determining what is analogous or similar work? If the productivity loss occurred during the installation of electrical conduit, is such work really analogous to installation of fire sprinkler piping? Factors such as size, length, weight, height above ground or off the deck, etc. must all be carefully considered and documented to successfully present such an analysis. The other form of a comparable work study is to calculate productivity during the impacted period on the project and compare this productivity to <u>similar work</u>, on the <u>same project</u>, performed by <u>another contractor</u> whose work was not impacted.[41] Typically, the comparable work study is only performed when study of the same work before and after a known event is not possible and thus a measured mile analysis cannot be completed. Perhaps change orders concerning the electrical conduit were so pervasive from the outset of the work that the contractor was never able to achieve a measured mile plateau. In such situations, project owners are unlikely to allow a comparison of actual productivity with as-bid productivity, even if they are responsible for the changes. So, in its place, the contractor may be able to compare actual productivity on conduit installation with productivity on fire sprinkler installation to draw some conclusions.

- **Comparable Project Study –** In the event that the comparable work study cannot be performed, an acceptable alternative may be to calculate productivity on the project in dispute and compare this productivity to that achieved on another project with similar work. Of course, to do this successfully the contractor must demonstrate that the comparable project was of similar size and magnitude, similar location, similar weather and labor conditions, etc. The more similarity between the projects, the more likely it is that this method will be given credence. Less similarity between projects obviously leads to decreased chances of success.[42]

➢ **Specialty Industry Studies –** In the event there is insufficient contemporaneous project documentation to allow preparation of one of the project specific or project comparison studies set forth above, or other circumstances dictate, recommended practice is to perform a productivity loss estimate using data developed by one of the specialized studies listed below. The claimant will, of course, be challenged to demonstrate entitlement and causation, as mentioned previously. Additionally, the contractor will have to demonstrate that the project encountered a situation similar to that of the specialized study or studies relied upon.[43] The primary distinctions between the specialty industry studies listed below and the general industry studies listed in the next section are that (1) these studies are <u>subject</u> specific; (2) are often limited to a specific industry; and, (3) are generally based upon a small number of specific projects rather than a generalized survey of the industry nationwide.

- **Acceleration –** These papers and studies offer observations on assessment of productivity impacts when a project is accelerated – sped up or required to perform work in less time than otherwise allowed. The studies look into such issues as trade stacking, crew overmanning and manning levels, that result from such a situation, among other things. See **Appendix A** for a list of studies and papers related to this topic.

- **Changes, Cumulative Impact and Rework –** These studies and papers offer an assessment of productivity impact when there are a large number of changes during performance of the work on a project. Additionally, some of these specialized studies look specifically at the issues of the cumulative (synergistic) impact of multiple changes. Also listed are a few studies addressing the issue of "What is the normal amount of change to be expected on a project?" See **Appendix B** for a list of papers and studies related to this topic.

 

- **Learning Curve –** Learning curve is the typical productivity encountered at the beginning of any project or any major project activity. Craft labor has to get used to working as a crew. They must learn the site and its layout (i.e., where the washrooms and tool cribs are located, where the laydown areas are, etc.) Crews must also acclimate to project requirements (level of quality required, level of inspection imposed, production output required to meet schedule requirements, etc.). Learning curve is typical. Learning curve may also occur later in projects if work is suspended and labor demobilized and later remobilized. These papers and studies look at productivity impact when a project encounters a delay or suspension of work causing craft to be removed from the site and later remobilized. See **Appendix C** for a list of studies and papers related to this topic.

- **Overtime and Shift Work –** These studies and papers consider productivity impact when there is a good deal of work on an overtime or shift work basis on a project over a lengthy period of time. See **Appendix D** for a list of papers and studies related to this topic.

- **Project Characteristics –** These papers and studies observe productivity impact related to differing project characteristics. See **Appendix E** for a list of studies and papers related to this topic.

- **Project Management –** These studies and papers review productivity impact resulting from project mismanagement including engineering impacts, lack of construction equipment, tools and materials, management turnover at the site, etc. See **Appendix F** for a list of papers and studies related to this topic.

- **Weather –** These papers and studies assess labor productivity impact caused by weather conditions. See **Appendix G** for a list of studies and papers related to this topic.

➢ **General Industry Studies –** Sometimes there is insufficient contemporaneous documentation to support a project specific study or a project comparison study, and further, the loss of productivity stemmed from numerous, non-specific causes. This is especially true when there is a lack of contemporaneous data from a project or when there is a surfeit of non-definitive data. In these situations then, recommended practice is to employ one of the general industry studies listed below. Caution must be exercised in using these studies for a number of generally well known reasons. Among these are the following.

- The source data for the factors listed in these studies is not always known. The data may be from a survey and comprised of anecdotal information as opposed to empirical data.[44]

- These studies do <u>not</u> address how to apply these factors in situations where multiple causes of productivity loss have been identified during the entitlement and causation analysis.[45]

- These studies do <u>not</u> address whether the factors are to be applied to the entire project, portions of the project, the changed work, etc.[46]

- These studies are rarely conclusive concerning quantification of productivity loss because they bear <u>no direct relationship</u> to the project in dispute.[47]

- These studies are perceived, by some, as being self-serving studies because they appear to serve the best interests of contractors from the industry association that prepared the studies.[48]

- These studies can be used to attack the reasonableness of the contractor's planned productivity ratios.[49]

 

- Courts and Board of Contract Appeals seem to be more willing to accept these studies as support or rebuttal evidence rather than direct evidence of productivity loss.[50]

- Finally, it is noted, these industry studies were initially prepared for estimating and forward pricing of change order or extra work order purposes and not for hindsight analysis of lost productivity estimates.[51]

Having made the above statements, Courts and Boards of Contract Appeals continue to allow the use of general industry studies under the proper circumstances. If the contractor can demonstrate causation and entitlement and, that there is no better method to estimate the resulting damages, then Court and Boards may allow use of these studies.[52]

The three most commonly referred to general industry studies are the following.

- Mechanical Contractors Association of America (MCAA), *Labor Estimating Manual: Appendix B, Factors Affecting Productivity,* Rockville, Md., August 1998. Appendix B addresses 16 factors, which can impact labor productivity. The manual presents a range of losses, expressed in percentages, for minor, average and severe cases.

- National Electrical Contractor's Association (NECA), *Manual of Labor Units*, Bethesda, Md., 1976 and 2003. This manual gave a job factor checklist addressing some 25 factors for consideration under certain circumstances. Current editions of the manual no longer contain this checklist but a summary of the checklist can be found in Schwartzkopf's book, *Calculating Lost Labor Productivity in Construction Claims,* §11.3 at page 128.

- U.S. Army Corps of Engineers*, Modification Impact Evaluation Guide*, EP 415-1-3, Department of the Army, Office of the Chief of Engineers, Washington, D.C., July, 1979.[53] This manual addressed a number of factors the Corps was willing to discuss and negotiate when considering the forward pricing of change orders.

Despite the identified and well-known weaknesses with these general industry studies they remain recommended practice under proper circumstances. First, the claimant must demonstrate entitlement and causation. Then, there must be a showing that there is no better information upon which to estimate resulting damages. Finally, the contractor must show that the impacts encountered on the project rationally fit one or more of these studies.

Additionally, there is another type of general industry study, which is available for the claim analyst to utilize. National estimating guides are classified in this Recommended Practice as general industry studies because the information and data contained therein is based upon studies of the construction industry in general. They are not, usually, as subject to the criticisms listed above. However, the claimant will still be challenged to demonstrate entitlement and causation and prove that there is no better way to estimate the resulting damages. If this can be done, estimating guides may be utilized and may be given some credence. The national estimating guides on the market generally are updated annually or, perhaps, even more frequently. These guides often provide productivity information. Unlike the general industry studies listed above (which list percentage factors to calculate productivity loss under certain situations) the estimating guides are useful to establish the norm or the baseline productivity the contractor should have been able to achieve but for the events encountered. Thus, an estimated Measured Mile approach can be constructed by calculating actual productivity on the project and comparing it to an estimated productivity from one or more of the estimating guides. See **Appendix H** for a list of estimating guides available for such use.

- **Cost Basis –** If it is possible to demonstrate entitlement and causation but there is insufficient project documentation to support damage calculations using any of the above techniques, recommended practice is to use one of the costing methods set forth below. These methods require analysis of the project job cost records. The purpose of such preliminary analysis is to determine actual direct labor hours and costs (having stripped out materials, installed equipment, supplies, field and home office overhead, small tools and consumables, etc.).

- **Total Unit Cost Method –** This method is a variation of the Total Labor Cost Method discussed below. Under this method, all costs incurred (labor, material, equipment, subcontractors, small tools and consumables, etc.) are divided by the units of work completed during that period of time. A similar calculation is made for units of work in a different period of time. Assuming no other variables arose during the second period of time then it can be posited that the difference in unit cost is the impact of the event identified by the claimant. Calculations then have to be made to determine and remove the costs of materials, equipment, small tools and subcontract costs. Once done, the remainder is all labor cost and the differential in labor cost per unit installed is, arguably, the labor productivity impact resulting from the event complained of.[54]

- **Modified Total Labor Cost Method –** This method is the same as the Total Labor Cost Method, except that the contractor subtracts out known bid errors, excessive costs (i.e., the failure to mitigate damages), field problems for which the contractor was responsible, etc.. As a result, the formula is as follows.

  **Total Labor Cost Owed** = Total Labor Cost Expended – Acknowledged Contractor Problems – Total Labor Cost Paid

  The contractor using this recommended practice is still faced with overcoming the challenge of the four-part test set forth by the courts noted below. It is imprudent to use this method when a more credible method is possible. However, by subtracting contractor problems from the cost equation, the contractor addresses the last three tests in an affirmative manner. Similarly, a contractor who corrects "busts" either in their bid or their budget will, at least in part, address the second, third and fourth tests outlined below.

- **Total Labor Cost Method –** The basic formula for a total labor cost analysis is the following.

  **Total Labor Cost Owed** = Total Labor Cost Expended – Total Labor Cost Paid[55]

  This method of estimating damages may be applied to the entire project, if the loss of productivity extended to all work. In the alternative, this estimating technique may be applied to a particular area of the work (i.e., glazing, masonry, etc.) if only specific areas or items of work were impacted. It may also be applied only to certain craft labor crews if it can be shown that only certain crews were subject to the loss of productivity. It is, however, the least accepted method to calculate decreased labor productivity.[56]

  When using a cost basis methodology, the contractor must remember that labor costs are a function of both the number of manhours and the unit cost of these hours. Thus, the total labor cost expended may exceed the total labor cost paid due to an increase in the average unit cost of labor not a loss of productivity (i.e., more hours expended than planned). While many of the factors that impact productivity may also increase the unit cost of labor, there may be other circumstances on the project that increase the unit cost of labor (i.e., a union requiring a different mix of apprentices to journeymen) that are unrelated to those affecting productivity. Thus, it is recommended practice that the claimant separately address both productivity losses (i.e., increase in hours) and differences in unit cost of labor, when utilizing a cost basis method.

  In utilizing this recommended practice, claimants must also be cognizant that a number of legal hurdles must be overcome if one is to be successful in using this approach in litigation. In order to safeguard against the potential inequities embodied in the above formula, courts have set up a standard four-part test. To use this method of pricing damages, the contractor must demonstrate the following.

1. The nature of the particular losses make it impracticable, if not impossible, to determine damages in any other more particular manner.

2. The contractor's bid or estimate was reasonable and free of any material errors.

3. The contractor's actual costs were reasonable (meaning that the claimant has the challenge of proving mitigation of damages).

4. The contractor was not responsible for any of the events leading to the loss of productivity.[57]

Assuming that the contractor can overcome these four tests, this recommended practice is an allowable method for estimating lost productivity damages.

- **Productivity Impact on Schedule –** It is not within the scope of this Recommended Practice to discuss scheduling and scheduling techniques. However, there is a relationship between a lost labor productivity analysis, lost labor productivity's impact to a project schedule and, possibly, the critical path of that schedule. It is recognized that schedule delay may not only result from productivity loss, but in many cases, may precede the productivity loss. The factor that often drives a contractor to perform work inefficiently is the lack of time to perform the work more efficiently. As a result, there is very little loss of productivity that does not involve some element of delay followed by attempted or actual acceleration somewhere in its chain of causation. Therefore, schedule analysis often plays a major role in analyzing entitlement and, perhaps, impact of productivity loss.

  In general terms the relationship between labor productivity and schedule impact is often as follows: If a contractor encounters productivity loss at some point during the progress of the work, then those activities, which are less productive, will tend to stretch out in duration. This, in turn, may impact other activities. For example, follow on activities may also have increased durations; may have to be resequenced in order to meet schedule end dates; or may be pushed from good weather or lower wage rate points in time into bad weather or periods of higher wages. It has been acknowledged by the Courts that, "…the contractor does not need to prove that contract performance was extended beyond the planned completion date in order to recover for lost productivity."[58] However, if planned work activities have been resequenced or moved from good to bad weather periods, it is likely that they too, will have suffered a loss of productivity. This can be the synergistic or ripple effect of productivity loss on otherwise unchanged work. The challenge then is for the claimant to determine such ripple impact, show entitlement, demonstrate the cause and effect relationship and then, estimate or document damages suffered.

  There is no industry-wide agreement on what scheduling technique should be applied when analyzing delay and impact. And, as noted above, it is not the intent of this Recommended Practice to facilitate such an agreement. This Recommended Practice addresses the issue of how to estimate and price lost labor productivity. It is noted that a separate Recommended Practice for Schedule Delay Analysis is under preparation at the time of this writing.

  - **Schedule Impact Analysis –** Recommended practice in this regard is to utilize some schedule analysis technique to determine overall project delay or delay to some activities within the schedule. Once a determination is made that some or all of the remaining activities on the schedule were delayed then the above techniques can be applied to determine whether any productivity loss grew out of such delay. Delayed activities are identified and recalculated[59] to estimate the effect of such delay in terms of productivity loss. Other activities must then be analyzed to determine whether they too suffered from productivity impacts. If so, then these activities may also have to be recalculated and the schedule analysis run yet again. This is an iterative process, which continues until all activities downstream of the initial productivity loss have been examined to determine whether they were affected by ripple impact. Once this process is completed then damages may be calculated using one or more of the recommended practices identified above.

## D. CONCLUSION

Under appropriate fact circumstances, all of the methods set forth herein are technically acceptable which is why they have been included in this Recommended Practice. Of all the methods identified above, the most reliable are those set forth in the section on Project Specific Studies. These methods are based upon contemporaneous documentation and knowledge from the project. Thus, they come the closest to approximating actual damages from a project. All other methodologies discussed in this Recommended Practice are estimating techniques with varying degrees of reliability. Therefore, they are considered somewhat less reliable that the Project Specific Studies. This again highlights the importance of keeping good project records from the outset of the project which captures contemporaneous project documentation by individuals actively involved in constructing the project.

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[40] See *Hensel Phelps Construction Co.,* GSBCA Nos. 14,744 & 14,877, 01-1 BCA ¶ 31,249. January 11, 2001.
[41] See *Robert McMullan & Sons, Inc.,* ASBCA No. 19,929, 76-2 BCA (CCH) ¶12,072 (1976).
[42] See Schwartzkopf and McNamara, *Calculating Construction Damages*, ibid, §2.09[B].
[43] It should be noted that this is not an all-inclusive list of specialized studies. As others are identified, this Recommended Practice will be modified, from time to time, to include them. It is also further noted that some of the studies listed herein have incomplete references as full information is not available at the time of publication of this Recommended Practice.
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[45] Ibid.
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[47] See Schwartzkopf and McNamara, *Calculating Construction Damages*, ibid, §2.09[C].
[48] Ibid.
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[50] Ibid.
[51] See Schwartzkopf, *Calculating Lost Labor Productivity in Construction Claims*, ibid, §11.2& 11.3.
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**53** It should be noted that although the Corps of Engineers officially recognized this Guide as a valid means to assess claims for more than twenty years, on June 14, 1996 the Corps of Engineers officially rescinded the *Modification Impact Evaluation Guide* by issuance of Circular No. 25-1-244. At that time, the Corps claimed that the Guide "has been updated and is incorporated in other publications to include higher level regulations, training course materials and other command guidance." See Mark G. Jackson, Carl W. LaFraugh and Robert P. Majerus, *Using Industry Studies to Quantify Lost Productivity*, Construction Briefings, Federal Publications, Washington, D.C., December, 2001. See also, Jones, Reginald M. and Thomas J. Driscoll, *Cumulative Impact* Claims, Federal Publications Seminars, LLC., Washington, D.C.,2002, page A-38.

**54** See *Appeal of Paccon, Inc., ASBCA* No. 7890, 1965.

**55** "Total Labor Cost Paid" = Labor cost in base bid + labor cost paid in change orders and previous claim settlements.

**56** See Schwartzkopf and McNamara, *Calculating Construction Damages,* ibid, §2.09[E]

**57** See Schwartzkopf and McNamara, *Calculating Construction Damages,* ibid, §1.03[C] and [D] and cases cited therein. See also, Jones and Driscoll, ibid, pp. A-31 through A-35 and cases cited therein. See also, Wickwire, Driscoll, Hurlbutt and Hillman, *Construction Scheduling: Preparation, Liability and Claims,* ibid, §12.05 and cases cited therein.

**58** See *Sauer, Inc. v, Danzig,* 224F.3d 1340, 1348 (Fed. Cir. 2000).

**59** In this context, the term "recalculate" is used to indicate changes to the previously identified and defined schedule activity. This may include, but is not limited to, increased duration, resequencing, changes to planned resources, etc.

**60** The R.S. Means Company has been purchased by Reed Construction Data. At present, these estimating manuals are still being marketed under the R.S. Means name but this may change.

**61** Ibid.

 