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Assessing Methodologies for Quantifying Lost Productivity

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CAUSES OF PRODUCTIVITY LOSSES

Contractors experience a loss of productivity when their work is disrupted. Gavin et al. defined disruption as a material difference between the performance conditions that were expected at the time of bid and those actually encountered, resulting in increased difficulty and cost of performance [10]. Tieder and Hoffar provide a list of disruptions including weather, overtime, increases to the number of crews or to the crew size, unavailability of skilled labor, stacking of trades, restricted site access, out of sequence performance, ripple effect of changes, delivery delays, other contractor delays, and increased storage and material handling [27].

The U.S. Army Corps of Engineers, the Mechanical Contractors Association of America (MCAA), and National Electrical Contractors Association (NECA) have all published lists of disruptions that can lead to productivity losses [20, 16, 19]. Comparing these lists shows that none are definitive and highlights the fact that a wide variety of factors can impact productivity. When one factor or a combination of factors affect productivity more than a reasonable contractor would expect, the activity is said to be disrupted. If the contractor did not cause the disruption, it may submit a change order request or claim (depending on the terms of the contract) for the cost of lost productivity associated with the disruption.

RECOVERING LOST PRODUCTIVITY DAMAGES

Gavin et al. distinguished disruption claims from delay claims, noting that the completion date of a contract need not be extended in order for a contractor to assert a claim for disruption [10]. Similarly, courts have treated disruption claims as a separate concept from delay claims by separating the calculation of damages for each claim [30]. Still, the available avenues for recovery of either type of damages are the same: (1) recovery under a specific contract clause or (2) recovery under the general principles of contract law. If an avenue for recovery is available, the most important element of the disruption claim is the establishment of the causal relation between the alleged disruption and the damages. The claimant must prove that the disruption caused the damage, as opposed to some other factor.

Because of the wide range of factors that can affect construction productivity, it is often difficult to isolate and quantify the productivity loss associated with a specific disruption. Thomas and Smith reviewed expert opinion on circumstances that affect productivity, considering factors that were both within the contractor's control and outside of the contractor's control [25]. They found that the interaction between multiple factors is not quantitatively understood, and that different construction activities are not impacted in the same way by the same disruption. Notably, expert opinion on how to quantify the impact of multiple causes of lost productivity is mixed.

In fact, any assumption on the cause of a productivity loss should be tested. For example, Sanders and Thomas found that the weather's effect on productivity may not be as well understood as thought [22]. In a study of masonry work, they found that performance in low humidity and moderate temperatures was not optimum. Instead, the masons' productivity was better at temperatures closer to 4 °C (40 F). With regard to the "ripple effect" of changes, Ibbs and Allen found that any compounding effect of multiple change orders is poorly understood and difficult to measure [13]. Thomas and Napolitan found that the productivity of change order work itself averages 70% that of base contract work and is often controlled by the procurement of materials, as opposed to other disruptions [23].

Bramble and Callahan stated that the two major obstacles to recovery for lost productivity claims are a realistic assignment of liability and an accurate quantification of damages [7]. In fact, the presentation of a reasonable quantification of damages is often closely tied to the establishment of cause, and therefore, liability in productivity claims. The available case law shows that if other possible causes are eliminated, and the calculated loss of productivity appears to be a reasonable result of the difference in circumstances created by a contract breach, then courts will award reasonably quantified damages. However, the burden of proof is on the plaintiff to establish liability, causation, and resultant injury.

Liability may be established by citing a breach of the owner's implied duty not to interfere with the contractor's operations; citing a breach of the implied warranty that the plans and specifications are adequate to construct the project (the Spearin doctrine [29]); or citing explicit contractual duties incumbent upon the owner, which it did not fulfill. These explicit duties may include the completion of precedent work by a certain date, provision of flagmen or security, provision of owner-supplied equipment, timely review of shop drawings, or any other duty that the contract specifically places upon the owner. Causation is often the most

difficult element to prove in lost productivity claims. Because there are so many factors that affect productivity, it is often difficult to prove that the owner's breach was the controlling factor and not one of many contributing factors. Causation is usually established by a detailed description of how the breach affected the work in question, and the use of a quantification methodology that eliminates or accounts for other factors that affected the work. Finally, the resultant injury is simply the calculated cost of the productivity loss associated with the breach.

METHODOLOGIES FOR QUANTIFYING LOST PRODUCTIVITY

The productivity loss that results from a disruption is the difference between the actual work and equipment hours expended on a task and the man and equipment hours that would have been expended to complete the same task had the disruption not occurred. The concept is simple, but there are obstacles to quantifying the loss absolutely.

First, hours must first be tracked in enough detail to isolate those that were expended on the task in question. For example, if the work on one floor of a multistory building is disrupted, the hours that were expended on that floor must be isolated from those expended on other floors. This can be impossible to do accurately if daily reports or other project documents do not track manpower and equipment by floor. Second, in order to compare actual data and project conditions to those that would have been present had a disruption not occurred, a hypothetical situation must be modeled, and no model is perfect. Third, the total productivity loss may be the result of several independent, or interrelated causes, which are impossible to isolate definitively.

Considering these obstacles, courts have found that damages must be proven not with "absolute certainty or mathematical exactitude," but "with a reasonable basis for computation, even though the result is only approximate [31]." The methodologies available for quantifying lost productivity are distinguished by the amount of information and level of detail that is necessary to apply each of them. The methodologies fall into the following categories:

1. Measured productivity comparisons
2. Actual cost comparisons
3. Actual-to-estimated comparisons
4. Published standards and factors
5. Total cost and modified total cost
6. Expert testimony (without supporting analysis)
7. Jury verdict/no methodology

The courts have traditionally preferred measured productivity comparisons to the other methodologies. This type of analysis compares the productivity of an activity in an impacted and unimpacted condition. Such a comparison can be impossible to make without detailed manpower and production data. Unfortunately, there is little agreement on how to quantify a productivity loss without this data, especially when multiple causes of productivity loss coexist, and the responsibility for these causes is divided between the contractor and owner. Claims for lost productivity often ignore some of the factors that are known to affect productivity, and highlight one or more factors that are the assumed cause of the productivity loss. In these cases, the methodology for quantifying the lost productivity is incomplete at best and incorrect at worst.

As stated previously, it is incumbent upon the plaintiff to establish liability, causation, and resultant injury. The success of a lost productivity claim lies in completing these three steps in a way that creates a logically consistent chain of events. Did the alleged breach actually occur? Did it affect the activity in the way described? Were there other circumstances that might have caused this effect? Have the damages been calculated to a reasonable degree of accuracy considering the information available? Is the amount of the damages reasonable considering the work performed and the circumstances of the breach?

Proving that a breach occurred establishes entitlement to recover the damages stemming from the breach, but the methodology used to calculate those damages will be successful only if it is successful in demonstrating that the breach caused the damages and that the damages have been reasonably quantified. The best methodology to use is that which makes the best use of the available data to isolate the productivity loss associated with a specific disruption.

Measured Productivity Comparisons

A comparison of impacted and unimpacted conditions on the same project is the preferred method of calculating lost productivity. This methodology is commonly referred to as a "measured mile" analysis. The strength of a measured mile analysis is that it establishes the productivity actually achieved as the basis from which the impact of a disruption is measured. Any inefficiencies that may be inherent to the contractor's management or the nature of the project are thereby considered in the analysis, and not charged in the claim. Unfortunately, even when the manpower and production data necessary to perform a measured mile analysis is available, many times it is difficult to perform the analysis because of the inability to identify a period unimpacted by the disruption. This is often the case when the plans and specifications are defective or incomplete.

In that situation, the productivity achieved on the project in question may be compared to that achieved on one or more similar projects that did not experience disruptions. However, that type of analysis must be subject to even more scrutiny. Differences in the contractor's workforce or management, differences in site layout, and differences in the timing of the contractor's work may make two seemingly comparable projects very different. Productivity can vary drastically from project to project depending on the activity considered, and it can be difficult to explain enough of the variation to make the comparison appear reasonable. Whenever possible, it is best to identify a level of productivity that was achieved on the project in question for use in a measured productivity comparison.

W.G. Yates & Sons Construction Co., was engaged to construct an aircraft hangar facility, two adjoining shops, and the administrative offices for the Mississippi Air National Guard [5]. Yates experienced productivity losses erecting steel truss members in the hanger after the failure of a truss member that resulted from modifications to correct design defects. In its claim for lost productivity costs, Yates compared its actual production rate (work-

hours per ton of steel erected) before the truss failure to its rate after the truss failure. The Armed Services Board of Contract Appeals accepted and endorsed the Yates analysis, holding that in "inefficiency claims, a 'good period vs. bad period' analysis, comparing the cost of performing work during periods both affected and unaffected by disrupted events is a well established method for proving damages."

Other courts have confirmed the finding in Yates, stating that the "comparison of the cost of performing work in different periods is a well-established method of proving damages [30]." In fact, the Yates claim was ideal for the measured mile approach, because it was able to identify specific unimpacted and impacted periods, before and after the truss failure, respectively. In addition, the lost productivity costs were isolated to one activity-truss erection-and Yates kept records of manpower and tons of steel in place, enabling it to calculate productivity for the unimpacted and impacted period.

Not all claims lend themselves to such a straightforward measured productivity comparison. For example, Nat Harrison Associates, Inc., entered into a contract with Gulf States Utility Company to construct 158 miles [254 km] of 500 kV single-circuit, three-phase transmission line in Louisiana [18]. Harrison claimed that it was unable to perform its work in sequence due to Gulf States' late delivery of materials and failure to provide right of way. Harrison presented three alternative measures of its damages. In two of these methodologies, Harrison compared its labor productivity before and after June 1, 1996, the date on which the breach allegedly began.

Gulf States contended that Harrison was actually more efficient during the period of the alleged breach than it was in its performance before the breach. Harrison's various comparisons either mixed costs that were incurred by subcontractors with Harrison's own costs or included costs for which it had not contended that Gulf States was liable. On appeal by Gulf States, the court concluded that Harrison's analysis was not sufficient to establish a causal link between Gulf States' actions and Harrison's productivity loss.

In general, the mere showing of a reduction in productivity between two periods is not sufficient to prove that a specific breach caused the reduction. A perfect measured productivity comparison would eliminate all other factors that may have affected the work by establishing a measured mile in which the only difference between the impacted and unimpacted work is the condition created by the breach. When the identification of such an ideal measured mile is impossible, as is frequently the case, the other factors affecting the work should be included in the analysis. When asserting or defending against a claim that uses a measured productivity comparison, the most important question to ask is: Are there factors other than the alleged breach that could account for some portion of the reduction in productivity? Those factors should be accounted for in the analysis.

Actual Cost Comparisons

When traditional productivity data (in the form of workhours per unit of work completed) is not available, comparison of the actual cost per unit of work completed in disrupted and undisrupted conditions has been effectively used to quantify lost productivity costs. This type of analysis has the advantage that it can include the costs of equipment, tools, and manpower at various labor rates in one comparison. However, these actual cost comparisons have also been rejected where they do not appear to accurately quantify the loss associated with the alleged impact.

Maryland Sanitary Manufacturing Corporation, a contractor engaged to manufacture approximately 170,000 M60 chemical shells for the U.S. government, experienced productivity losses related to directed acceleration, overtime, and the government's failure to timely supply equipment that had been designated as owner-furnished [15]. Maryland Sanitary compared its total unit cost per manufactured shell during impacted and unimpacted periods. It then arbitrarily charged half of the difference in its claim, arguing that the impact was at least that.

The court found that the comparison of the unit costs during two periods is not the proper way to estimate the difference in direct labor costs caused by an impact. However, it found taking half of the amount calculated by that method was reasonable, considering the government's directed acceleration. The court also cited a study by the U.S. Bureau of Labor Statistics (*Bulletin No. 917*, 1947) to support the fact that increased overtime impacts productivity in manufacturing processes.

F.H. McGraw & Co., was contracted by the U.S. government to perform excavation and install concrete piers to support air and steam lines at the Badger Ordnance Works in Baraboo, WI [9]. The government's designer did not timely complete drawings, and McGraw experienced disruption when work was pushed into winter weather. McGraw compared the unit cost of digging a sample of holes in the warm months with the unit cost of digging a sample of holes in the cold months. McGraw found a difference of $22.01 per hole, an increase of 144% over the warm-weather cost of $15.29 per hole. Finding this excessive, McGraw claimed only $17.00 per hole. Alternatively, the government proposed an increase of only $8.25 per hole, based on the unsupported expert testimony of its architect-engineer-manager.

The court found that the sample used in McGraw's comparison was too small, questioning why McGraw did not compare all warm-weather holes to all cold-weather holes. The court felt that the much higher cost that McGraw had found was due to its use of a skewed sample. Finding McGraw's quantification excessive, even reduced to $17.00 per hole, the court awarded $9.00 per hole based on its own expertise, stating that the government witness's figure of $8.25 per hole appeared to be close to the truth.

The lathing and plastering contractor involved in the construction of a 500-bed hospital complex at Fort Bragg, NC, experienced disruption due to out-of-sequence work in hospital rooms where a tile wainscot was to be installed after the lathing and before plastering [28]. The contractor compared its average labor cost per square yard of lath and plaster installed before October 1, 1957, and after that date. Almost all plaster work in the affected rooms was performed after October 1, 1957. The comparison was based on lath and plaster crew payrolls and a measurement of total square yardage installed during the impacted and unimpacted periods.

The court found that the productivity of lathing and plaster work was affected by (1) small rooms, (2) careless workmanship causing crews to work out-of-sequence, (3) acceptable change orders, and (4) rework. The court did not find that the delays to tile work substantially impacted the lathing and plaster, and the contractor was not entitled to recover its losses. If the contractor in

this case had recognized the four factors that the court found and adjusted its claim accordingly, it would have had a better case for proving that at least a portion of the damages was due to the tile delays. For example, the contractor could have made an adjustment to recognize the fact that productivity in the small rooms where the tile was located would be worse than the productivity in the larger rooms it used in its comparison.

In summary, courts have found that productivity data based on workhours per unit of work is preferred to cost per unit of work. Even in the Maryland Sanitary example, in which the court accepted the use of cost data, the court noted that the use of cost data was not the preferred method for comparing impacted and unimpacted productivity. Still, the cases reviewed highlight how an actual cost comparison methodology can be applied successfully when traditional productivity data is not available. Similar to the measured productivity approach, the key to applying an actual cost comparison is the proper accounting for differences in the impacted and unimpacted periods that are unassociated with the breach. In an actual cost comparison, these differences are expressed as an increase in the cost per unit of work completed.

Actual-to-Estimated Comparisons

In contrast to direct comparisons of actual productivity or costs, some claims have asserted comparisons of the actual productivity or unit cost for an activity to that estimated. Comparisons of actual manpower usage to planned manpower usage are often used in conjunction with assertions that disruptions forced the contractor to apply a less than optimal crew size or number of crews. Analyses that consider the estimated cost of labor as opposed to manpower usage have been called "should cost" approaches because they attempt to estimate what the activity should have cost, absent the impact.

In a claim before the Armed Services Board of Contract Appeals, Paccon, Inc., was able to show the link between government breaches and its productivity loss [3]. Paccon then presented detailed testimony on the preparation of its estimate, including a discussion of how it intended to apply its labor. The board found that Paccon's estimate had been "prepared with care by a competent engineer." Paccon asserted a claim for the difference between its estimated and actual labor costs. The government did not offer an alternative to Paccon's methodology, and the board awarded Paccon the difference between its estimated and actual labor costs.

The distinction between the methodology applied by Paccon and a total cost claim is that Paccon first established the fact that the government's actions were the cause of its productivity loss. Paccon then presented a detailed actual-to-estimated comparison in order to quantify that loss. It is also noted that Paccon's analysis met the three tests that will be discussed in relation to total cost claims. Because estimates of what an activity should have cost if a disruption had not occurred are conjectural, they are not preferred over actual data comparisons and should only be used when actual data of unimpacted work is not available.

Published Standards and Factors

Published standards and factors are often used to estimate lost productivity. Factors have been used alone or in conjunction with expert testimony with varying degrees of success. The following examples detail these uses and address separate instances in which the application of a factor was successful or unsuccessful in quantifying a contractor's loss of productivity.

Stroh Corporation was awarded a contract for replacement of the cooling tower, two chillers, and sections of the roof around the cooling tower at the Des Moines, IA, federal building [4]. The contract required that Stroh immediately commence with construction upon receipt of the notice to proceed. However, the government restricted Stroh's ability to begin construction, thereby extending Stroh's performance into the winter months and requiring Stroh to accelerate in order to complete the project on time.

In determining Stroh's productivity loss, its expert applied two of the 16 potential factors affecting a mechanical contractor's labor productivity specified in the *MCAA Labor Estimating Manual* [17]. Stroh's expert used the percentages identified in the *MCAA Manual* as impacts of adverse weather and schedule compression, applying them to the actual costs of the affected work to compute Stroh's damages. The government did not offer an analysis of Stroh's productivity loss.

The board concluded that Stroh met its burden to show that the government's actions reduced the efficiency of its labor in two ways: (1) the work was shifted into adverse weather conditions, and (2) the reduced amount of time required Stroh to use less than optimum crew size to perform the work. The board agreed that the use of MCAA factors to calculate Stroh's labor productivity loss was reasonable.

Hensel Phelps Construction Company was contracted to construct a new building for the National Oceanic and Atmospheric Administration in Boulder, CO [1]. Trautman & Shreve, Inc., (T&S) was the mechanical subcontractor that claimed the government impacted its operation by insisting that T&S perform additional work related to vibration isolation that it interpreted was not required by the contract. T&S's expert assessed the impact of the government's actions on T&S by applying six of the sixteen potential factors affecting a mechanical contractor's labor productivity as identified in the *MCAA Manual*. Instead of relying exclusively on the percentages recommended in the *MCAA Manual*, the expert modified the percentages for the factors in question based upon his knowledge and understanding of the project, derived from his numerous interviews with project personnel, his extensive review of the project documents, his analysis of an as-built schedule, his experience in the construction industry, and his expertise in assessing labor productivity losses.

The government discounted T&S's analysis and presented an expert who relied on the CPM schedules. The government's expert contended that a properly maintained and updated CPM schedule can more effectively identify the potential for lost labor productivity than an application of the MCAA factors. However, the court concluded that the T&S expert's assessment of labor productivity losses was far from a "guesstimate" and stemmed from a thorough knowledge of the contract requirements and the actual history of contract performance. In addition, the court concluded that this type of analysis was founded upon and involved the continual application of the principles of cause and effect. The court found that the conclusions that T&S reached were reasonable and well supported.

The court in *Havens Steel Co. v. Randolph Engineering Co.*, had a finding in contrast to the Hensel Phelps court [12]. Havens

was contracted to fabricate and erect ductwork for the wet-to-dry conversion of a cement plant in Michigan. Havens subcontracted the erection to Randolph. When large portions of the ductwork failed, Havens brought a claim against Randolph. Randolph contended that the ductwork was manufactured incorrectly, and lost productivity was one of nine counts in its counterclaim.

Randolph retained an independent expert, who was a professional engineer and vice president in charge of planning and scheduling for a structural steel contractor. Randolph's expert testified that the defective manufacture of the ductwork necessitated Randolph's use of overtime and that the use of overtime results in a reduction in productivity. However, the expert also testified that he had not personally engaged in any studies of the effect of overtime on productivity. Instead, he identified a chart of unknown origin, which allegedly incorporated data from NECA, MCAA, and the Bureau of Labor Statistics. The expert stated that his opinion was based on those studies.

The court rejected Randolph's expert, citing Rule 702 of the Federal Rules of Evidence. The court noted that an expert is someone whose "knowledge, skill, experience, training, or education qualifies him to render an opinion on scientific, technical, or other specialized subjects." Randolph's expert had simply read the studies and made logical inferences, which the court did not consider an "expert" opinion. The court found that the expert testimony was being used to introduce the chart, which it would not accept as a "learned treatise" under Rule 803. Because the court had rejected Randolph's expert and his chart, it was left with no way to quantify the lost productivity damages. Although it found that Randolph would be entitled to these damages, without a valid quantification it awarded none.

In summary, the Hensel Phelps Board found the analysis performed by T&S persuasive, but another court rejected a similar analysis performed by Randolph in the Havens case. These examples show that the use of published standards and factors can be successful in quantifying lost productivity. However, the factors should be applied by someone who can justify their use based on experience estimating lost productivity and knowledge of the specific conditions on the project. Ultimately, the analysis must establish a causal link between the actions of the defendant and the loss of productivity. The application of a published factor often assumes this link, instead of establishing it. Finally, it is noted that an analysis based on published factors can be dismissed as speculative, especially when compared to an analysis based on measured productivity [2].

Total Cost and Modified Total Cost

Contractors that believe their entire loss is the result of the owner's action frequently assert total cost claims, based on the difference between their estimate and the actual total cost of performing the work. This type of claim is generally subject to three tests: (1) was the estimate reasonable, (2) were the costs incurred reasonable given the circumstances of performance, and (3) was the entire cost increase due to the owner's actions? These are difficult tests to meet.

In one case, the United States contracted with Wunderlich Contracting Co., for the construction of a new 500-bed neuro-psychiatric-tubercular hospital complex in Salt Lake City, UT, from 1950 to 1952 [31]. The complex consisted of 14 buildings on 28 acres, including a main building representing 35-40% of the overall contract work. Discrepancies in the plans and specifications necessitated a large number of changes, and the project was impacted by a shortage of labor caused by a Korean-war-related project in the immediate area.

Wunderlich's three claims were for: (1) breach based on defective plans and specifications, (2) breach based on changes amounting to a cardinal change, and (3) a contract action based on the suspension of work clause. The plaintiff used total cost claims under all three causes of action. Under the second cause, it argued a *quantum meruit* theory, but this theory was simply based on the total cost of the work. The government did not offer direct rebuttal of Wunderlich's quantification methodology.

The court noted the plaintiff's essential burden to prove liability, causation, and resultant injury. Wunderlich's claims failed to prove liability and causation, and the court noted that there are strict requirements to use a total cost methodology to prove resultant injury. The court specifically noted the three tests required in order for a contractor to assert a total cost claim. With regard to Wunderlich's cardinal change claim, the court stated that there is no exact formula for determining the number or quantity of changes that produce a cardinal change. Each project must be addressed separately. In general, if the nature of the project has not changed, there is no cardinal change. In Wunderlich's case, the actual project constructed was consistent with the original intent–a 500-bed hospital complex. Thus, there was no cardinal change.

In *Bagwell Coatings, Inc. v. Middle South Energy, Inc.*, the plaintiff successfully applied a modified total cost approach to quantify its damages [6]. In 1976, Middle South Energy contracted with Bagwell to perform the cementitious fireproofing of the structural steel on Grand Gulf Nuclear Station in Claiborne County, MS. Bechtel was the construction manager.

Bagwell had predicated its bid on spray application of the firestopping without obstructions, but when it arrived at the site, previously installed HVAC equipment obstructed access to the work. In addition, Bagwell did not receive timely work releases to perform the fireproofing. In its claim, Bagwell determined its "extra costs" as a result of these disruptions by comparing its actual costs to estimated costs in various "management" cost categories. Admitting that it had experienced some internal inefficiencies, Bagwell then deducted ten percent from its total cost claim.

On behalf of Middle South, Bechtel testified that a more precise proof of damages would be "difficult but not impossible." Middle South contested that "jurisdictions utilizing the total cost method have held that in order for it to apply, the claimant must demonstrate that *inter alia*, 'the nature of the particular losses makes it impossible or highly impractical to determine them with a reasonable degree of accuracy.' "

The court agreed with Middle South in part, stating "The party who seeks to recover damages has the burden of proving the extra costs it has incurred as a result of the breach." However, the court also stated that ". . . a party who has broken his contract will not be permitted to escape liability because of the lack of a perfect measure of damages caused by his breach." Citing another case, the court stated, "There is a clear distinction between the measure of proof necessary to establish the fact that [the plaintiff] sus-

tained some damage and the measure of proof necessary to enable the jury to fix the amount."

Bechtel's employees had testified that Middle South had caused Bagwell to incur "substantial" damages. Although Bagwell's quantification was perhaps inadequate, the court awarded damages based on that quantification, which was the only one available. Middle South erred in not offering a more reasonable quantification of the damages, after its expert, Bechtel, acknowledged that Bagwell was entitled to recover "substantial" damages.

The total cost and modified total methodologies are often appealing to claimants because they provide for the maximum possible recovery. However, claimants should analyze the risk associated with asserting such a claim. If the defense is able to find some part of the estimate that is in error, some costs that were not reasonable, or some cost increases that were the fault of the contractor, the entire claim could be dismissed as inadequate and overreaching. Defendants can cite numerous precedent cases to support such a dismissal.

Expert Testimony (Without Supporting Analysis)

A surprising portion of lost productivity quantifications are asserted based solely on an expert's testimony, unsupported by any detailed quantification methodology. These "guesstimates" are often alleged to be based on the expert's substantial field or estimating experience and an evaluation of the conditions at the job site in question. Unsupported expert testimony can be successful, but only if the expert's opinion is accepted by the court as unbiased.

In *Luria Bros. & Co. v. United States*, the government had contracted with Luria for the construction of an airplane hanger and lean-to structure in Pennsylvania [14]. The project was delayed due to design problems related to the subgrade bearing capacity and foundation design, and work was pushed into the winter. Luria submitted a claim for delays and lost productivity. In the U.S. Court of Claims, Luria's former chief of construction estimated productivity losses during four periods finding losses as follows: (1) a 33% loss due to cold weather, (2) a 25% loss due to water conditions on the site, (3) a 20% loss due to confusion and interruption caused by the design revisions, and (4) a 20% loss due to cold weather.

The government offered no direct testimony to contest Luria's quantification; instead, it simply argued that Luria was not entitled to recover lost productivity costs. The court found that the government's specifications were inadequate, and that Luria was entitled to recover its damages in accordance with the Spearin Doctrine. The court also found that it was reasonable to assume that cold weather reduced Luria's productivity.

However, the court chose not to accept Luria's quantification of the productivity loss, stating that the contractor's expert was naturally biased, being a former employee. The court revised Luria's estimates to 20%, 10%, zero, and 20% for the four periods that Luria had examined. The court made these revisions with little discussion, as Luria's expert testimony did not appear to be supported by any substantial analysis. It is likely that Luria could have recovered more of its damages if it had supported its quantification with a more detailed analysis. For its part, the government erred in not asserting its own quantification. When it lost the entitlement argument, quantification was left in the hands of the court. The government was fortunate that the court did not simply accept the only quantification that had been presented.

In *S. Leo Harmony, Inc. v. Binks Manufacturing Co.*, delays to the construction of a new car-body painting facility led to directed acceleration and overtime, which led to disruptions, including excessive working hours; overcrowding; unavailability of tools, materials, and storage; confusion; and work interruptions [21]. The U.S. District Court found that Binks breached its subcontract with Harmony by not affording Harmony the opportunity to perform in a manner consistent with what it would reasonably expect.

Harmony personnel testified that it had suffered a loss of efficiency across its entire workforce during the four-month acceleration period. Klapp, the vice president of Harmony and its principal expert witness, provided testimony based on his estimation of the job and onsite observations. He testified that the amount of pipe installed per "gang day" during the acceleration period was reduced by 10% to 30% for small pipes and as much as 50% for 6"-8" pipes in some areas. It did not appear that Klapp used any actual productivity measurements to determine these figures. For Harmony's final quantification, it applied a factor of 30% to all labor applied during the acceleration period. Harmony's expert later admitted that he had seen this factor in a manual produced by MCAA, but he did not introduce the manual into evidence.

Binks attempted to impeach Harmony's expert testimony by stating that Harmony's workers were not adequately tracked between the painting facility project and other projects on the same site. However, the court disagreed on this point, finding evidence that there was such tracking. Binks stated that Harmony's 30% factor was "speculative," but offered no alternative factor.

Accepting Harmony's quantification of its damages, the court stated that "the extent of harm suffered as the result of a delay, such as the loss of efficiency claim in issue, may be difficult to prove . . . The law is realistic enough to bend to necessity in such cases . . . we are persuaded by the uncontradicted testimony of Leo Harmony and Klapp that their personal observations led them to agree with the 30% figure."

Unlike the Luria case, the court did not reduce the claimant's quantification of lost productivity, although the principal expert was the claimant's vice president. The court did not cite any perceived bias, and accepted the expert's uncontradicted quantification, although it was clear that the quantification was not based on any real analysis. Binks erred in arguing that Harmony could not adequately quantify its damages, while offering no alternative to Harmony's estimate of the loss. In general, an expert's estimate of lost productivity should be supported by an analysis. A claimant should expect to be awarded damages based on unsupported expert testimony only if the expert is extremely persuasive, and no reasonable alternative to quantification is available. In defending against such a claim, the expert's opinion should be labeled as speculative, and a more reasonable quantification methodology should be proposed in case the court finds that the plaintiff is entitled to recover damages.

Jury Verdict/No Methodology

It is rare for a claimant to come before a court or board with no quantification of its damages. Claimants that do typically assert some version of a total cost claim with the caveat that they do not

seek to recover the total loss, only the portion that the judge, jury, or board feels is appropriate considering the circumstances. The presentation typically includes an assertion similar to one expressed in the Harmony case, in which the expert "analogized the situation to 'a zoo, a fiasco, a nightmare [21].' "

It is far more frequent for an owner to arrive in court with no quantification methodology, believing that the contractor's claim is totally unfounded. The defense presents the contractor's faults and breaches, asserting that the contractor is not entitled to recover anything. By offering no estimate of the loss that may be associated with the owner's alleged breach, this defense can be an "all or nothing" argument. In many of the cases reviewed, the court has accepted dubious quantification methodologies when there was no other methodology available.

While defendants often argue that they do not want to "build" the contractor's claim for him, it appears to be unwise to appear before a court or board without some quantification of the contractor's loss, to be presented in the event that the owner loses the entitlement argument. This is especially important when the contractor's quantification is speculative, or asserts that all cost overruns are the responsibility of the owner, as is the case with an applied factor or a total cost claim.

IMPROVING PRODUCTIVITY DATA

According to the Business Roundtable, in the past, the U.S. Bureau of Labor Statistics has stated that it does not compile productivity data for the construction industry because it considers the data to be unreliable [8]. Considering that there may be a shortage of contractors that effectively track productivity, it is not surprising that some of the methodologies for quantifying lost productivity are either difficult to apply, or speculative in nature.

In a claim situation, contractors often argue that the lack of good productivity data is due to the fact that they are not in the business of data tracking. They want to construct projects, not claims. That point is valid in that data tracking can be burdensome. However, it is invalid in that it assumes that the data is being compiled for the purpose of asserting a claim. In fact, the use of productivity measurements by the manufacturing industry to establish a baseline from which to assess productivity improvements, demonstrates that the construction industry could benefit from better data tracking.

Recent research on construction productivity can provide a starting point from which a contractor can judge its productivity in a variety of trades. Thomas and Zavrski provide a method for contractors to measure their baseline productivity, which can be used to judge the performance of individual projects, or as the starting point for measurements of productivity losses due to disruptions [26]. Hanna et al. provide a method for establishing a baseline productivity for mechanical and electrical projects [11]. Those methodologies may not be appropriate for every contractor, but they can provide a list of the elements that should be incorporated into a calculation of baseline productivity, from which a contractor might develop its own measurement.

Once a baseline has been established, a system must be put in place to monitor productivity on future projects. Two types of data must be tracked; usage of manpower and equipment, and the quantity of work in place. More importantly, usage must be tracked in such a way that it can be associated with the quantity of work in place. Although almost all contractors track manpower on a daily basis, multiple tasks are under way, and the manpower tracking often does not report how many workhours were spent performing each task. Thomas and Kramer have developed a manual that provides contractors with a variety of techniques for tracking productivity data and using it to evaluate performance [24]. While contractors may look upon such tracking as burdensome, the data will be extremely valuable if they find themselves in a claim situation and even more valuable if applied by a contractor to identify areas of inefficiency and measure productivity improvements across its business.

A successful claim for lost productivity is one that establishes liability, causation, and a reasonable estimate of the resultant damage. Courts recognize that the calculation of lost productivity is not an exact science. However, loss estimates that are not based on measurements of actual productivity are often dismissed as speculative. Of the methodologies available, measured productivity comparisons are preferred. However, that methodology can be difficult to apply without detailed data tracking manpower, equipment usage, and the quantity of work in place. Cost comparisons have been successfully substituted for productivity comparisons, but courts have noted that usage-based productivity measurements are preferred.

Comparisons with estimated productivity and the application of published factors have been successful when they are able to demonstrate causation and are adjusted appropriately for the specific project in question. Rote application of published factors and unsupported expert testimony have been dismissed as speculative. When those methodologies are applied by a claimant, the defendant should assert a more reasonable quantification, as preparation in the event that the claimant is entitled to recover damages.

The construction industry could benefit from better tracking of productivity data and the application of this data to identify areas of inefficiency and measure productivity improvements. A contractor that tracks its productivity on a regular basis, in a good-faith effort to achieve efficient operations, will be well prepared in the event that it must assert a claim to recover productivity losses.

REFERENCES

1. Appeal of Hensel Phelps Construction Co., GSBCA No. 14744.
2. Appeal of Groves-Black, ENGBCA No. 4557, 85-3 B.C.A. (CCH). (Example of a case contrasting a measured productivity comparison to the application of a published standard from the *Army Corp's Modification Impact Evaluation Guide*).
3. Appeal of Paccon, Inc., ASBCA No. 7890, 1965.
4. Appeal of Stroh Corporation, GSBCA, No. 11029.
5. Appeals of W.G. Yates & Sons Construction Company, ASBCA Nos. 49398, 49399.
6. *Bagwell Coatings, Inc. v. Middle South Energy, Inc.*, 797 F. 2d 1298 (5th Cir. 1986).
7. Bramble, B.B., Callahan, M.T., "Disruption and Lost Productivity," Chapter 5 of *Construction Delay Claims*,

Second Edition. Aspen Law & Business, 1992, and Cumulative Supplement, 1999.
8. Business Roundtable. *Measuring Productivity in Construction*, Report A-1 (Sept. 1982).
9. *F.H. McGraw & Co. v. United States*, 82 F. Supp. 338 (Ct. Cl. 1949).
10. Gavin, Donald G. et al. "Disruption Claims," Chapter 6 of *Proving and Pricing Construction Claims*. Cushman, Robert F., Carpenter, David A., Eds. John Wiley & Sons, New York, Coopers & Lybrand Edition, 1990.
11. Hanna, Awad S., Peterson, Pehr, and Lee, Min-Jae. "Benchmarking Productivity Indicators for Electrical/ Mechanical Projects." *Journal of Construction Engineering and Management*, July/Aug. 2002, pp. 331-337.
12. *Havens Steel Co. v. Randolph Engineering Co.*, 613 F. Supp. 514 (W.D. Mo. 1985).
13. Ibbs, C., and Allen, W. *Quantitative Impacts of Product Change*. Construction Industry Institute, Source Document 108, May 1995.
14. *Luria Bros. & Co. v. United States* 369 F.2d 701 (Ct. Cl. 1966).
15. *Maryland Sanitary Mfg. Corp. v. United States*, 119 Ct. Cl. 100 (1951).
16. Mechanical Contractors Association of America. "Factors Affecting Productivity." *Management Methods Committee Bulletin* No. 58, Jan. 1978.
17. Mechanical Contractor's Association of America, *Labor Estimating Manual*, Appendix B, Aug. 1986. (Reference is an example. It is not clear which addition of the *MCAA Manual* Stroh used in its analysis.)
18. *Nat Harrison Associates, Inc. v. Gulf States Utilities Company*, 491 F.2d 578, (5th Circuit, 1974).
19. National Electrical Contractors Association. *Rate of Manpower Consumption in Electrical Construction*, 1983.
20. Office of the Chief of Engineers, Department of the Army. *Modification Impact Evaluation Guide*, EP-415-1-3, July 1979.
21. *S. Leo Harmony, Inc. v. Binks Manufacturing Co*. 597 F. Supp. 1014 (S.D.N.Y. 1984).
22. Sanders and Thomas, "Factors Affecting Masonry Labor Productivity," 117 Journal of Construction Engineering and Management, 626, 640, No. 4, Dec. 1991. (Note: Sanders, who is author of the reference, is not the author of this paper.)
23. Thomas and Napolitan. *The Effects of Changes on Productivity: Why and How Much*. Construction Industry Institute, Source Document 99, Aug. 1994.
24. Thomas, H.R., and Kramer, D.F. *The Manual of Construction Productivity Measurement and Performance Evaluation*. Report to the Construction Industry Institute, Austin, TX, Source Document 35, 1987.
25. Thomas, H. Randolph, and Smith, Gary R. *Loss of Construction Labor Productivity Due to Inefficiencies and Disruptions: The Weight of Expert Opinion*. The Pennsylvania State University, The Pennsylvania Transportation Institute, PTI Report 9019, December 1990.
26. Thomas, H. Randolph, and Zavrski, Ivica. "Construction Baseline Productivity: Theory and Practice." *Journal of Construction Engineering and Management*, Sept./Oct. 1999, pp. 295-303.
27. Tieder, Jr., John B., and Hoffar, Julian F. *Calculation of Labor Costs, Proving Construction Contract Damages*. Federal Publications, Inc., Course Manual, 1991, pp. 157-179.
28. *United States v. Citizens and Southern National Bank*, 367 F. 2d 473 (4th Cir. 1966).
29. *United States v. Spearin*, 248 U.S. 132 (1918).
30. *U.S. Industries v. Blake Construction Co.*, 671 F. 2d 539, 546 (D.C. Cir. 1982).
31. *Wunderlich Contracting Co. et al. v. United States*, 351 F.2d 956 (Ct. Cl. 1965).

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